Health Impact Assessment of Increased Irrigation in the Tana River Basin, Kenya

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Summary of Health Impacts

I. Upper Tana

Health Hazard	Community Risk Factors	Environmental Risk Factors	Institutional Risk Factors	Health Risk Associated with Increased Irrigation
Malaria	Important cause of morbidity among communities. Immune status low due to seasonal transmission.	Increase in potential mosquito breeding habitats expected with increase in irrigated agriculture. Increase in seasonal colonization of the breeding sites by mosquitoes. *Anopheles arabiensis* is the main vector of malaria and exploits varied habitats ranging in size from cattle hoof prints to rice fields.	Hospital facilities congested or difficult to access. No regular surveillance for malaria or its mosquito vectors. MOH and NGO-supported programs for insecticide-treated nets in some communities.	Increased malaria risk due to irrigation.
Schistoso-miasis	Exposure to parasites expected along edges of micro-dams or shallow wells among children having a swim and women doing laundry and fetching water.	Vector snails expected to rapidly colonize micro-dams including areas frequented for domestic purposes.	Curative. No surveillance and vector control at present.	Increased risk of infection with *S. mansoni*.
Human nutrition	An increase in farmers producing vegetables and fruits.	Local diet will improve if there is irrigated agriculture.	There will be a reduction in delivery of relief food by either the government or the NGOs.	Improved nutrition for Upper Tana communities.
Other hazards	Awareness of pesticides poor among communities.	Increased exposure to pesticides used in production of high-value crops.	Community health education programs inadequate.	Increased risk in agrochemical poisoning.

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II. Lower Tana

Health Hazard	Community Risk Factors	Environmental Risk Factors	Institutional Risk Factors	Health Risk Associated with Increased Irrigation
Malaria	Leading cause of morbidity among communities in the Lower Tana area.	Increase in mosquito-breeding habitats expected in case of expanded irrigation. *Anopheles arabiensis* is an important vector of malaria along the Lower Tana area.	Hospital facilities congested or difficult to access. No regular surveillance for malaria or its mosquito vectors. MOH and NGO-supported programs for insecticide-treated nets in some communities.	Increased malaria risk.
Schistoso-miasis	Exposure to parasites expected in the increasing number of smallholder irrigation schemes.	Populations of vector snails expected to increase with increase in smallholder irrigation.	Curative. No surveillance and vector control at present. Management of two downstream irrigation schemes has collapsed.	Increased risk of infection with *S. haematobium* in the Lower Tana area.
Human nutrition	An increase in the number of smallholder farmers expected in the Lower Tana area.	Food production will improve under renewed irrigation activities.	There will be a reduction in the requirement for delivery of relief food by either the government or the NGOs.	Improved nutrition for the Lower Tana area communities in case of enhanced irrigation.
Other hazards	Poverty and illiteracy generally high among downstream communities.	Exposure to pesticides and other agrochemicals used in upstream crop production systems.	Hospital facilities congested or difficult to access.	Increased risk in chronic and acute agrochemical poisoning.

Introduction

Agricultural policies, products and processes are major determinants of people's health. More than two-thirds of the people in developing countries derive their livelihood from agriculture. Most working time is spent in agriculture, and most income on food. The health of most people is integrally linked with the agriculture sector, and agriculture dominates life in the rural areas (WHO 1986).

Agriculture involves transforming inputs, e.g., soils, solar radiation, rain, irrigation water, labor, agrochemicals and seeds through technologies and structures of work, into foods and other outputs. While agricultural policy makers may collaborate readily in the elimination of known, existing and clearly visible health risks that can slow agricultural growth, equal effort is often not directed at uncovering health risks implicit in existing and planned agricultural processes, which often negate the efforts of health and have negative feedback effects on agriculture.

Health and agricultural sectors need to work together to reinforce and support each other's goals. At the local level, the two sectors should address themselves to the impact that agricultural processes have on the health of vulnerable groups in particular and the farming population as a whole. Both health and agriculture should concentrate on the equity-oriented components in agriculture. These tasks should be complemented by a clear definition of the contribution of the health sector to agriculture and of agriculture to the health sector.

In Kenya and many other African countries, only a small fraction of the irrigation potential has been developed (see Ngigi's first paper). A considerable part of the area under irrigation is for rice production. The demand for rice on the continent is growing rapidly and the total area under its cultivation is likely to increase. Unfortunately, the flooding of agricultural land during rice cultivation has often resulted in increased health risks due to malaria and other vector and water-borne diseases (Lacey and Lacey 1990). In Kenya, research in an irrigated area has, for instance, shown a 70-fold increase in the number of malaria vectors biting people, compared to nearby nonirrigated areas (Surtees 1970). Species succession and peaks in vector densities related to the rice cultivation cycle are well-described phenomena.

