Vector-borne disease implications and their control

by Brian Kay

Sadly, decisions to develop large-scale water resources are usually based on economic and political rationales. Considerations of health have often received only cursory attention. The author details the problems of vector-borne diseases and provides selected case histories for their control.

WHEN A STREAM is dammed, the new lake presents different ecological conditions in terms of shoreline availability, water flow, thermal stratification, oxygen levels and respiratory demands. Following an initial burst of activity to utilize the organic matter in drowned vegetation and flooded soil, it would be expected that plankton populations will develop. Populations of mosquitoes, blackflies, molluscs, zooplankton, crustaceans and fish become plentiful when such conditions prevail. It will be shown that many of these are implicated in the transmission of pathogens to the developing human community.

Fluctuations in water levels caused by initial flooding, seasonal changes, or as part of water management policy cause dramatic effects to both terrestrial and aquatic flora and fauna inhabiting the peripheral zone. In the tropics, however, new terrestrial pastures may be established to provide extensive food and shelter for many animals during the dropping water-level period, which may last several months. On Lake Kariba, for example, birds feed on chironomid larvae stranded by falling water levels and these animals, in turn, provide an abundant source of blood for arbovirus vectors such as mosquitoes.

Downstream from the dam wall, the ecological changes may be diverse, affecting fisheries, soil quality, nutrient levels and aquatic biota. For example, the spawning grounds of the bivalve mollusc, *Egeria radiata* were changed with the creation of Volta Lake, and other consequences relating to the Nile dams will be discussed later.

Kainji, Nigeria

Prior to 1962, the Government of Nigeria investigated the hydrological and hydro-electrical potential of the Niger, Benue and Kaduna rivers. With financial assistance from UNDP, the Kainji area of the Niger river was investigated further, although socio-economic and health issues were excluded. In 1962, the Niger Dams Act was announced, resulting in the Niger Dams Authority, which was responsible for administration of the Act. Although arrangements for public health administration had originally been left out, 12 per cent of the total project costs (US$208 million), was finally allocated for resettlement. This resulted in 44,000 people being rehoused in 141 new villages and two towns which had reasonable general services, e.g., a water supply was provided.

One year after construction had started in 1965, several consultants from WHO/UNDP were asked to make recommendations relating to health and socio-economic development. The Federal Government of Nigeria acted on these recommendations which resulted in the FAO/WHO Kainji Lake Research Project from 1966-1974, and thereafter, the Kainji Lake Research Institute.

The health status prior to construction, as in other parts of northern Nigeria, was characterized by high infant mortality, endemic malaria transmitted by *Anopheles gambiae* and *A. funestus*, and endemic areas of onchocerciasis along the rivers. Sleeping sickness had been brought under control but tsetse flies were still common. It was also presumed that the snails

P. Almasy/WHO

Bulinus truncatus, *the snail that transmits schistosomiasis or biharzias, lives in shallow stream-beds or irrigation ditches.*

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Bulinus globosus and *B. pfeifferi* were intermediate hosts of *schistosoma haematobium* and *S. mansoni* respectively, but transmission probably occurred at low levels.

Prior to construction, snail vectors of schistosomiasis were found to be abundant throughout the valleys of the Niger and some of its tributaries and also in the construction camp area. Not surprisingly, the occurrence of these snails suggested that schistosomiasis might become a problem in the future, introduced by the migrant labour force.

Along the Niger river and tributaries, onchocerciasis effectively prevented local settlement and full utilization of the natural resources. Since 1962, larval control of both *Simulium* and *Anopheles* larvae was instituted to protect workers from river blindness and malaria, respectively. DDT at concentrations of 0.33 -2.0ppm were introduced into the river for thirty minutes every ten days. These applications were done manually in the construction area and for ten miles downstream in the catchment of the Oli river. Because these treatments gave only temporary relief, this expenditure was ongoing.

On the flooding of the impounded area of 1250km^2, a number of known blackfly breeding sites were submerged, and water turbidity and the steep shoreline undoubtedly reduced snail breeding. Since the colonization of the shoreline by snails, mainly *Bulinus globusus*, was influenced by weeds and vegetation, only the flat eastern side of the lake provided the necessary moist and shady conditions. Thus only five to ten per cent of the marginal length harboured snails and, as such, schistosomiasis was limited to localized areas of infection. In 1970, however, 31 per cent of the 1,656 residents of four major villages were infected, mainly with *Schistosoma haematobium*, but also with *S. mansoni*. The major sites of infection were identifiable either as being flat or of intense human activity around a ferry jetty. These areas were targeted for molluscisiding and health education programmes to alleviate the problem.

Periodic seasonal flooding between August to October and December to February, and a dry season which sometimes reduced the dam to one-third of its capacity, also had health implications. Reduced water-levels caused weeds and vegetation to dry out, thus reducing the areas of suitable summer refuge for snails. During the wet season the water became turbid, which was also detrimental to the snails.

Frequent adjustments to water flow over the spillway effectively eliminated onchocerciasis for 16km downstream along the Niger river. Consequently, more than seventy villages or fishing camps were established in an area which previously contained no more than ten. In general, however, the effects on downstream populations were far reaching. The damming of the Niger river seriously reduced the seasonal harvests of downstream farmers by terminating annual flooding, and the livelihood of over 20,000 Nupe families was affected as the annual income from fishing and grain production decreased by 50-70 per cent. This reduction extended over hundreds of kilometres to the apex of the Niger delta.

Only marginal improvements were created in health care. The accessibility of the two, and later three, hospitals remained poor, and the dispensaries continued to serve as the major health care providers, hampered by problems of inadequate support and inaccessibility because of the lack of passable roads. Mobile clinics were first introduced in 1974 from New Bussa, and later on, following a survey in 1979 which established that 60 per cent of the villagers had not received any health care services, the introduction of primary health workers in the villages was proposed. The larviciding of *Simulium* infested streams in a 50km radius around the dam site constituted the only planned intervention for vector control.

Despite the fact that the resettlement operation at Kainji was reasonably successful, and that a large investment in health improvement and vector control ($600 per person) for this purpose was made, there were few advances. Greater consideration in siting the new villages could have alleviated the schistosomiasis and, in some cases, the onchocerciasis problems. Malaria mortality could have been considerably reduced by a balanced network of basic health services. The general health situation could have been improved through the provision of better water supply and sanitation to reduce gastroenteritis, guinea worm infection, and intestinal helminth infection; improved housing to reduce infections and epidemic meningitis; and enhanced road communications to improve the accessibility of health care.

Coming in the January issue

A Water Decade Roundup

Waterlines provides some food for thought about where to go from here.

Welcome CARE Canada and AMREF

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Thank you!

The Nile dams, Egypt

From 1953-1954, an international group of experts examined the viability of the Aswan project to dam the Nile river for irrigation and power production. The consequences of restricting considerations to technical and economic aspects, thus neglecting environmental issues, were far reaching. Following six years of negotiations between Egypt and Sudan, the engineering work began, along with preparations for the resettlement of some 110,000 Nubians living in an impounded area of 65,000km^2.

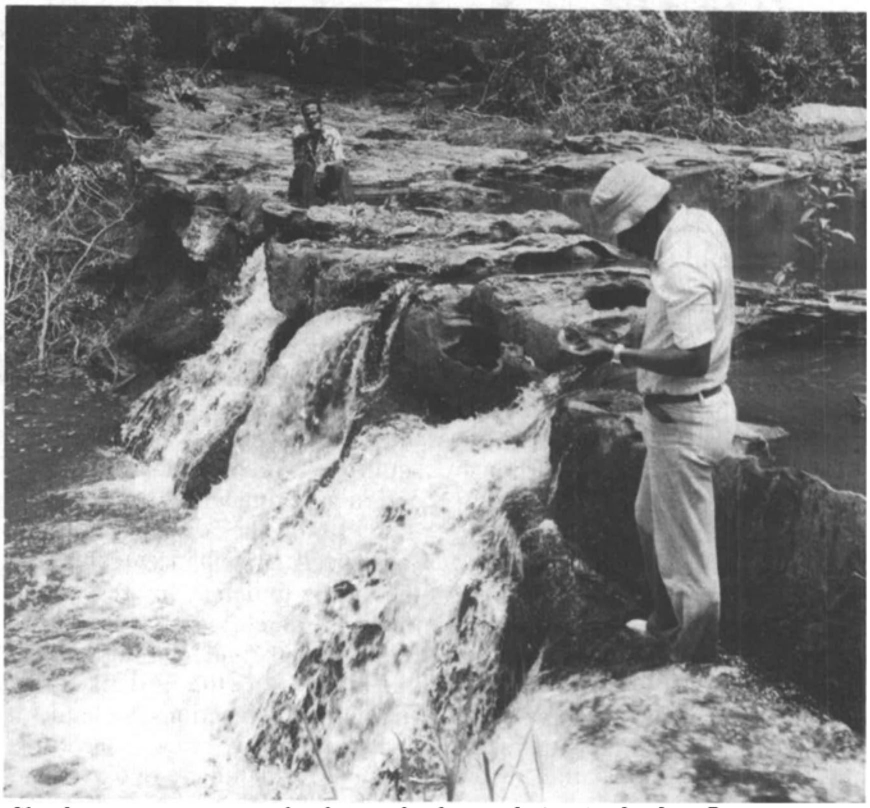
The Aswan project, costing $625 million, created Lake Nasser, extending some 900km from the town of Aswan to the confluence of the Blue and White Nile. It was designed to convert an almost rainless zone in the Nubian desert into arable land (506,000ha) and to increase the productivity of rice and summer maize growing areas totalling over one million hectares. Along with other benefits, it was expected that the national income of Egypt would increase by more than ten per cent or approximately $470 million per year. That is, 75 per cent of the costs would be recovered every year, an extremely profitable investment by any terms.

Drastic reductions in the amount of silt carried into the Nile delta had broad ramifications, however, including the increased salinity of the subsoil water, the loss of approximately 14,500 tonnes of calcium nitrate which was deposited as natural fertilizer on flooded lands, and the loss of the sardine fishing industry, which supported 150,000 people and was worth $7 million. The disappearance of the sardines from Egyptian shores was attributed to the lack of flood-borne nutrients and the changes in water salinity. In order to offset erosion problems along the Nile, additional irrigation and power dams were constructed between Aswan and Cairo with a further $100 million.

On the positive side, by 1975 Lake Nasser was yielding 2,000 tonnes of fish per year and had attracted a substantial fishing community, mostly from Upper Egypt. But most of the fishermen lived on board their boats and were carriers of urinary schistosomiasis. By defecating and urinating into the waters, the fishermen introduced a source of infection into the lake.

By 1971, aquatic weeds and plants such as *Potamogeton pectinatus* had become established and provided a suitable habitat for *Bulinus truncatus* snails in at least three areas on the western shores of the lake. Because of increased human contact with water, *Schistosoma haematobium* (urinary schistosomiasis) prevalence rose by ten-fold giving infection rates of 100 per cent in some communities. The ecological conditions for the spread of intestinal schistosomiasis also became more suitable with the stabilization of the waters. Snails of the genus *Biomphalaria* colonized the northern areas of the scheme and the incidence of *Schistosoma mansoni* also increased to high levels.

The Nile area has experienced profound ecological changes in modern times because of a series of water-resource projects carried out since 1925 when the Gezira-Managil Scheme began. Following the creation of Lake Nasser, the Rahad Scheme began in 1975 and as a consequence, conditions have become more suitable for the breeding of the indigenous malaria vector, *Anopheles pharoensis*, but more importantly it has allowed the northward expansion of one of Africa's worst malaria vectors, *Anopheles arabiensis*. During 1941-2, this mosquito caused the death of 130,000 people in Upper Egypt, and in 1950, *A. arabiensis* reached Abu Simbel. In both of these cases, *A. arabiensis* was eradicated in the newly invaded areas.



J. Bland/WHO

Checking a remote stretch of river for larvae living in the fast-flowing water.

In 1967 it was estimated that an additional 2.65 million people in Egypt would become victims of schistosomiasis, resulting in an economic loss of $560 million per year. In the Blue Nile Health Project alone, more than $1.2 million per year was spent on molluscicides to control the snail hosts of schistosomiasis. With respect to malaria control, indoor residual spraying and larviciding were required to depress transmission. On the Blue Nile, malaria prevalence in children was low, 0.4 to 4 per cent, but widespread insecticide resistance of *A. arabiensis* is forcing changes in the control strategy. Should vector control through insecticide use fail, the negative economic consequences of the Nile projects will become even more obvious.

Kamburu, Kenya

Kamburu is one of four dams on the Tana river of central Kenya, designed for the power generation of 350MW as well as for irrigation. Although no budget provision was made originally, $50,000 became available for multidisciplinary ecological and health surveys in 1974 and 1977. Experts from WHO, FAO, UNDP and the World Bank had deplored the absence or inaccessibility of such data.

This case history demonstrates that it is possible to document the health effects of dams through modest means. The guidelines for epidemiological studies concentrated on schistosomiasis, malaria and onchocerciasis, with attention being paid to vector snail populations in the inundated area and upstream. The effect of the dam on local food supplies and water-borne enteric disease nutrition were also considered. Demographic and epidemiological surveys were conducted with the Kamba people, some living on the lakeside and others 4 to 11km inland as a control group for comparison. Blood was collected by fingerprick; simple tests were done to determine anaemia and to diagnose malaria. Stool and urine samples were taken for diagnosis of schistosomiasis and determination of albumin levels. Those with enlarged spleens of grade three or higher received splenic punctures for diagnosis of visceral leishmaniasis. Blood plasma was also available for serological studies to determine the range of previous infections. Migration was monitored as an indication of habitat desirability. The Quetelet index (a height to weight statistic) was used to indicate nutritional status; and property and cattle holdings and number of people residing per house was used to indicate socioeconomic status; and sickness, immunization status, overall crude birth and death rates, and lakeside contact were also recorded.

In relation to health, lakeside residents were worse off than those inland. They suffered from incapacity an average of two to three days per fourteen. Although lakeside people were better nourished than inland residents in 1974, by 1977 this advantage had largely disappeared; iron deficiency and a haemolytic factor related to spleen enlargement contributed to a local anaemia problem. It was thought that much of this was due to malaria and other parasitic infections. The colonization of the margins of Kamburu lake by the major malaria vector, *Anopheles gambiae* was probably responsible for the increased malaria parasitaemias of 7.5 per cent in 1974 to 33.9 per cent in 1977.

Three surveys of snail prevalence from 1974-6 indicated that although *Biomphalaria pfeifferi, B. africanus, Bulinus globosus* and *B. nasutus* occurred upstream, they were poorly established in the lake due to the slow establishment of suitable plants. Surprisingly, *Bulinus truncatus*, a vector of urinary schistosomiasis, was found breeding in the lake. Because the prevalence of *Schistosoma mansoni* infection was six to eight times greater in the lakeside residents than in those from the inland villages, it has been concluded that the lake could easily become a focus of infection once the higher plants were established.

Cukorova Plain, Turkey

Malaria has long been endemic in Turkey, but prior to the 1950s there was a dearth of statistical data even with respect to parasite prevalence. By 1957, the national malaria eradication programme, employing indoor residual spraying of DDT, was started and was reported to cover a population of 30 million. The annual parasite incidence (API) per 100,000 was reported as 126 in 1957-58 and by the early 1970s, the API had been reduced to almost three per 100,000 with only 49 cases in the Adana area. Eradication and control services were then considerably reduced, to the point where they were unable to detect in time or deal with a crisis which occurred in 1977.

In the mid-1970s an extensive irrigation project was started in southern Turkey which resulted in a large increase in irrigated land in the Cukorova Plain, including the immediate area around Adana. The rapid increase in agricultural and industrial development in this area caused a substantial migration from the eastern areas of Turkey to the south-west, first on a seasonal basis, and then permanently.

In 1977, the dispersal of the specialized surveillance teams and the failure to detect and respond in time to an increase in cases among the migrants and the indigenous inhabitants in the Adana area, culminated in a serious epidemic of malaria. *Anopheles sacharovi* populations had increased vastly as a result of the irrigation programme. In 1977, some 115,000 cases were reported and the API rose to 278 cases per 100,000. The problem was further compounded by the development in *A. sacharovi* populations of resistance to organochlorine insecticides. When malathion was introduced as a replacement, inhabitants in the infected area refused to accept continued sprayings due to the odour of the insecticide. Various spray measures reduced the API to 67 per 100,000 and resulted in a reduction of malaria to 29,234 cases in 1979. Refusal rates increased further, however, and during 1982 and 1983 respectively, 18,537 of 62,038 and 35,919 of 66,681 malaria cases in Turkey were diagnosed from the Adana area.

The irrigation system, starting from small collector dams, consisted of large irrigation canals, over 15m wide with concrete bottoms and sides, which distributed huge quantities of water to major localities. The major problem, however, was caused by the numerous irregular run-off ditches used to drain off excess irrigation water.

Although the irrigation authorities were slow to accept that inadequate drainage was the major problem, some 3.6 million m^3 of discharge channels are now cleared annually to ensure that they remain unsuitable for *A. sacharovi* breeding. The average income of farmers in the area has increased three to five times but at the expense of a resurgence of *Plasmodium vivax*. Although the poor social acceptance of indoor residual spraying and the widespread insecticide resistance of *A. sacharovi* has helped to compound this problem, there is no doubt that the provision of drainage channels would have prevented most transmission.

Future Prospects

The case histories demonstrate that lack of foresight with respect to health issues consideration at the planning stage can lead to economic underachievement and considerable human distress. The diverse ecological ramifications of the Kainji and Nile dams suggest that multidisciplinary advice is needed. The failure to design adequate drainage facilities in the Cukorova Plains scheme is surprising in view of the care taken with the irrigation canals. The massive outbreak of malaria was totally predictable in view of the reduction in national surveillance.

Despite considerable outlays for health and related services (albeit as an afterthought), Kainji has not been as successful as it could have been. Health workers and consultants were never given the opportunity to engage in preventative medicine (the most cost-effective type) but were forced into the continuing curative mode. Although the situation at Kamburu was similar, this case study demonstrates an approach which provides effective guidelines at low cost. The importance of the incorporation of such studies at the planning stage cannot be overemphasized.

These case studies show the positive value of sound planning and management in relation to complex environmental changes is well-documented and the need to use them in a positive way is essential.

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