# Health Impact Assessment (HIA) of Development Projects with Reference to Mosquito-borne Diseases

It is recognized that the very development that intends to improve the quality of life of the people, if not managed properly, often leads to conditions hazardous to health of the people and their environment. Poor environmental conditions are the cause of most water-borne, air-borne and vector-borne diseases and contribute to poor health and a poor quality of life. Economically poor communities, children, women, most people in least developed or developing countries and the migrant work force generally constitute the most vulnerable groups. Rio de Janeiro Earth Summit in 1992 stressed that development was about meeting the needs of people, their health, well-being and lives, and a safe environment.

Broadly, the health impact assessment (HIA) is a change in health risk reasonably attributable to a project, programme or policy where a health risk is the likelihood of health hazard affecting a particular community at a particular time. Health impact assessment can make health benefits more explicit

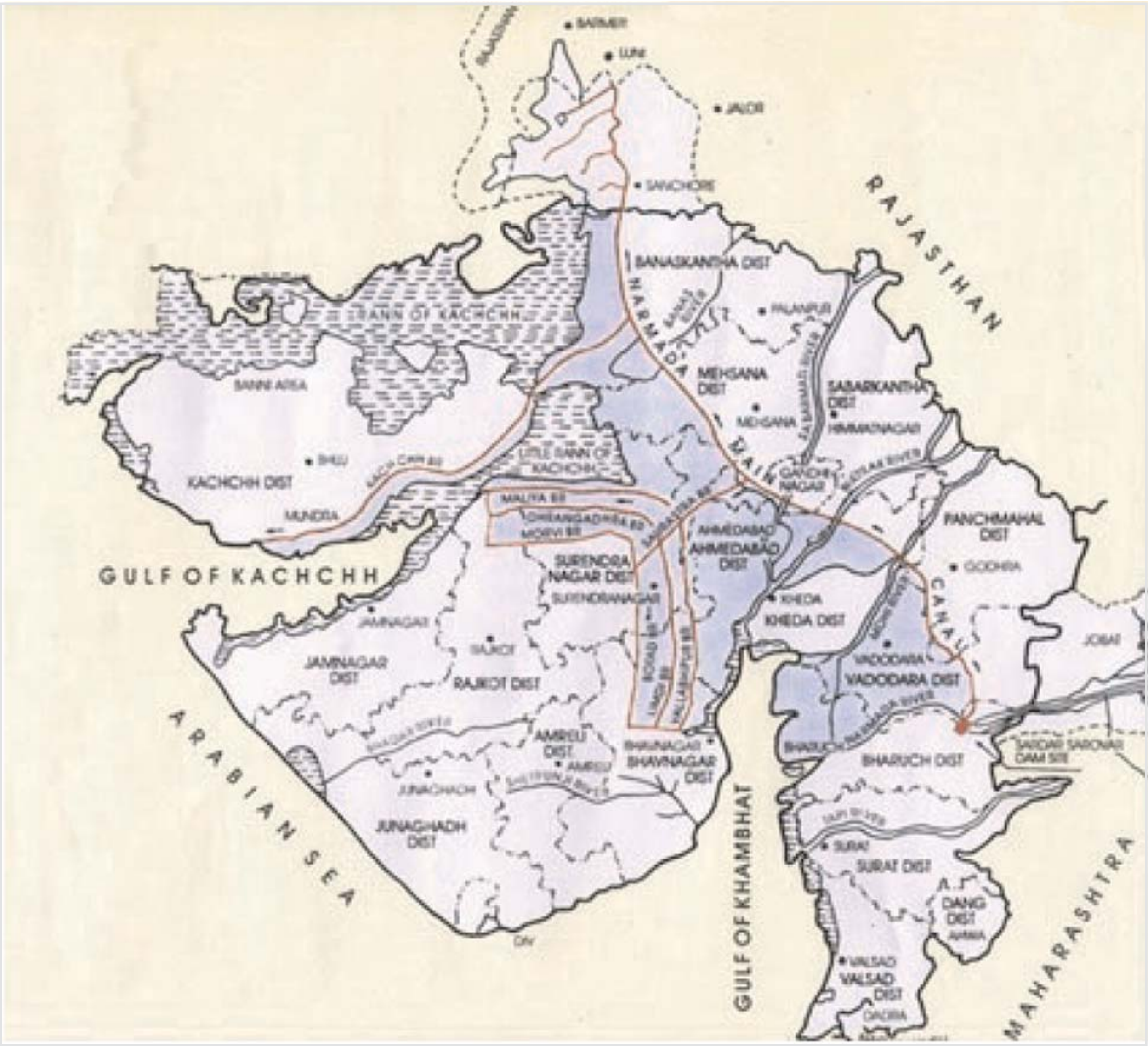


**Fig. 105: Command area of the Sardar Sarovar Project in Gujarat**

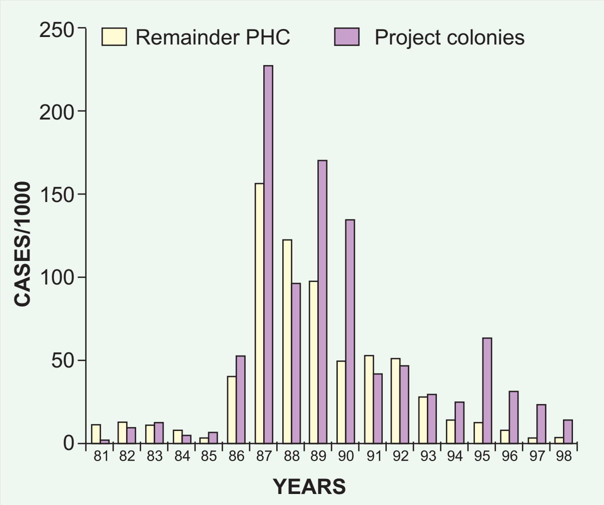


**Fig. 106: Secular trend of malaria in project colonies and the surrounding PHC villages (Sardar Sarovar Dam)**


**Fig. 107: Malaria incidence in the project colonies and the surrounding villages (Sardar Sarovar Dam)**

in non-health areas, can look at the unintended health impacts of non-health policies which would not otherwise be explicit and help in either incorporating health safeguards in the project cycle or taking mitigating measures. Whereas positive impacts of development improve overall well-being, the types of health hazard associated with a development project are broadly classified as communicable diseases, non-communicable diseases, nutrition, injuries and psychosomatic disorders.