Objective

This report presents a prospective health impact assessment (HIA) of increased smallholder irrigation in Kenya. The purpose of the assessment is to identify opportunities for improvement of human health and enhancement of household incomes through better agro-ecosystem management. Thus, an HIA provides the means by which inter-sectoral collaboration can be facilitated for the incorporation of health safeguards and mitigation of health impacts for water resources projects and other types of development (Bolton et al.1990; Birley 1995).

Methodology

The approach used in the present HIA was mainly qualitative, using secondary information from both published reports and key informants. A social-environmental model of health was used where the health, environmental and social impacts were interlinked. In this regard, reports and other materials compiled during the previous environmental assessment (EA) projects of the Tana river were found to be particularly useful in the absence of site visits. The latter were not feasible within the limited duration of the HIA, more so in view of a general lack of security in most of the study area.

The procedure for HIA consisted of the following four main steps (Birley 1995; Birley et al. 1997):

- *Identification of stakeholder communities.* Stakeholder communities refer to the different populations in the project area, mainly grouped according to their occupation, geographic location or ethnicity in the present HIA.

- *Identification of health hazards.* According to the HIA procedure, a health hazard is a potential source of harm. Health hazards can be conveniently discussed under the following five categories: communicable diseases; noncommunicable diseases; malnutrition; injury; and psychosocial disorders.

- *Health risk assessment.* Health risk is a measure of the likelihood of a potential hazard affecting a particular group of people at a particular time and place. For the present project, assessment was limited to an indication as to whether there would be an increase or decrease of health risks if there was a substantial increase in smallholder irrigation along the Tana river basin. Health risks associated with increased irrigation were assessed on the basis of the following considerations: population risk factors; environmental risk factors and institutional risk factors.

- *Recommendations for risk management and mitigation measures.* Safeguards and mitigating measures can reduce the negative health impacts and optimize health opportunities if planned for in advance or incorporated in the project design. They include environmental management measures and the provision of certain basic health services.

Stakeholder Communities

Indigenous Rural Populations

For purposes of the HIA, the stakeholder communities in the proposed project area were arbitrarily grouped into Upper Tana and Lower Tana areas on the basis of geographic location. The site for the proposed Grand Falls/Mutonga Hydro Power Project (figures 1 to 3) represented the dividing line between the Upper and Lower Tana areas. The Upper Tana area crosses three districts: Embu, Tharaka Nithi and Mwingi. The population comprises several ethnic groups, including Embu, Meru, Mbeere, Tharaka and Kamba (Ominde 1974). Communities in the Upper Tana area practice mixed farming. The staple food crops include maize and millet and the most common cash crops are cotton, millet and green gram. Livestock forms an important component of the farming systems.

The larger part of the Lower Tana administratively falls under the Tana river and Garissa districts, with the Tana river itself acting as the boundary between the two. Major groups of people in the area include the Somali, Boran, Pokomo and Orma. The Tana river district is mainly occupied by the largely Orma pastoralists and Pokomo recession farmers while the rural population of Garissa is almost entirely Somali pastoralists. According to the previous EA report (Acropolis 1995), both arable and pastoral farming systems have evolved to make use of, and depend on, the natural flooding pattern of the river. Among the main economic activities, the Pokomo practice flood-recession farming for their staple crops while the Orma have evolved a transhumance system that links dry-season grazing in the floodplains with wet-season grazing in the hinterland. Despite being nomadic, the Somali pastoralist system depends on the river for stock water for up to 6 months of the year.

In the past, a number of irrigation schemes have been established on the Tana river. Two of the previous projects, Bura and Hola irrigation schemes were large scale but both collapsed for different reasons (JICA and Nippon Koei 1995). In the case of Hola, the Tana river changed its course in 1989, leaving the main inlet at Laini pumping station dry. The

Figure 1. Health facilities generally available in the Upper Tana and Lower Tana areas.

Figure 2. Endemicity of malaria in Kenya (after MOH 1998).

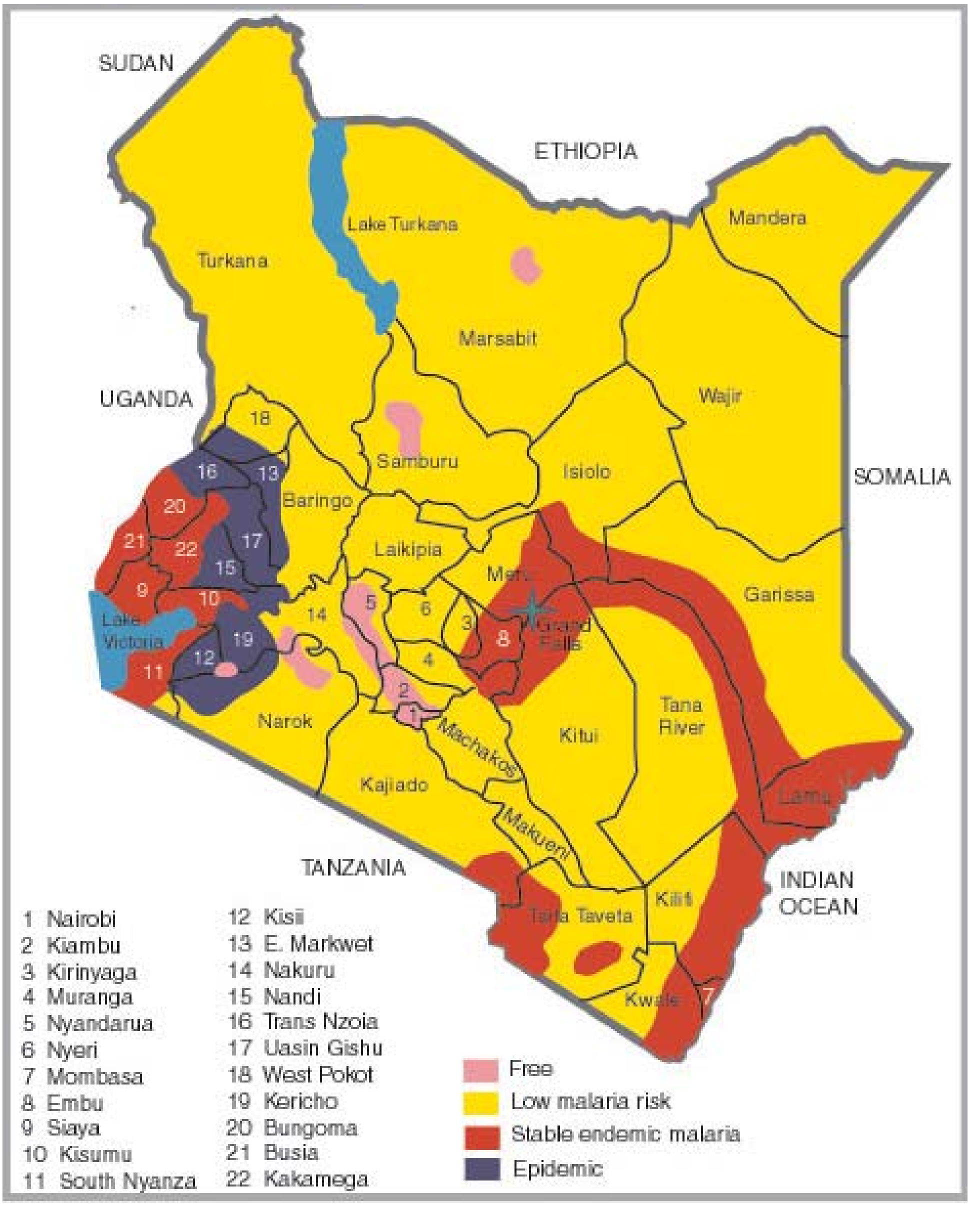
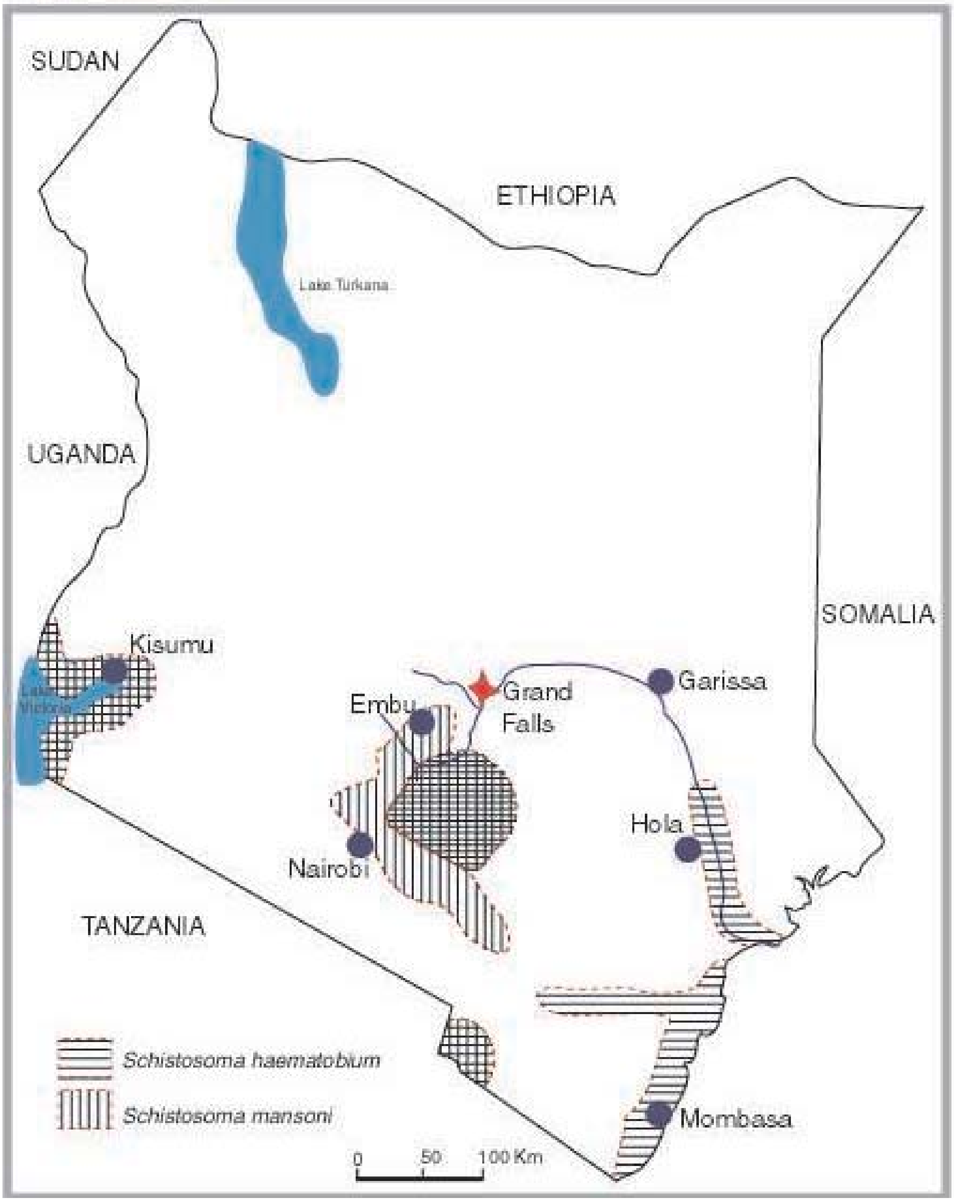


Figure 3. Prevalence of schistosomiasis in Kenya (after Highton, 1974).



cessation of irrigation at Hola since 1989 has affected the performance of the scheme and its tenants who have been unable to do any cultivation. Farmers who were previously dependent on the scheme for their livelihood have since become destitute without the means to feed and clothe themselves and their children or pay their children's educational fees. The supply of relief food is a common feature of the area.

The Bura Irrigation Settlement Project was an ambitious scheme started in 1977 to create, among other things, employment and to contribute to foreign exchange earnings through cash crops, e.g., cotton. The scheme has since collapsed due to a host of problems including the breakdown of machinery and general mismanagement. As early as 1979, the World Bank recommended abandonment of the project since it was no longer considered economically or financially viable. The original government target to settle more than 5,000 families in 23 villages to cultivate cotton and maize on 6,700 hectares of land (i.e., 1.3 ha per tenant farmer for cotton) was never achieved (JICA and Nippon Koei 1995). Currently at Bura, the settler communities and their families live in abject poverty, suffering drought and famine. The total population of about 20,000 is composed of former herdsmen or farmers who had migrated to Bura for the promise of irrigated land.

Secondary Communities

Many development projects draw poor and unemployed immigrants from a wide hinterland. As they become squatters in the project area, they are especially vulnerable to the diseases resulting from poor living conditions. They retain links with their original homes and may carry diseases back home with them to dependents who, in turn, become vulnerable. Women immigrants are particularly at risk of specific hazards, such as domestic violence, while both men and women are at risk of sexually transmitted diseases including the acquired immune deficiency syndrome (AIDS).

Assessment of Health Risk

Common Health Hazards

Prior to the advent of AIDS, the most comprehensive account of health hazards in Kenya was perhaps that compiled by Vogel et al. (1974). At the time of that publication, substantial documentation already existed in relation to medical and epidemiological research in Kenya. Specific health problems discussed by the publication included communicable diseases, e.g., malaria, filariasis, meningitis and schistosomiasis; noncommunicable diseases, e.g., diabetes, cancer, malnutrition; injury, e.g., due to traffic accidents; and mental-health disorders.

The seven most common endemic communicable diseases in the Upper Tana and Lower Tana areas are shown below (table 1) ranked according to their relative occurrence during the 1990s (MoH 1996; JICA and Nippon Koei 1995; Campbell and Hodgson 1997).

Table 1. The seven most common endemic communicable diseases along the Tana river basin.*

Upper Tana	Lower Tana
Malaria	Malaria
Upper respiratory tract infections	Upper respiratory tract infections
Diarrhea	Diarrhea
Eye infections	Intestinal worms
Intestinal worms	Urinary tract infections
Urinary tract infections	Gonorrhea
Others	Schistosomiasis

* Excluding AIDS.

Up to now, malaria has been the leading cause of morbidity and attendance at outpatient health facilities not only in the study area but generally in most of Kenya (MoH 1996). More than 5 million cases of malaria are reported in the country annually. However, despite malaria being also an important cause of inpatient admissions at various hospitals, it is of interest to note that according to unpublished reports, hospitalization due to malaria was surpassed by that due to AIDS in 1998. Both malaria and AIDS infections are present in the project area.

The two communicable diseases likely to be most impacted on by an increase in smallholder irrigation are malaria and schistosomiasis. The following risk assessment places emphasis on those two hazards in addition to malnutrition and agrochemical poisoning.

Health Services

Operations under the Ministry of Health (MoH) in Kenya can be conveniently discussed under two broad categories: a) curative services and b) preventative and promotional services (Snow et al. 1998; GoK 1991). In most cases, these services are provided on an integrated and comprehensive basis.

As regards curative services, each of about 41 districts in Kenya has a general hospital located at the district or provincial headquarters. The average number of beds in a district hospital is 200. Provinces have at least one general hospital with 500 beds on average. Services of specialists in different medical disciplines are available at the provincial hospitals.

At the local, community or village levels basic or primary health care is provided at clinics (static or mobile), health centers and dispensaries. Most of these facilities belong to the central government, local government authorities and NGOs.

Preventive and health promotional services are mainly catered for under several Divisions of MoH including the Division of Vector-Borne Diseases (DVBD) that, as part of the Division of Communicable Disease Control, works alongside other MoH Divisions, including the Division of Environmental Health, the Division of Health Education and the Health Information Systems Department. The stated objectives of the DVBD are to coordinate control of vectors of diseases in general, coordinate control of disease reservoirs, coordinate and participate in research activities related to vector-borne and parasitic diseases in general, evaluate pesticides and rodenticides for public-health use, and assist in teaching at various institutions of MoH.

Figure 1 shows the distribution of government and mission health facilities that serve the populations resident along the Tana river basin (GoK 1991; Snow et al. 1998). The highest concentration of facilities is in the more densely populated areas of central Kenya. Hospital facilities in Garissa and the Tana river districts are comparatively much fewer being only found in the Garissa town, Hola and near the delta at Garsen. The long distances that residents of the two districts must travel to the nearest hospital pose a major constraint to the timely provision of adequate health services for the majority of the population. Health services provided by the MoH in Garissa, Tana river and, to a lesser extent, in Embu and Tharaka Nithi are of necessity heavily supplemented by those from NGOs. Table 2 shows the main NGOs involved in malaria control and provision of other community-based health care services along the Tana river (Snow et al. 1998).

Table 2. Organizations involved in malaria control and provision of other community-based health care (CBHC) along the Tana river.

Area	District	NGO
Upper Tana	Embu	African Medical Research Foundation (AMREF)
	Tharaka Nithi	Chogoria PCEA Mission Hospital
		Christian Children’s Fund (CCF)
Lower Tana	Garissa	Medicins Sans Frontiere (MSF), Belgium
		Action Nord-Sud
	Tana river	Catholic Relief Services (CRS)
		World Vision

Malaria

Review of disease

Malaria is endemic along the Tana river from Embu all the way to the Indian Ocean (figure 2) (MoH 1998). According to a recent classification of malaria endemicity (Snow et al. 1998), the Upper Tana area is characterized by unstable endemicity in the relatively higher and cooler areas, and low stable endemicity on lower ground. The Lower Tana area has stable endemic malaria all the way to the Kenyan coast.

In areas of unstable malaria, clinical manifestations of the disease appear seasonally during periods of peak transmission and people of all age groups may suffer severe attacks. The disease in such areas is characterized by intermittent transmission, which may be annual, biannual or variably epidemic. Districts with unstable malaria along the Tana include Embu, Tharaka Nithi and Mwingi.

Areas of stable malaria have intense perennial transmission of *Plasmodium* parasites. Severe infections are most common in children in the first 5 years of life and in women during pregnancy. The mortality rate is highest in children under 5 years of age. Partial immunity develops in communities in areas of stable malaria due to recurrent exposure to the parasite leading to protection against severe disease in the majority of older children and adults. Districts with stable malaria within the proposed project area include the Tana river, Garissa and Lamu.

Community risk factors

Upper Tana communities. Generally, the local population has low immunity to malaria due to the unstable characteristics of the disease. Employment and various commercial activities generated by an increase in smallholder irrigation will attract both immune and nonimmune immigrants. The former group is likely to constitute an asymptomatic reservoir of Plasmodium parasites acquired during previous stays in areas of high endemicity.

Lower Tana communities. Communities in Bura, Hola and further downstream in the delta area have higher immunity to malaria than those in the Upper Tana area, due to a more extensive prior exposure to the disease. Any expansion of smallholder irrigation will lead to renewed immigration into the areas by both immune and nonimmune populations.

Environmental risk factors

Variation in climatic conditions has a profound effect on the life of a mosquito and on the development of malaria parasites (Bruce-Chwatt 1985); hence its influence on the transmission of the disease and on its seasonal incidence. The most important climatic factors are rainfall, temperature and humidity.

Rainfall exerts its influence on malaria transmission mainly through the creation of aquatic habitats that are suitable for vector breeding. The *Anopheles gambiae* species complex is the main vector of malaria in most of East Africa (Gillies and De Meillon 1968). The species complex is represented at the delta of the Tana river by a mixture of *An. gambiae s.str.* and *An. arabiensis* while the latter is the main or only species upstream in parts of Lower Tana and in all of the Upper Tana area (Mutero et al. 1999; Mutero and Birley 1987). Generally, both *An. gambiae s.str.* and *An. arabiensis* breed in a great variety of types of water, the most striking being open sunlit pools. The origin of such pools is varied and may range from hoofprints around ponds and water holes to pools resulting from the overflow of rivers, or those left behind by receding rivers. Human activity is implicit in many of these sites, especially during the reclamation of seasonal swamps for cultivation. In this connection, rice fields constitute a prolific source of *gambiae*, particularly *An. arabiensis* (Mutero et al. 1999). A flooded or partly flooded rice field presents many different types of water whose characteristics are often difficult to describe with precision. In general, rice fields are most productive of mosquitoes about 2–3 weeks after transplantation of rice seedlings. Later on, when the rice is fully grown, breeding is at a lower level and confined mainly to the margins of the fields.

As regards the influence of other climatic factors, malaria parasites cease to develop in the mosquito when the temperature is below 16 °C. The best conditions for the development of plasmodia in the *Anopheles* and the transmission of the infection are when the mean temperature is within a range of 20–30 °C, while the mean relative humidity is at least 60 percent. A high relative humidity lengthens the life of the mosquito and enables it to live long enough to transmit the infection to several persons.

Upper Tana area. Climatic conditions in districts serving as a catchment for the Grand Falls reservoir area vary from the modified tropical climate of the Kenya highlands to the tropical continental/semidesert climate of eastern Kenya (Ojany and Ogendo 1988). The highland climate is characterized by high rainfall with the long rains occurring between March and May and the short rains between October and December. The continental/semiarid zone is drier, receiving less than 500 mm of annual rainfall. The mean annual minimum temperature in the modified highland climate is 15–20 °C while the mean annual maximum temperature is 25–30 °C. Temperatures in the semiarid zone are higher. The range of temperature and humidity conditions is conducive to the breeding of *Anopheles arabiensis*, the main vector of malaria in the area, especially in the Mwea rice irrigation scheme (Mutero and Birley 1987; Rapuoda 1995). The population of *An. arabiensis* is likely to expand with expansion of irrigated agriculture in the Upper Tana. The climatic conditions in the area also favor transmission of malaria parasites for most of the year.

Lower Tana area. Both the Tana river and the Garissa districts have a mean annual minimum temperature of more than 25 °C and a mean annual maximum temperature higher than 30 °C. Malaria levels along the Tana river flood plain are among the highest in the country (figure 2). Even so, the prevalence of *P. falciparum* at Hola was 54 percent more than in the nonirrigated surrounding area (JICA and Nippon Koei 1995). A severe outbreak of cerebral malaria that caused serious child mortality in 1981–82, leading to increased desertion of the scheme, is indicative of the seriousness of the problem. Irrigation schemes introduced in areas of high -malaria endemicity have generally led to an expansion of the malaria-vector populations that, in turn, has led to an escalation of the malaria problem (Service 1984; Renshaw et al. 1998). For instance, irrigation in the Kano plain of western Kenya led to a 70-fold increase in the main malaria mosquito while both the Mwea and Hola/Bura irrigation schemes switched to perennial rather than to seasonal malaria transmission.

Despite the collapse of the Hola and Bura irrigation systems, the number of smallholder irrigation projects has increased (JICA and Nippon Koei 1994). This development is, to a large extent, attributable to the reduction of available pasture by the limitation of annual floods, resulting from the existence of several large dams upstream. The area upstream of Garissa is, for instance, host to a large number of displaced and refugee Somali and other pastrolists, some of whom have taken up irrigated farming. In the Ngao area towards the delta, farmers now utilize floodplain land formally providing dry-season pasture for a combination of rain-fed and small-scale irrigated farming. A considerable number of oxbow lakes previously surrounded by seasonal wetlands are now under crops.

In terms of vector populations and associated malaria transmission, smallholder irrigation systems can be just as notorious as the bigger schemes if water drainage is not properly managed. Even in the large rice irrigation schemes, mosquito breeding is most prolific among the many small pools that are created by footprints during rice transplanting. Assuming that the trend in smallholder irrigation is likely to grow, especially if there were more regular floods in the Tana, the vector-breeding habitat is also likely to expand, leading to a worsening of the current malarial situation.

Institutional risk factors

Both the MoH and NGOs operating in the Upper and Lower Tana areas are involved in the promotion of insecticide-impregnated bed nets for protection against mosquito bites and malaria. Community-based structures are mainly used to initiate grassroots organizations of full-cost recovery bed-net programs. Unfortunately, the failure rate of many such community programs is high mainly because the communities cannot afford either the nets or the chemicals with which they are treated. The MoH's Division of Vector-Borne Diseases (DVBD), despite having stations at each of the sites with hospital facilities, is, to a large extent, inactive due to lack of funds for operations and vehicles. A further confounding factor for malaria is the now widespread resistance of malaria parasites to the commonly available curative drug, chloroquine. The cost of alternative drugs, e.g., Fansidar, is beyond the reach of most families.

Conclusion

An assessment based on community, environmental and institutional risk factors suggests that there will be an increase in the risk of malaria among communities living in both the Upper and the Lower Tana areas in the event of an expansion in smallholder irrigation for rice and other crops. The creation of mosquito-breeding habitats due to small-scale irrigation activities in the Upper Tana area will lead to an increase in malaria vector populations. Immigrants from malarious areas will provide a parasite reservoir that could result in malaria transmission taking place for most of the year. The vector habitat will similarly expand in the downstream area due to human activity, particularly related to trans-humance and enhanced smallholder irrigation.

Schistosomiasis

Review of disease

The term schistosomiasis describes the pathological condition resulting from infection by flukes of the genus *Schistosoma*. Two species of the genus occur in Africa, namely *S. haematobium* and *S. mansoni*. Clinical signs for the two infections are blood in urine and blood in stools, respectively. *S. haematobium* has the highest prevalence along the Kenyan coast and in the downstream areas of the proposed Grand Falls/Mutonga project (Highton 1974) (figure 3). In 1956, when the irrigation scheme at Hola began, there were no snail vectors present on the scheme, owing to elevation of the scheme above the river and the absence of a suitable habitat for them (JICA and Nippon Koei 1995). A decade later, the prevalence of urinary schistosomiasis among Pokomo schoolchildren was 70 percent, rising by 1982 to 90 percent in Pokomo and Orma. The snail vectors for this disease in Hola and Bura areas include *Bulinus nasutus*.

S. mansoni, on the other hand, is absent from the coastal belt but is common in the more central areas of Kenya around Nairobi and the Upper Tana area. During the mid-1950s, an examination of 1,000 members of the indigenous population of the Embu/Kirinyaga areas failed to detect a single case of *S. mansoni* or *S. haematobium* (Highton 1974). A few years after the establishment of the Mwea rice irrigation scheme, surveys revealed a rapid increase in the prevalence of *S. mansoni* with up to 60 percent of schoolchildren having infections. The intermediate snail hosts for *S. mansoni* belong to the genus *Biomphalaria,* which has a wide distribution in Kenya. However, *Biomphalaria* has not been reported from the coastal plain and its absence is substantiated by the lack of *S. mansoni* in the area.

Community risk factors

Upper Tana area. In this area, communities come into contact with infected water in the course of their routine activities e.g., washing, fishing and swimming. Immigrant workers, fisherfolk, farmers from nearby infected areas and hawkers of petty domestic merchandise can introduce the disease in their urine and excreta. It is likely that enhanced irrigation activities combined with washing and recreation on the edges of micro-dams would result in a rapid increase in the number of people infected with schistosomiasis. As discussed elsewhere in this report, a similar phenomenon has previously occurred at the Mwea rice irrigation scheme and downstream at Bura. Both these areas started with a relatively infection-free population.

Lower Tana area. Increased expansion of smallholder irrigation will lead to renewed immigration into various downstream sites by farm workers and petty business people. Some pastoralists will also convert to a more sedentary life, which will bring them into more frequent contact with water for irrigation. An established human reservoir of schistosomiasis infection already exists in the local population and will spread to more people.

Environmental risk factors

Upper Tana area. Development of water utilization projects for hydropower and irrigation schemes has, during the last few decades, provided ideal habitats for vector snails of intestinal schistosomiasis in the Tana river basin upstream of the proposed Grand Falls/Mutonga project. *S. mansoni* is, therefore, present in Upper Tana areas. In one of the main foci of *S. mansoni,* namely the Mwea rice irrigation scheme, control of vector snails has, in the past, involved the application of molluscicides to the snail habitats, and proper maintenance of canals. Currently, the management of the irrigation scheme is in transition from the centrally managed structure of the government-owned National Irrigation Board (NIB), to community-run grassroots organizations. A decline in previous standards of snail control could lead to an increase in the snail populations in the scheme and, in turn, to an increased risk of their being washed downstream to other areas of the Tana river basin.

Lower Tana area. Snail vectors of urinary schistosomiasis are well established in Bura and Hola irrigation schemes (JICA and Nippon Koei 1995). They include *Bulinus globosus* and *B. nasutus.* The snails breed in poorly maintained irrigation channels. The collapsed state of both Bura and Hola schemes is potentially conducive to large increases in vector snail populations in the event of renewed irrigation activities. Snail populations flushed down from these areas by regular floods could easily end up as an addition to local colonies in the more recently established smallholder irrigation schemes further downstream.

Institutional risk factors

Both the Upper Tana and Lower Tana areas where schistosomiasis is a major health hazard have access to facilities that could play a role in schistosomiasis control, including hospitals and laboratories of the DVBD. The preventive role of the DVBD would be the most effective approach in the control of schistosomiasis compared to the curative approach of many hospitals

(Verhoef 1996). Unfortunately, operations of the DVBD are often hampered by lack of facilities and vehicles, and the fact that members of the staff are normally idle and demoralized.

Conclusion

The assessment concludes that there will be an increase in intestinal schistosomiasis in the Upper Tana and Lower Tana areas in case of increased irrigation activities.

Human Nutrition

Review of disease

Protein calorie malnutrition (PCM) is, in Kenya, one of the main public-health problems as it is in most tropical countries with a predominantly rural population (Blankhart 1974). The major types of PCM in Kenya are kwashiorkor and marasmus. Kwashiorkor refers to the disease of the child weaned too early on a low protein staple diet, usually maize. Kwashiorkor is caused by an unbalanced food intake with relative excess of carbohydrates and lack of proteins. Predisposing factors for kwashiorkor include infections such as measles, tuberculosis and enteritis. Marasmus, on the other hand, is due to a total lack of food, proteins as well as calories. It may affect the infant in its first 9 months of life if breast-feeding is inadequate. It occurs in older children when there is disease or shortage of food. However, to a large extent, it seems to be associated with unhygienic bottle-feeding often resulting in diarrhea.

Community risk factors

Famine is a perennial problem in some of the districts in both the reservoir and downstream areas including Mwingi, Garissa and Tana river district. Famine relief has been a feature of the Tana river district since the collapse of the Hola and Bura irrigation schemes about a decade ago (JICA and Nippon Koei 1995). Both marasmus and kwashiorkor are prevalent in the downstream districts. A survey conducted in the 1980s showed that 52 percent of the children in the Bura division were malnourished. Despite comparatively higher levels of nutrition in the reservoir area, the situation could change for the worse during resettlement of displaced communities.

Environmental risk factors

Part of the reservoir and all of the two main downstream districts are semiarid and prone to frequent severe droughts. The droughts seriously affect crop yields and animal communities. There is also a general lack of security, particularly in the Tana river and Garissa districts where bandit attacks are common.

Institutional risk factors

In the past, the Government of Kenya supplied relief food to the Tana river district, with assistance from the World Food Programme, CARE and Catholic Relief Services. A lack of adequate government resources combined with insecurity in the downstream area poses a big problem to the effective distribution of relief food.

Conclusion

The assessment concludes that increased irrigation will improve food production systems along the length of the Tana river basin and, in turn, maintain good nutrition among the resident communities.

Other Hazards

Review of disease

Other hazards associated with irrigation might include injury from irrigation equipment and agrochemical poisoning.

Community risk factors

An increase in irrigated crop production would result in increased movement of both secondary and primary communities in the Upper and Lower Tana areas. This movement would be mainly related to transportation of produce to various markets including Nairobi. The Kenyan public-transport system is prone to high accident rates and it is likely that many people will get involved in vehicle accidents.

Environmental risk factors

Expansion of irrigated agricultural production, particularly for vegetables, e.g., tomato, kale, etc., will lead to increased use of pesticides and, consequently, risk of death from accidental poisoning or when pesticides are used to commit suicide. In the Lower Tana area, agrochemical poisoning could be confounded by the washing down from the Upper Tana of additional persistent organic pollutants, e.g., organochlrorine pesticides.

Institutional risk factors

Hospital facilities in both the Upper and Lower Tana areas are, like in many other places in Kenya, inadequate under the best of times. Any increases in the local population due to an influx of people into an area with expanded irrigation activities will lead to a further deterioration in the currently available health care, unless provision for additional services is made. As regards vehicle accidents, the prevailing poor road maintenance combined with unchecked corruption in the ranks of traffic police officers have all contributed to the existing poor road-safety record for Kenya.

Conclusion

The assessment concludes that there will be an increased risk of road accidents and other forms of injury in the event of a significant expansion in irrigated agriculture. