MALARIAL IMPACT OF SURFACE IRRIGATION PROJECTS: A CASE STUDY FROM GUJARAT, INDIA

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ABSTRACT

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Year-round irrigation and multiple cropping with paddy as a dominant crop in the monsoon months have given rise to an increase in the incidence of malaria over an 18-year period in the Mahi-Kadana Irrigation Project in Gujarat State, India. Further man-made disturbances such as over-irrigation, and lack of drainage have also compounded the problem. The remedies, apart from the conventional control and prevention measures, are better water management practices and continuous monitoring of the projects by an inter-disciplinary team which should include a public health administrator.

INTRODUCTION

While the benefits of irrigation in terms of multiple cropping and raising crops of high yielding varieties to meet the growing food and primary raw material needs of the fast increasing populations in developing countries are readily recognizable, the health hazards associated with irrigation cannot be ignored. Surface water tends to spread communicable diseases in two distinct ways: (a) contamination of water used for drinking and domestic purposes by human and animal wastes leading to viral infections such as poliomyelitis and hepatitis, bacterial infections such as typhoid and paratyphoid fevers, bacillary dysentery and cholera, and protozoal infections such as amoebiasis and intestinal flagallates, and (b) creation of suitable conditions for the breeding, multiplication and dispersion of intermediary hosts and vectors transmitting parasitic diseases (Worthington, 1977). Two of the most dreaded diseases are malaria and schistosomiasis (Amin, 1977; Farid, 1977).

Public health measures including mass health education as to how to use water sources, washing facilities and latrines, epidemiological surveillance and immunisation campaigns are normally undertaken as part of the efforts to improve the quality of life. These are generally sufficient to deal with the cases referred to in the first category above. However, it is more difficult and complex to tackle those diseases mentioned in the second category, since it has been recently observed in certain localised areas that there has been a development of resistance in the vectors to the insecticides commonly used in the malaria eradication or control campaigns. Thus, it is obvious that what is required is not merely control measures but certain engineering measures such as varying the water levels in the lakes, keeping the canals free from weeds and good irrigation practices, which would reduce the possibility of mosquito and snail breeding. These are water management measures which minimise the risks arising from man-made disturbances of the environment. Bearing this in mind, the international financing agencies such as the World Bank often stress in their project feasibility reports and appraisal studies that adequate control steps should be taken for minimising the hazards of malaria and other water-related diseases in areas covered by their lending programmes.

The objectives of this paper are to examine the malarial impact of an irrigation project known as the Mahi-Kadana Project in the State of Gujarat in India, to assess the efficacy of measures undertaken for containing the spread of malariogenic factors and to suggest steps in the light of past experiences.

THE IRRIGATION PROJECT BACKGROUND

The study area

The Mahi river rises in the Vindhya hills in the State of Madhya Pradesh in central India and flows through the State of Rajasthan and then traverses the middle of Gujarat State from the north-east to south-west before discharging into the Gulf of Cambay, 580 kilometers away from its source. The total drainage is about 32,090 square kilometers, approximately 45% of which is in Gujarat.

The Mahi-Kadana Irrigation Project in Gujarat State consisted of two phases. The first phase relates to the construction of a diversion weir across the river Mahi at Wanakbori in the district of Kheda, whereas the second phase of the project refers to the construction of the dam at Kadana in Panchmahals District, 70 miles (112 km) up-stream of the river. The first phase was completed in 1960 and the second phase in 1978. The cultivable command area of the project is estimated at 0.212 million hectares covering either the whole or part of the seven revenue units of the Kheda district, known as *talukas*, on the right bank and 0.011 million hectares covering parts of the two *talukas* of the Panchmahals district on the left bank.

The distribution system, consisting of the canal and distributaries and the farm level field channels, has only very recently reached the completion stage on the left bank. But a large part of the area on the right bank has been receiving irrigation supplies for the last two decades due to the completion of the first phase of the project. The diversion weir has enabled intensive irrigation in the *kharif* (monsoon) season from July to October and limited irrigation in the *rabi* (winter) season from October to March and in hot weather from March to June depending upon the river flows. After completion of the dam in 1978, year-round irrigation has become a reality with a greater area under irrigation in the *rabi* and hot weather seasons as well. Since the left bank is new to irrigation compared to the right bank, our attention in this paper is confined to the right bank.

Soil and crops

The area under study (Fig. 1) is one of the most progressive areas in the State in terms of agricultural practices and of cooperative ventures such as milk processing. The upper and the upper-middle parts of the command area (Thasra and Nadiad *Talukas*) have the most fertile land of the area, viz. sandy loam to sandy. The lower middle part of the area (Anand, Petlad and Borsad *Talukas*) is of medium black soil type. The tail part of the area (Matar and Khambhat *Talukas*), which is mostly coastal saline, is poorly drained and less fertile.

Table I presents the basic data relating to gross area irrigated during the year in all the three seasons, area irrigated during the *kharif* season, and cropping intensity defined as the ratio of gross cropped area in three seasons to the net cultivable area and rainfall. It is obvious that with improvements in the distribution system consisting of the network of canals and branches, and on-farm development works comprising field channels and levelling, irrigation intensity has gone up over time and as a result the cropping intensity has also registered an appreciable increase. Farmers have also switched to paddy cultivation from the rainfed and much less water-intensive pearl millet during the *kharif* by using irrigation supplies. An increase in the spread of new improved varieties of paddy and in the availability of fertilisers has also greatly influenced the farmers in their choice of more water-intensive crops (Jayaraman, 1980).

The command area being situated in a fairly good rainfall zone [25—30 inches (625—750 mm) per year with more than two seasons of irrigation in the upper and middle parts, in recent years has displayed increased incidence of waterlogging and inalnd salinity. To correct these unfavourable developments a massive drainage programme is being undertaken.

Paddy, pearl millet and pulses are the important *kharif* crops of the upper and middle area. Tobacco is grown extensively in this area as a *kharif*-cum-*rabi* crop accounting for 40% of the gross cropped area. The exclusive *rabi* crops are wheat and potato. In hot weather, pearl millet and fodder sorghum are grown.

The tail part of the project area is essentially a paddy growing area in the *kharif* season with no major crops in the *rabi* season. The reasons are two: first, since the area is a saline tract it is used to raise paddy during the mon-

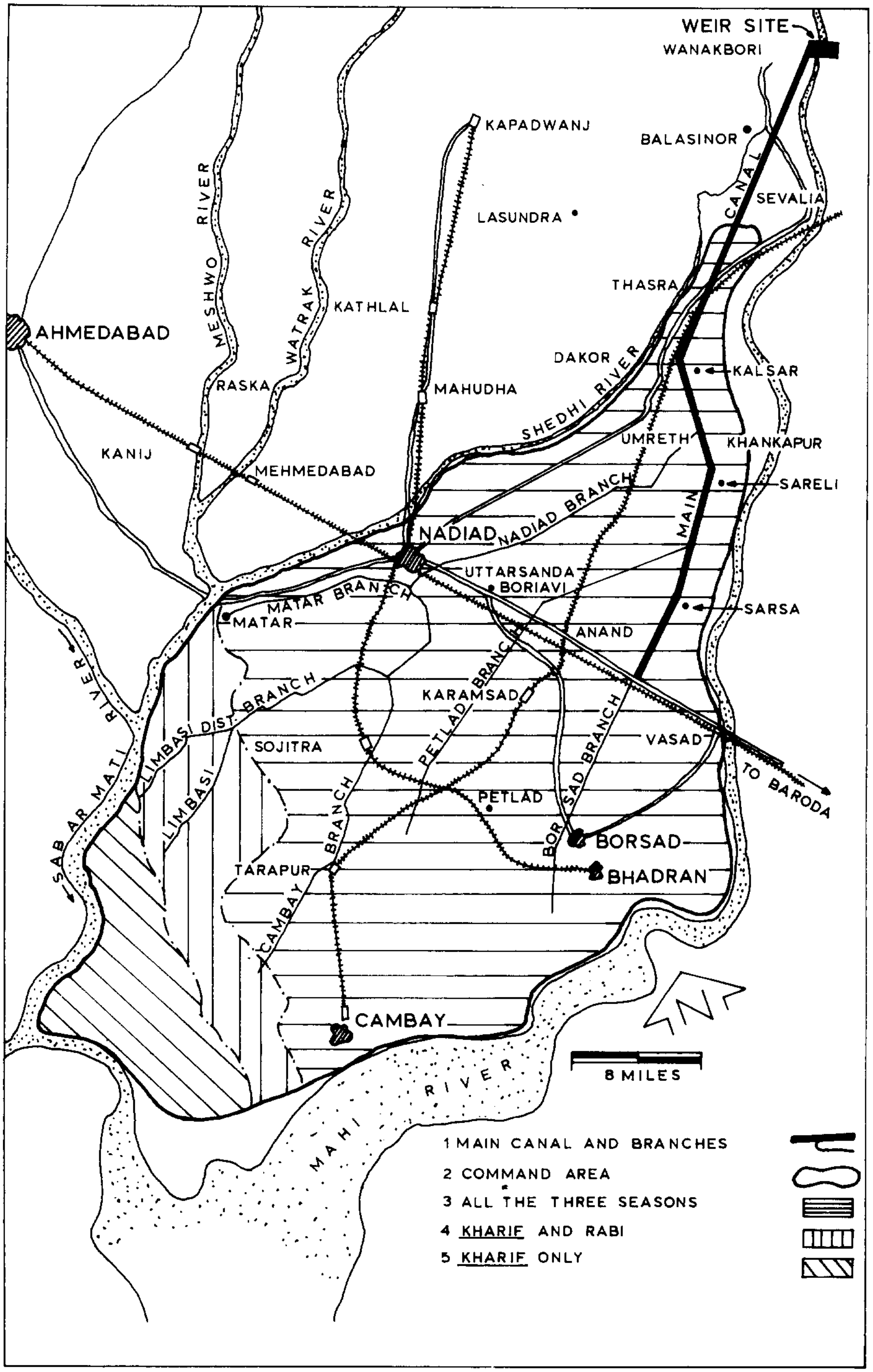

Fig. 1. Mahi-Kadana Irrigation Project area.

TABLE I

Basic data on irrigation and cropping intensity in the Mahi-Kadana Project

Year	Annual gross area irrigated during all the three seasons (ha)	Area irrigated during the *kharif* season (ha)	Cropping intensity index	Rainfall (mm)
1961	6,258	1,603	105	825
1962	15.842	6,299	105	878
1963	13,293	6,256	106	858
1964	18,705	10,146	106	590
1965	21,320	19,578	109	777
1966	28,747	24,998	100	704
1967	38,350	28,669	102	1092
1968	46,713	46,571	102	413
1969	64,654	49,645	102	765
1970	61,714	43,283	132	1318
1971	61,776	47,107	184	699
1972	43,111	38,417	155	384
1973	66,666	45,808	199	1094
1974	84,539	65,839	139	299
1975	74,550	49,503	142	966
1976	69,980	48,211	160	1646
1977	78,420	53,276	146	1200
1978	81,081	65,672	160	1066

soon with irrigation supplies along with rainfall, salts come up on the surface after the harvest of paddy and as a result, the land is rendered unsuitable for *rabi* cultivation; secondly, the area being in the tail region does not receive irrigation supplies during the *rabi* and the hot weather seasons. Farmers, therefore, either grow paddy in the monsoon with no follow-on crops or leach the salts from their fields by irrigation or rain waters during the monsoon and grow wheat in the residual moisture of the soil during the *rabi* without any irrigation.

Year-round irrigation and the consequent multiple cropping coupled with increased waterlogging due to poor drainage, and coastal and inland salinity conditions have given rise to an increase in the incidence of malaria in the project area.

TRENDS IN MALARIAL INCIDENCE

Malarial vector

The primary malarial vector identified in the command area of the Mahi-Kadana Project is *Anopheles culicifacies*. The available literature on malaria refers to this species as occurring frequently in fresh water and as sun-loving as well as favouring moderate shade. The rate of growth of larvae depends upon the temperature and inherent or genetic characters of the species. Larval habitats are generally classified into (1) permanent or semi-permanent standing fresh water such as (a) small ponds, pools, burrow pits, stagnant canals and ditches and (b) standing agricultural water as in rice fields, (2) transient fresh-water pools in cart tracks, ground hoof prints and the like, and (3) permanent or semi-permanent fresh water such as (a) open streams in association with irrigation and (b) canals and distributories (Russell, 1952).

Annual parasite indices

To illustrate the incidence of malaria over the 18-year period, annual parasite indices (API) have been calculated and are shown in Table II. The API is defined as the number of positive cases detected per thousand of the population. The procedure is that each Multi-purpose Health Worker employed by the Public Health Department covers 5000 to 7000 population in his or her beat each fortnight and takes blood smears on slides for testing at the Primary Health Centre located at each *taluka* headquarters serving about 100,000 population. Fig. 2 is the graphical representation of malarial incidence over the period of 18 years.

The highest API in the project area (37.9) was recorded in 1976. This was the year when the malaria situation deteriorated in five out of eight countries in South and South-East Asia and when the number of detected and confirmed malaria cases on a global level exceeded all the previous annual figures (WHO, 1978). It is no surprise to observe that the command

TABLE II

Malaria incidence in the Mahi-Kadana Project area

Year	Annual parasite index
1961	0.01
1962	0.01
1963	0.09
1964	0.13
1965	0.10
1966	0.10
1967	0.35
1968	0.35
1969	0.91
1970	2.23
1971	11.80
1972	11.60
1973	8.10
1974	24.00
1975	26.90
1976	37.90
1977	23.40
1978	11.40

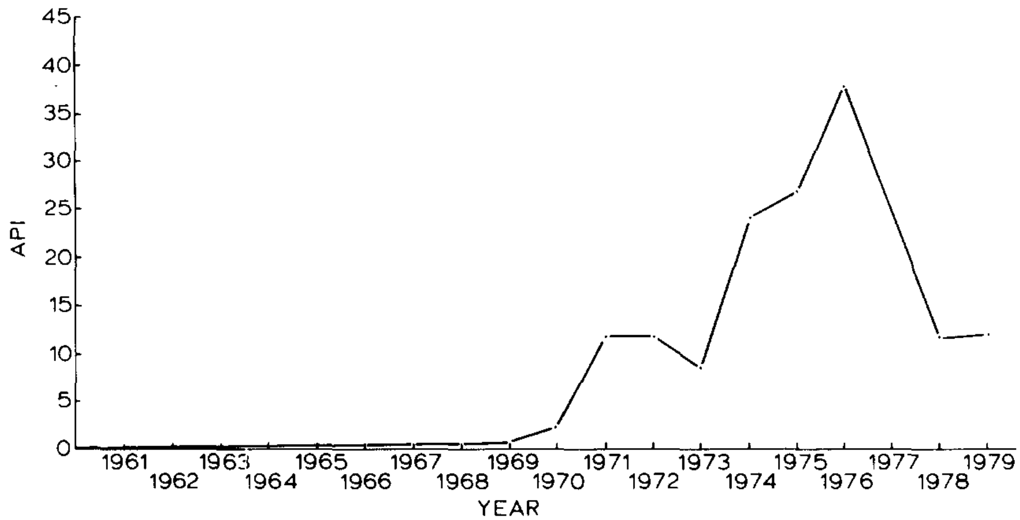

Fig. 2. Trend in malarial incidence (API) during 1961—1979.

area under study also recorded the highest incidence during the 18-year period. Within the project area, the tail part was the worst sufferer; the Matar *taluka* had the highest incidence (123 .3).

This *taluka* is the largest paddy growing area in the *kharif* and has the fewest drainage facilities. Next to the Matar *taluka*, the Khambhat *taluka* had the highest incidence (83.5) among the six *talukas*. The conditions are very similar to Matar. But Thasra, the *taluka* with the third highest incidence (46.1), is largely different from both Khambhat and Matar *talukas*. It does not suffer from coastal salinity, but receives the largest annual gross irrigation supplies as it is the closest to the weir and because of year-round irrigation in all the three seasons of *kharif, rabi* and *hot* weather. Added to this, the ground water level is observed to be rising, and a large part of the area is submerged during the monsoon and subsequent winter seasons.

Excessive July and August monsoon rains lead to greatly increased production of *culicifacies* in September. It is about the same time paddy cultivation is in full swing when the rice fields are flooded. The seasonal epidemic normally breaks out at this time when atmospheric and surface water conditions are most favourable for the development of insects. Fig. 3 illustrates the monthly incidence of malaria, with the highest incidence in September in 4 out of 5 years during 1975—1979.

Added to these there are other man-made disturbances such as over-irrigation, lack of drainage facilities to take away excess water, neglected channels, leaking sluice gates and fallow fields unnecessarily wet for prolonged periods, which compound the malarial problem in the command area.

Relationship between API and irrigation

On the basis of the data available, one could suggest that there is a direct relationship over time between malarial incidence and year-round irrigation,

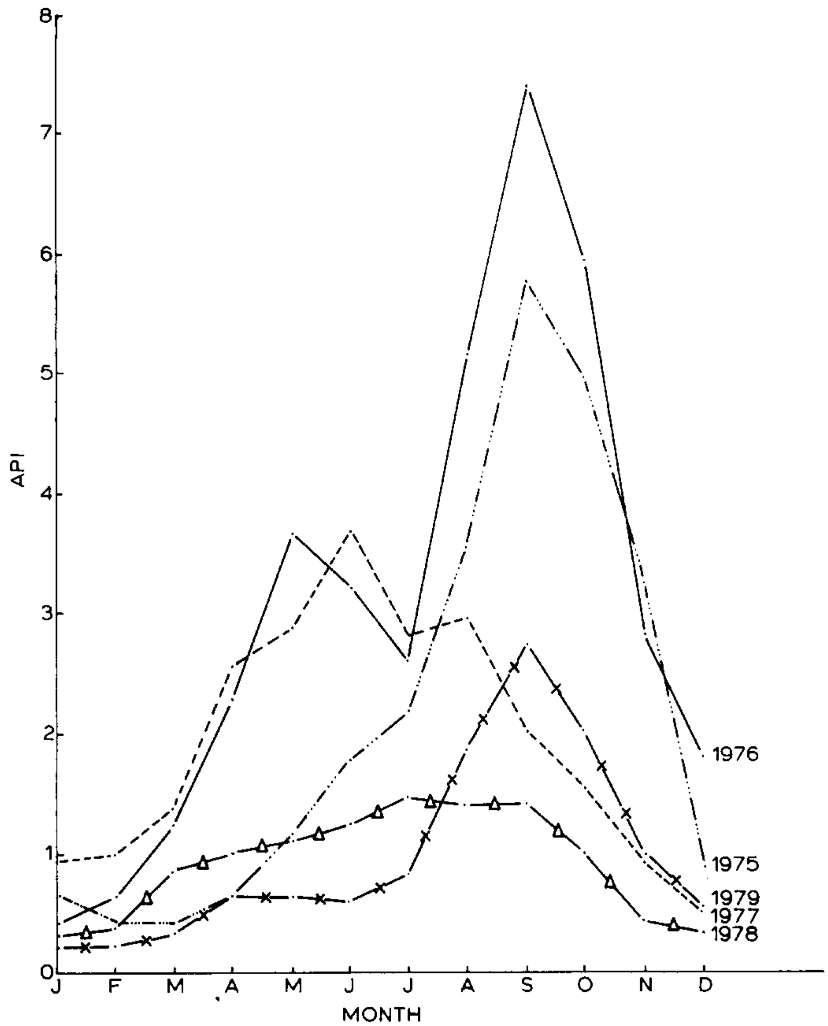

Fig. 3. Monthly incidence of malaria during 1975—1979.

irrigation during the monsoon season and cropping intensity. Table III presents the correlation matrix of these variables. There are fairly high degrees of association between API and the gross area irrigated during the year, API and the area irrigated during the *kharif* season, and API and the annual cropping intensity, all of them being statistically significant.

Anti-malaria programme

Following the serious outbreak of malaria in 1976, disease control and prevention measures were stepped up under the leadership of the local self-government organisation known as District Panchayat. The latter functions as an agent of the State Government in regard to public health programmes which include control and prevention of epidemic diseases. The District Health Officer, an offical of the District Panchayat is in overall charge of the malarial control and eradication programme, assisted by a special officer called the District Malaria Officer.

Under the District Panchayat there are 19 Primary Health Centres (PHC)

TABLE III

Correlation matrix

Variable	API	Annual gross area irrigated during all the three seasons of the year	Areas irrigated during the *kharif* season	Cropping intensity index
API	1.000			
Annual gross area irrigated during all the three seasons of the year	0.7090	1.000		
Area irrigated during the *kharif* season	0.5865	0.9538	1.000	
Cropping intensity index	0.5919	0.6535	0.5920	1.000

which have exclusive malaria clinics. These clinics have laboratory facilities for testing blood smears and they have stocks of medicines for treatment of fever. For example in 1979, some 26,298 blood smears were tested at the clinics. The average number of blood smear tests per day per Primary Health Centre is 11.

In addition to the malarial clinics of Primary Health Centres which administrate free drugs to the patients, the Multi-purpose Health Workers (who are full-time employees of the Public Health Department serving 7000 people), Community Health Visitor (who is an honorary worker, normally a primary school teacher serving a population not exceeding 1000) and Auxiliary Nurse Midwives (who are full-time employees of Health Department, serving 5000 female population) are also pressed into service for the distribution of drugs free of cost to the patients. In addition to these, a Fever Treatment Depot also functions at bigger villages with more than 5000 population to administer drugs to the malarial patients besides treating patients suffering from other seasonal ailments. These depots function under the guidance and control of PHCs. These arrangements have been made with a view to avoid the trouble of travelling to the main PHC, which is usually about 10 to 20 km away from the village, and to provide simple drugs in the village itself as far as practicable. Table IV presents data in regard to the number of fever cases treated and quantum of drugs distributed.

Prevention measures

As regards malarial prevention measures, it has been found over time that the malarial vector was resistant to DDT and BHC. Hence malathion was introduced in 1976. Besides spraying, the malarial prevention measures

TABLE IV

Data on treatment of cases and drugs

Year	Number of cases treated	Amino chloroquine consumed (tablets)	Value of amino chloroquine (rupees)
1961	116,417	294,736	29,472
1962	180,302	393,859	39,385
1963	231,887	480,884	48,087
1964	261,231	538,710	53,872
1965	340,999	751,885	75,188
1966	495,005	715,188	71,516
1967	413,922	943,557	94,357
1968	427,365	989,662	98,967
1969	486,950	1101,164	110,117
1970	474,118	1092,431	109,245
1971	510,608	1215,439	121,544
1972	488,791	1079,878	107,988
1973	512,608	1215,439	121,544
1974	593,685	1348,189	134,819
1975	584,769	1407,047	140,704
1976	587,923	1178,748	117,874
1977	488,506	1068,450	106,846
1978	517,347	1174,494	117,448
1979	546,485	1224,179	122,418

include the supply of carnivorous fish to villages for controlling mosquito breeding in their traditional habitats such as ponds and tanks. Towards this purpose 70 hatcheries are in operation supplying the fish to villages.

Further, mass education programmes such as the annual observation of National Malaria Eradication Programme Fortnight and frequent seminar-workshops are conducted each year. During the NMEP Fortnight, meetings are held in villages and the content of the programmes is explained to the villagers. Movie and slide shows are also arranged and free posters and pamphlets are distributed during this fortnight. As a result, awareness about prevention and control measures is fostered.

In the seminar-workshops which are meant for village leaders and panchayat members, the NMEP activities are discussed and the techniques of taking blood smears and their importance are explained to them. Further, anti-malarial literature is also freely distributed to these participants.

Thus, four major ecological changes which have resulted from intensive irrigation practices have given rise to a serious malaria problem in the project area. These changes are simplification of the habitat of the malarial vector, changes in water supply availability, changes in agricultural practices leading to a greater area under paddy cultivation, and rise in groundwater table level. Though the malarial incidence in the late seventies was also part of a national malarial epidemic in India, it is apparent that the irrigation practices have their own contribution to it since it has been statistically shown that there was a strong degree of positive association between irrigation and the annual parasite indices.

SOME POLICY CONCLUSIONS

Better water management

The malarial impact of the irrigation project under study is highly correlated with intensive cultivation made possible by year-round irrigation. Though conventional control steps such as surveillance and free supply of drugs and prevention measures such as spraying of insecticides and mass education have been increasingly resorted to in the project area, ultimately only better water management measures are likely to have a lasting effect.

Rotational water supply

Better water management measures include those at the farm level as well as in the main system of branches and network of distributories. Farm level irrigation, as it exists today in India, is chaotic with its own problem of uncertainty and irregularity in distribution. This uncertainty and unpredictability lead the farmer to resort to over-irrigation whenever he has a chance to irrigate since he is not sure when his next opportunity for irrigation will come. To meet these deficiencies, rotational water supply (RWS) is being increasingly introduced in various projects in India under which the crops in a given outlet command are irrigated at weekly or fortnightly intervals in accordance with crop-soil-water-requirements, and amounts of water are administered on a per-hectare-time basis (Jayaraman, 1981). The World Bank, as the financing agency for many new projects, has been vigorously campaigning for RWS on the grounds of saving water and equity in its distribution to all the farmers. In addition to these gains, one more favourable result would be a reduction in the possibility of mosquito breeding.

Above the gated turnouts the irrigation system consisting of branches, minors and sub-minors should be properly graded, maintained and cleaned from weeds which are generally the habitats for the vector. The lining of canals is also a good solution in the long run, though the initial investment cost is high. Adoption of rotational water supply would also mean rotation of the minors and sub-minors and distributories and helping them remain periodically dry, though the main branches would have to be kept running all the time.

Importance of drainage

In regard to the reservoir lakes, varying the water levels and keeping the verges free from weeds has been advocated for controlling the vectors' growth, based on the successful experience of the Tennessee Valley Authority. Along with the supply of water to crops, one should pay equal attention to drainage. Poor drainage damages the crops and adversely affects the soil ultimately. In the short run the mosquito problem assumes menacing proportions in the absence of good drainage facilities. In most of the irrigation projects drainage gets ignored in the initial years and only when waterlogging and salinity conditions develop, do the authorities realise its importance, rather late. Therefore, in all new projects drainage has to be given equal importance along with distribution.

Inputs from public health administrators

While it is usual to associate agronomists with irrigation engineers and economists in the preparation of the feasibility study of a project, it never occurred to anyone to have inputs from a public health administrator. Though the World Bank has started insisting upon measures to minimise the hazards of malarial and other inter-related diseases, so far no project feasibility report has had the benefit of expert advice in this regard at the early preparation stage. Similarly, at the implementation stage of the project as well as at the operating stage of the irrigation system, continuous monitoring by an inter-disciplinary team of irrigation engineers, land development specialists, agronomists and public health administrators is necessary to contain the malarial problem, since the epidemiology of malaria in arid zones has shown that malaria is mainly a man-made problem.

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