The problem of vector-borne diseases associated with water resource projects has received a considerable attention for many years. During the pre-DDT era, most major projects in India were being prospectively assessed for adverse health impacts. By providing proper subsoil drainage, the Sarda Canal Barrage in Uttar Pradesh did not create malariogenic conditions. Other noteworthy examples of assessment of impact on malaria of the water resources development projects include Upper Krishna Irrigation Project, Irwin Canal (Karnataka), Thermal Power Plant in Delhi and Vizag Steel Plant, Visakhapatnam.

## HIA Studies undertaken by NIMR

### Sardar Sarovar Water Resources Development Project (Gujarat)

The Sardar Sarovar is a multipurpose water resources development project created on river Narmada in the Gujarat state (Fig. 105). It will generate electricity, provide irrigation and drinking water to nearly 110 cities and towns in the semi-arid areas of Gujarat and Rajasthan states in western India. Construction of dam started in 1979 and picked up momentum in 1986. Several residential colonies for engineers, workers, labourers and other supporting communities came up in the close vicinity of the dam.

An unusual increase in malaria was recorded at the project site following commencement of the construction of the dam (Fig. 106). An epidemiological investigation undertaken by NIMR during 1994–98 showed that *An. culicifacies* and *An. fluviatilis* were present in the colonies at the project site and in the surrounding villages. *An. culicifacies* was the predominant species. Although the dam has been built in the valley area, creation of dyke ponds and interruption of downstream flow of water caused potential breeding habitats of vector species resulting in a built up of high vector densities. The incidence and prevalence rates of malaria were far higher in the population at the project site as compared to those in the surrounding villages (Fig. 107). The increased transmission of malaria at the project site was attributed to the factor such as the congregation of migrant work force from the malaria endemic areas of the country in close proximity of the mosquito breeding habitats created by the project.

Assessment of the impact of the project on vector-borne diseases was undertaken since July 2002 in Phase I area covering the districts of Narmada, Bharuch, Vadodara and Panchmahals in Central Gujarat. The project was implemented in collaboration with the Department of Health, Govt. of Gujarat, Sardar Sarovar Narmada Nigam Limited, Sardar Sarovar Punarvasvar Agency and Bhaskaracharya Institute of Space Applications and Geometry, Gandhinagar. The main aims were to assess changes in environmental receptivity of the project area, community vulnerability to various diseases and the preparedness of health services to mitigate any adverse effects. Various parameters were monitored regularly at the dam site colonies, in selected villages in the command and non-command areas and rehabilitation and resettlement (RR) sites in the four districts. The activities included geographical reconnaissance (GR) of borrow pits and other mosquito breeding habitats created by construction of the canal network, studying abundance of mosquito vector population, bionomics of vectors of malaria, filariasis and dengue, evaluating insecticide susceptibility of mosquito vectors, measuring overall vectorial potential, determining parasite prevalence by mass blood/rapid fever surveys, asses malaria risk by application of GIS, and training needs assessment.

The GR of outdoor breeding habitats revealed that *An. culicifacies* was predominant species and preferred irrigation related structures, viz. dyke ponds, canals, siphons, seepage channels and seepage water pools, for breeding. Breeding of JE vector *Cx. vishnui* group was also recorded from some of the structures, particularly during the rainy season. No breeding of *Ae. aegypti* and *Ae. albopictus* was found in any of the peri-domestic breeding sources surveyed. The GR revealed that the development of canal network has considerably increased the environmental receptivity for vector borne diseases in the command area especially near the canal network.

In adult collections by pyrethrum space spraying, *An. culicifacies* was collected in all seasons and accounted for 78–82% of all mosquitoes at the dam site, followed by 61–69% in the non-command area, 32–51% in the command area and 36–44.2% in the RR sites. *An. fluviatilis* and *An. stephensi* were recorded from three districts (except Bharuch) only and their density remained considerably low (<1/room) in all areas. The composition of *Aedes* species in all mosquitoes ranged from 0 to 1.2% and that of all *Culex* spp from 8.2% at the dam site to 23.1% in the non-command area.

*An. culicifacies*, the main malaria vector in the area, was found to be highly zoophilic (Anthropophilic Index— 0.3%; 7/2660) and its population composed of sibling species B (87.2%; 130/149), C (7.4%), A (4.8%) and B/C (0.7%). *An. fluviatilis* was exclusively zoophilic (0/154) and was represented by species T only (100%; 14/14), which is a non-vector, in this area. During 2003 to 2006, out of 5201 specimens evaluated by ELISA, only three were found to have sporozoites (*Pf* 2; *Pv* 1).

*An. culicifacies* was found to be resistant to DDT (mortality—51.7%) and malathion (mortality—61.7–86.7%), whereas it was largely susceptible to various synthetic pyrethroids tested (mortality >90%).

To know whether intermediate hosts of Guinea worm disease and Schistosomiasis are present in the project area, a survey of Cyclops and snails was done. Cyclops and some species of Molluscs were found in habitats such as dyke ponds, minor canals, branch canals, siphons of distributory and main canal. Guinea worm disease was last reported in Gujarat in 1994, while Schistosomiasis has never been reported in this area.

Comparison of malaria incidence in the command and non-command area revealed that the disease followed an identical pattern. Annual parasite incidence (API remained low (<1) in the command and non-command areas of Vadodara district during 2000–03 and although it increased during 2004, it remained low (1.9/1000 pop.) in the command than in the non-command (2.7/1000 pop.) areas. Correspondingly, proportion of *P. falciparum* too remained low (18.1%) in the command area than that in the non-command area (26.4%). Malaria indices in both areas in Panchmahals district remained identical. Further, to verify this, two cross-sectional mass blood surveys (MBS) were carried out in the command and non-command area during 2003 (pre-monsoon). Parasite rate was low in both areas (command area—0.19%; 12/6175), non-command area (0.11%; 6/5222). In another MBS in 2005 (post-monsoon), the overall parasite rate was 0.5% (31/6091). GIS-based mapping of malaria incidence in the phase I districts showed low incidence of malaria although malaria showed variations from year to year. In the year 2005 and 2006 too, malaria API was <2 in Vadodara and Panchmahals. In Bharuch, API was >2 in 2005 and declined to <2 in 2006. On the contrary, in Narmada district, there was some increase in malaria in 2006.

The low parasite rate as shown by mass blood surveys, or a low incidence of malaria as shown by low sporozoite rate and routine surveillance data in spite of creation of more mosquitogenic conditions in the project area, were mainly due to an effective anti-malaria programme wherein pyrethroid insecticides were sprayed indoors in all high risk villages or RR sites each year together with strengthening of malaria surveillance and treatment services. The health services at various tiers have largely been strengthened to deal with any real increase in risk of vector borne diseases mainly due to the high priority attached to the project. Yet a few gaps in the form of vacancies and training needs in various cadres of health staff need urgent addressing. Since water release for irrigation has been started in some areas and so far the study covered the pre-irrigation baseline phase, the health impact study will continue both in phase I area as well as well in new areas where canal network is being created.

## Bargi Dam Project (Madhya Pradesh)

Bargi Dam has also been created on the River Narmada in Madhya Pradesh during 1974–88. Building of the dam has resulted in the submergence of 162 villages in Jabalpur, Mandla and Seoni districts. A study by NIMR on the impact of the project on malaria following the report of deaths in some submerged villages of District Mandla (Singh *et al* 1997) showed that the villages had high incidence of malaria, gametocyte carriers (13%) and splenomegaly among the children. Submergence caused a several fold increase in the malaria incidence and *P. falciparum* cases. There is substantial evidence to indicate that *Pf* has invaded almost the whole region and caused immense misery, including many deaths.

Among the malaria vectors—*An. culicifacies* and *An. fluviatilis*, the former was resistant to DDT and HCH. In a newly irrigated area in District Jabalpur, *An. annularis* was the predominant species in the head-end villages and its abundance was directly related to the opening of the canal, whereas *An. culicifacies* was the most abundant species in tail-end villages with scanty irrigation. Malaria infection was due to *P. vivax* and *P. falciparum*. The annual parasite incidence in children and adults was 4-fold higher in head-end villages as compared to that in tail-end villages.

Some of the risk factors identified are: widely distributed clusters of hamlets, increasing operational difficulties in disease surveillance, continuance of the people in some submerged villages, increased groundwater level, fishermen's preference to live close to the reservoir (Fig. 108), migrant fishermen and lack of commensurate increase in medical care and insecticide spraying. Effective prevention and control of malaria in affected villages should include improved disease surveillance, use of effective antimalarial drugs, use of rapid diagnostic kits in epidemic situations, health education, use of effective insecticides, promotion of the use of insecticide impregnated nets. Displaced people should be resettled in healthy areas. Poor engineering design is difficult to correct after construction, and hence early planning is critical. It is already too late for Bargi Dam to prevent some of these consequences. Construction is progressing and action is required now to develop an effective health care programme based on local transmission involving multisectoral action and community participation to prevent the spread of disease in the whole region.

**Fig. 108: Photograph showing hutment in Bargi Dam area**

## Health Impact Assessment of Indira Sagar Dam and Resettlement and Rehabilitation Colonies in SSP Reservoir Impoundment Areas in Narmada Valley in Madhya Pradesh

The project on Health Impact Assessment on Indira Sagar Dam and RR Colonies in SSP Reservoir was submitted to Narmada Valley Development

**Fig. 109: Mosquito breeding habitats found near the dam site**

Authority, Bhopal in August 2003 and study was initiated in January 2004 with the following objectives: (i) to raise bench mark data on the incidence of vector born diseases (VBD) especially malaria in the rim villages adjacent to estimated high flood level (HFL) on Indira Sagar Dam for comparison during subsequent phases of construction operations; (ii) to assess the adverse health impact of reservoir, in "Drawdown" zone, downstream, canals and command areas on incidence of malaria other vector borne disease; (iii) to assess risk factors related to malaria and other vector borne diseases and water born diseases in Resettlement and Rehabilitation colonies; (iv) to assess the quality of drinking water in terms of toxic minerals in the existing water sources (if any) and microbial contamination in the canal drinking water sources; (v) to make recommendations of mitigation measures for each component in dam, conveyance, command areas and resettlement colonies for control of malaria and other vector borne and water borne diseases.

Till April 2008, 13 surveys in different seasons were carried out in seven districts, viz. Khandwa and Dewas (ISP & OSP), Khargone and Harda (ISP), Badwani, Dhar and Jhabua (SSP). Mosquitogenic conditions created due to dam construction, viz. seepage of the reservoir, pits and pools of down streams, new canals created, curing tanks etc. (Fig. 109) have been identified. Surrounding to these, a total of 32 villages, 18 rehabilitation and resettlement centres and five command area villages and six labour colonies under seven districts have been surveyed for entomological and epidemiological data for all the vector borne diseases, i.e. malaria, dengue, JE and filariasis.

Man hour density/room density of malaria vector *An. culicifacies* and *An. stephensi*, filaria vector *Culex quinquefasciatus,* JE vector *Culex vishnui* and Dengue vector *Aedes aegypti* were calculated in all surveys. Impact of dam construction was observed in nine villages as the vector density was reported high till July–August 2005. To establish the transmission, other entomological parameters, viz. biting habit, parity rate, gonotropic cycle, sporozoite rate, human blood index and presence of sibling species were also carried out. Breeding sites created due to dam construction were surveyed for larval breeding and species-specific breeding sites were identified for all the disease vectors. The susceptibility test for *An. culicifacies* was also carried out in pre-, post-monsoon and winter seasons. *An. culicifacies* was found resistant to DDT and susceptible to synthetic pyrethroids. Report on the vector breeding and malaria positive cases was sent to the state health department and NVDA health authorities.

GIS mapping of all the seven districts had been completed. Digital maps of villages were prepared and attached with attribute and malaria data. Trend analysis of epidemiological data from 2002–05 has been done. The data on various entomological and parasitological parameters which are being collected through periodic surveys are regularly put into GIS based frame work to view the impact of the construction of dams in space and time.

**Fig. 110: Meeting with NVDA authorities**

Water samples collected from tap, hand pump, tube-well in each survey were analyzed by Public Health Engineering Department and was found safe for drinking. Recently, in April 2008, tap and hand pump water samples from 11 villages of three districts, namely Jhabua, Barwani and Khargone were tested for Coliform and other harmful bacteria. All the tests were negative and water was found safe for drinking.

After completing each survey, meetings was held with Vice-chairman, NVDA and state authorities and survey highlights and actions required for developing situation specific mitigating measures, i.e. engineering, epidemiological and entomological to control the vector borne diseases were suggested (Fig. 110).

From October 2005, the following suggested mitigation measures were implemented in the field by State Health Department, NHDC and NVDA: de-weeding in canals, release of larvivorus fishes in tanks of Narmada Nagar, RR center and ponds and wells of villages, source reduction, spray of pyrethroids in Narmada Nagar and DDT in problematic villages/RR Centers, cleaning and oiling of drains in Narmada Nagar on weekly basis, fogging in power houses, construction of mosquito proof house in Omkareshwar Dam site, IEC activities (Fig. 111) in villages/RR Center and Narmada Nagar and radical treatment to all the *Pf* cases.

Due to this the vector density of malaria, dengue, chikungunya, JE and filariasis were reduced drastically and the impact of this density was also observed on the number of malaria cases which have been reduced from 250 in 2005 to five cases till April 2008. It is important to note that in Sharda Canal area, within four years (1924–28) about 38,000 malaria cases and thousands of deaths were recorded whereas in our study, within three years (2004–07), about 500 malaria cases were recorded with no deaths.

Blood samples were also collected for dengue,

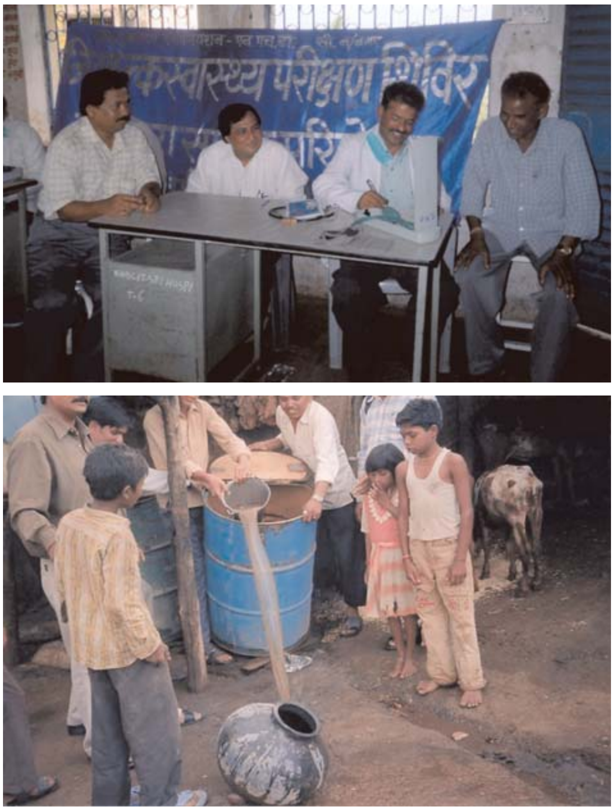

Fig. 111: IEC activities near the dam site

JE and filariasis but none was found positive (Fig. 112). It is also worth to mention that no vector species of kala-azar was recorded from this project area. Schistosomiasis was also not recorded but the detailed study on schistosomiasis and kala-azar will be initiated soon and report will be submitted to NVDA. The health impact study is in progress and will be continued up to December 2010.

In a recent survey (September 2008), we found that drinking water from hand pump is being used in Kakrana, Mahammadpur, Dogargaon, Collector Nagar and Jogakalan. Tube well water stored in tank is supplied in the Borlay village for drinking while in Piplood village drinking water is being supplied from open well. This water was tested for *Salmonella typhimurium*, *S. enteritidis, Citrobactor freundii*, *Vibrio cholerae* and *Vibrio parahaemolyticus* using Hiwater test kit (HiMedia). Presence of *Salmonella typhimurium*, *S. enteritidis, Citrobactor freundii* was recorded in the drinking water of Borlay, Piplood, Mahammadpur, Dongarkalan and Collector Nagar. *Vibrio cholerae* and *Vibrio parahaemolyticus* were also found in the drinking water of Mohammadpur and Dongargaon respectively. None of the bacterial species tested were found in the drinking water of Kakrana and Joga Kalan village.

Fig. 112: Parasitological surveys in the RR villages

## Konkan Railway Project

### Historical Account

Construction of Railways in malaria endemic tracts was always associated with serious outbreaks of malaria causing enormous morbidity and mortality in the workforce. As a result, these projects were subjected to inordinate delays and cost escalation. In 1900, the survey of line at Liang-Biang (Indo-China) caused 77% mortality amongst Europeans and 80% amongst natives in 8 months. In India, in the hilly tracts between Vizianagram and Raipur, malaria was invincible. Attempts to survey the area failed in 1883, 1897 and 1907. Surveys could only be completed in 1925 when all the staff was duplicated. In the words of Senior-White, the cost in terms of human lives was astounding and the popular phrase to describe the social cost during the project was "A death a sleeper". Similarly, when the Ambda-Jambda branch of Bengal-Nagpur railway was built through Singhbhum district of Chhota Nagpur in 1923–24, mortality due to malaria amongst engineers and labour was so high that the Frontier Army had to be called in to complete the project amidst large-scale revolt and desertions by the workers. Even after the commissioning of the railway line, malaria transmission continued resulting in heavy economic burden on the railways on account of morbidity and mortality among the railway employees.

On the Western Coast of India, a tentative survey on the Konkan Railway (KR) route had been done about a century ago but owing to a very difficult terrain, railway line could not be built until 1977 when a 65 km stretch was built between Apta and Roha. British had avoided laying a line in this region due to high cost involved in bridging many rivers and valleys and boring of tunnels through several hill ranges. KR project is the biggest new railway line construction undertaken on the Indian sub-continent in the past century. Konkan Railway Route passed through Raigad, Ratnagiri and Sindhudurg districts of Maharashtra, North and South Districts of Goa, Uttara Kannada and Dakshina Kannada Districts of Karnataka State (Fig. 113). KR project, which now connects Roha to Mangalore has been described as a marvel and a rare fete in the civil engineering because an almost impossible 760-km project was executed in a little over 7-years. To have such a railway project along the west coast was the dream

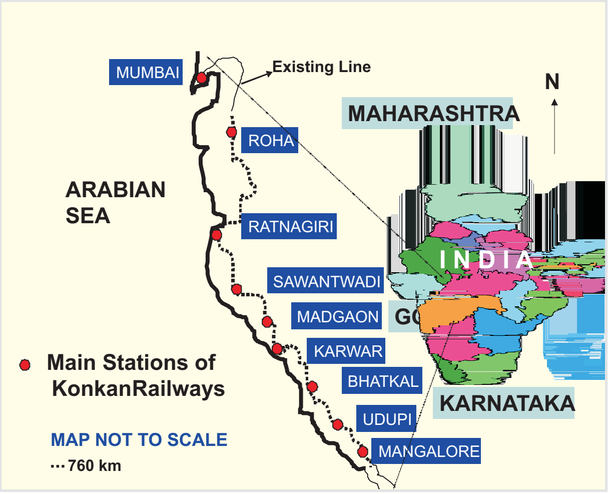


Fig. 113: Konkan Railway line along the west coast of India

of many in Maharashtra, Goa and Karnataka but only a few thought it would ever be realized. The Konkan Railway line was commissioned in phases from 1993 onwards in 11 sectors and finally fully commissioned in 1998 when it was formally declared open by the then Hon'ble Prime Minister of India Shri Atal Bihari Vajpayee.

## Environmental Concerns about Konkan Railway Project

In Goa sector, a stretch of 55 km from Mayem to Bali became subject of controversy as it was argued that irreversible damage would result to Goa's ecology and social life. Particularly, it was felt that the coastal silt lands ('Khazan' Lands) which are highly productive would sink and get inundated leading to mosquito breeding and outbreaks of mosquito borne diseases especially malaria and Japanese encephalitis. It was also felt that railway line was passing close to a heritage structure and continuous vibrations would cause damage to the structure of the shrine in Old Goa. The Ministry of Railways appointed a former Railway Board Chairman to give his opinion on the alignment and barring few suggestions concurred with the existing alignment. In June 1992, the Ministry of Environment appointed a 15 member committee headed by Late Mrs. Kamla Chowdhary to examine environmental, heritage and other issues. The committee with majority opinion suggested retaining of the approved alignment. However, 5 dissenting members submitted a separate report. Hence, the Ministry could not take any decision on this report. The agitation continued and chain hunger strikes, rallies, human chains, the burning of contractors' machinery and labour camps were resorted to. To oppose Lathi charge by the police three persons went on fast unto death and this issue and works on Mayem to Bali section was suspended on 25 March 1993. Justice G.J. Oza, a retired Supreme Court judge was appointed to inquire into demand for change of alignment. Justice Oza studied the approved and proposed alignments, held public hearing and submitted a detailed report suggesting remedial measures and extensive additional changes which were accepted by the Government which cost additional Rs. 30 crores.

## The Konkan Terrain

The entire coastal belt is characterized by plentiful and regular seasonal rainfall, oppressive weather in the hot months and high humidity throughout the year. There are four distinct seasons, i.e. summer from March to May, the monsoon from June to September, the post monsoon season from October to November and mild winter from December to February. The rainfall increases from North to South and from Coast to Western 'ghats'. It is generally around 2100 mm in the coast while Amboli ghats of Ratnagiri district receive about 7500 mm rainfall annually. Terrain and climatic conditions were highly conducive for malaria transmission in villages, towns and railway colonies all along the track. The scope of water stagnation and consequently mosquito breeding in and around depressions near embankment, cutting sections, pipe and box culverts, drains of washing yards, abandoned masonry and curing tanks, overhead and septic tanks, depressions between two tracks at the stations were enormous to favour mosquito proliferation round the year. The apprehension of enhanced malaria transmission in the entire region was further strengthened by the fact that malaria was already endemic in Mumbai and had also invaded Panjim town in Goa. Accelerated vector breeding and aggregation of tropical labour and movement of carriers (people with malaria infection-reservoir of infection) would establish indigenous transmission of malaria in the entire coastal zone.

## KR Project Major Works

- There are 71 tunnels with a total length of 75 km which is 11% of the total length of the project. The Karbude tunnel in Ratnagiri district is 6.5 km long followed by Nathuwadi tunnel (4.4 km), Tike and Bardewadi tunnel (4 km).
- Minor bridges with total span of less than 12 m which included irrigation openings, RCC Pipes, slabs, boxes, arches, were 1599 in number covering about 5.73 km. A total of 171 major and important bridges covering a length of 21.5 km were constructed approximately one in every 4.2 km length (Fig. 114).
- The earthwork constituted major proportion of the line about 627 km (84.8%). The earthwork included cutting of hills or embankment for laying tracks.
- Konkan Railways has in all 56 stations, so designed that they merge with the ambience of the Konkan region.

In the environmental impact assessment (EIA) report prepared by RITES India Ltd., no specific mention was made of any mosquito-borne disease

Fig. 114: To lay railway line long bridges had to be constructed over the broad perennial rivers

potential due to the project activities. This necessitated conduction of an independent HIA especially with regard to malaria. The first step in the risk assessment was the constitution of two teams one for parasitic surveillance to assess the existing load of malaria infection in migrant labour force and the second team to conduct detail vector surveillance and record observation especially on water stagnation points near minor and major construction sites such as pipe culverts, bridges, box culverts, tunnels, stations, staff quarters, yards, sleeper curing tanks, etc.

### The Challenge

There were mainly two challenges to ensure prevention and control of malaria along the Konkan Railway: (i) To enumerate the problems arising out of the construction works and suggest remedial measures; and (ii) To supervise field work to ensure that mosquito breeding potential was eliminated on long term basis.

### Objective

- Prevention of mosquitogenic conditions and indigenous transmission of malaria and other mosquito borne diseases along the Konkan Railway track.

### The Strategy for Prevention of Outbreak of Mosquito Borne Diseases

The following strategy was drafted in consultation with the Konkan Railway management and other stakeholders.

1. Health impact assessment of all works related to Konkan Railway construction.
2. Selection of cost effective and environmentally sustainable interventions
3. Develop team work with the KR, contractors, communities and staff of the NIMR
4. Monitor progress through entomological and parasitological indices.

### Cost Sharing

The cost involved in the planning, monitoring and supervision was contributed by the NIMR. Cost of material, equipment, and labour and engineering related inputs/interventions were provided by the Konkan Railway Corporation.

### Activities

- Establish linkages and coordination with Konkan Railways
- Provide consultation at planning and design stages
- Blood smear collection of all migrant labour and examination
- Delineation of mosquito breeding potential and ensure interventions
- Monitoring of the mosquito control and malaria treatment works
- Cost estimation of various interventions
- Review, plan and implement decisions taken from time to time
- Make recommendation for maintenance of works

## Major findings

### Entomological surveys

The entire line of 106 km in Goa sector was covered on foot to conduct a comprehensive survey to detect potential water stagnant areas where breeding of mosquitoes could occur. The NIMR survey team comprised of entomologists, engineers, draftsmen and field workers to assess vector potential at all the sites where water stagnations were possible and to prepare engineering drawings, suggesting corrections to ensure prevention of water stagnations and mosquito breeding. Altogether, 581 sites were inspected including pipe culverts, box culverts, major and minor bridges, tunnels at excavation sites,

**Table 24. Mosquito breeding habitat surveys at the project sites and along railway embankment in Goa sector**

| Type of breeding site | No. checked | No. positive for mosquito breeding (%) |
|---|---|---|
| Pipe culverts | 147 | 12 (8.16) |
| Box culverts | 15 | 3 (20) |
| Masonry tanks | 33 | 7 (21.2) |
| Earth depressions | 179 | 23 (12.84) |
| Drains in the cutting sections | 16 | 5 (31.2) |
| Drains in the tunnels | 40 | 1 (2.5) |
| Overhead tanks | 7 | 0 (0) |
| Fire buckets | 20 | 0 (0) |
| Water channels | 103 | 17 (16.5) |
| Sleeper curing tanks | 21 | 12 (57.14) |
| Total | 581 | 80 (13.76%) |

sleeper manufacturing plants, station buildings, staff quarters, etc (Table 24). The mosquitogenic features of each site were recorded and location drawings were prepared by the engineers and draftsman for easy understanding of the problem by railway engineers concerning mosquito potential for rectification.

### Mosquitoe Vectors Encountered

*An. stephensi*
*An. culicifacies*
*An. fluviatilis*
*Cx. quinquefasciatus*
*Cx. vishnui* group
*Ae. aegypti*
*Ae. albopictus* and
Other species —7

### Parasitological Surveys

All the 23 project sites under construction such as bridges, tunnels, embankment and sleeper construction plants were visited by the team of NIMR and Medical Officers of Directorate of Health Services, Goa. Konkan Railway site engineers and construction companies ensured availability of all workers and their families for blood screening and clinical examination. Demographically, out of 706 construction workers examined, 665 had migrated from 14 different states of India. Only 36 were natives of Goa and five were natives of Nepal. All 706 construction workers were clinically examined for hepatomegaly and their blood smears were examined for malaria. Of these, six (*P. vivax* 5 and *Pv+Pfr* 1) were suffering from malaria (SPR 0.84%). Presumptive treatment was given to all and positive cases were administered radical treatment within 24 hours as per NVBDCP drug policy. As many as 153 (21.6%) workers had suffered from malaria in the past one year. The spleen rate was 11.7% and average enlargement spleen (AES) was 0.19. Hepatomegaly was observed in 9.91% labourers mostly associated with alcoholism (Table 25). Although, only six cases of malaria were detected in mass surveys, it clearly indicated a threat of outbreak of malaria amongst labour force engaged in the project. Secondly, labour from 14 different states with different parasitic strains and immune status residing in common camps could lead to outbreaks.

### Engineering Works

Monitoring of Konkan Railways Project during Operational phase ensured that all interventions were implemented according to the approved designs as illustrated by the following examples.

1. Sloping roof of station and residential quarters (Fig. 115).
2. Installation of mosquito proof over head tanks at station buildings and residential quarters.
3. Construction of septic tanks and soak pits at staff

**Table 25. Results of clinical examination for hepatosplenomegaly of Konkan Railway Project workers and malaria diagnosis**

| Item | Nos. |
|---|---|
| No. of project sites visited | 23 |
| No. of workers examined | 706 |
| No. of migrant workers (665 from 14 states of India and 5 from Nepal) | 670 |
| Workers native of Goa | 36 |
| Positive for malaria (5 *P. vivax* and 1 mix of *Pv* + *Pf*; SPR = 0.84%) | 6 |
| No. with history of malaria | 153 (21.6%) |
| Spleen rate | 11.7% |
| Average enlarged spleen | 0.19 |
| Hepatomegaly | 9.91% |


**Fig. 115:** Konkan Railways Station at Margao and Karmali-Old Goa (Inset). With the timely intervention of NIMR, the design of station building was changed by the Konkan Railway Corporation and sloping roofs were provided to prevent water stagnations on station terrace during heavy monsoons experienced in the Konkan Region

**Fig. 116:** Pacca drains were provided all along the track in the cutting section for efficient flow of water

**Fig. 117: All abandoned masonry tanks were filled with soil to prevent water collection and mosquito breeding**

quarters and railway stations.

4. Clearance of drains near the cutting section near the mouth of tunnels and providing concrete drains along the track (Fig. 116).
5. Efficient drainage of water at the railway station and coach washing yards.
6. Filling or demolition of tanks after construction of major and minor bridges tunnels, etc (Fig.117).
7. Clearance of mud/silt from the mouth of the pipe and box culverts to ensure smooth flow of water.
8. Filling up of depressions near major bridges to avoid stagnation of water.
9. All abandoned sleeper curing tanks were either filled and leveled or repaired and converted to larvivorous fish hatcheries (Fig. 118). A system of fish supply to establish hatcheries at the Primary Health Centre's was made operational.
10. Removal/drying up of water stagnations during construction of railway quarters (Fig. 119).
11. Re-usable fibre glass plastic food trays/cups and waste collection system were introduced in the trains.

Konkan Railway Corporation and sloping roofs were constructed to prevent water stagnations on

**Fig. 118: Abandoned sleeper curing tanks were stocked with larvivorous fish *Poecilia reticulata* and handed over to the Directorate of Health Services Goa for fish propagation and distribution**

**Fig. 119: Konkan Railway Engineers and Scientists of NIMR inspecting Railway Quarters site under construction where water stagnation was supporting anopheline breeding**

station terrace during heavy monsoons experienced in the Konkan Region.

## Cost Profile

In consultation with Konkan Railways financial and technical experts, we computed the cost of anti-malaria surveys along the entire Konkan Railway alignment of 760 km at Rs. 4.566 million (US $ 0.1014 million) (Table 26). While the cost of intervention measures, viz. earth work for bringing soil from hill slopes for creating raised railway embankment, g er y d d n s e ). s e al s

## Recommendation for Routine Maintenance

The recommendations currently under implementation to ensure mosquito free environment in and around the Konkan Railways are listed in Table 27 and few drawings are shown in Figs. 120 and 121.

## The Reward

In the entire line no outbreak was reported from anywhere in 760 km line. Even in Goa, where NIMR maintained close watch on the situation, no outbreaks were observed anywhere along 106 km line in labour camps or nearby villages. The inter-sectoral collaboration proved fruitful in averting not only outbreaks of malaria but also of other mosquito-borne diseases.

**Table 26. Summary of estimated expenditure for anti-mosquito measures for entire KR project of 760 km from Roha to Mangalore**

| Item | Description | Cost in millions (Rs) | Cost in million US$* |
|---|---|---|---|
| 1 | *Cost of survey* | | |
| 1.1 | Manpower | 3.5 | 0.07 |
| 1.2 | P.O.L. | 0.35 | 0.007 |
| 1.3 | Consumables | 0.716 | 0.0159 |
| | Total survey cost | 4.566 | 0.1014 |
| 2 | *Intervention cost* | | |
| 2.1 | Earth work | 211.5 | 4.7 |
| 2.2 | Mosquito proofing of water tanks | 0.168 | 0.0037 |
| 2.3 | Sloping roofs | 2.352 | 0.0522 |
| 2.4 | Demolition/filling of masonry tanks | 1 | 0.022 |
| 2.5 | Laying half round drainage pipes | 25.8 | 0.573 |
| 2.6 | Minor earth work : filling and levelling of depressions | 9.12 | 0.2 |
| 2.7 | Repeated clearing of drains in cutting sections, tunnels, coach washing yards | 1 | 0.02 |
| 2.8 | Cost of re-usable trays | 1.46 | 0.032 |
| Total | HIA and Intervention cost | 257.46 | 5.721 |
| | Intervention cost per km of railway line | 0.338 | 0.0075 |
| | Total cost of KR project | 25200 | 560 |
| | *Cost of mosquito intervention in per cent to total Project cost was 1.0%* | | |

*Rs. 45 – 1 US$

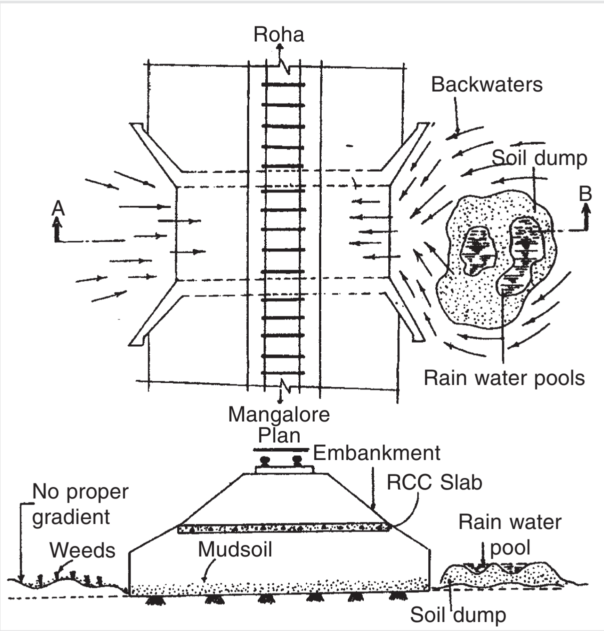


**Fig. 120: A line drawing of concrete passage built through the railway embankment submitted to Konkan Railway Corporation highlights water stagnations in the depressions in the soil dump near its mouth in which mosquito breeding was detected**

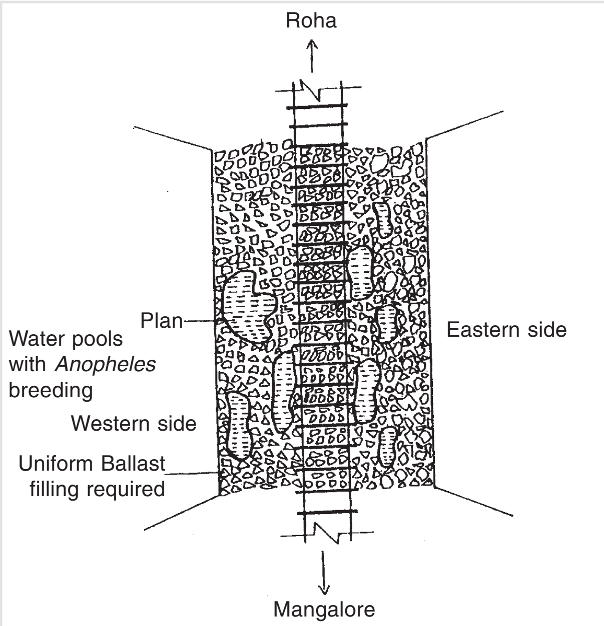


**Fig. 121: A line drawing submitted to Konkan Railways highlighting water stagnations in the depressions in ballast on embankment in which *Anopheles* breeding was detected**

## General Recommendations for Future Railway Projects

Following list for preventive steps in the future projects of Konkan Railway as corporate anti-mosquito policy were suggested.

1. All the future stations, staff quarters and other buildings built by Konkan Railway should have sloping roofs.
2. Only mosquito proof over head tanks and flush tanks should be installed and their over flow pipes will be fitted with mosquito proof arrangement.
3. Large water tanks including over head tanks and

**Table 27. NIMR Recommendations for maintenance of Konkan Railway**

| S.No. | Potential of mosquitoes | Frequency of inspection | Recommended intervention |
|---|---|---|---|
| 1. | Overhead tanks | Weekly | Ensure mosquito proofing/repair leakages |
| 2. | Masonry tanks (Abon.) | Recurrent | Demolish and level |
| 3. | Culverts (RCC, Pipe, Box) | Quarterly | Clear silt and debris |
| 4. | Major and Minor bridges | Six monthly | Clear obstructions/filling depressions |
| 5. | Cutting sections | Monthly | De-weeding and clearing drains |
| 6. | Tunnel-side drains | Monthly | Clearing with gradient |
| 7. | Septic tanks | Weekly | Sealing and netting vents |
| 8. | Drains at station/washing | Monthly | De-weeding, de-silting, clearing |
| 9. | Sleeper curing tanks | Annual | Filling of unwanted tanks |

ground water sumps should always be fitted with mosquito proof lid assembly as per the specifications given in the enclosed sheet.

4. Septic tanks in the buildings should be kept hermetically sealed and their vents covered with nylon/iron mesh at all times.
5. The masonry tanks should be demolished completely after construction so that no opportunity for water stagnation is provided.
6. Buildings and staff quarters should be provided with mosquito proof wire netting in the doors and windows.
7. No burrow pits shall be created anywhere.
8. Larvivorous fishes should be introduced in water bodies and tanks along the railway alignment.

❑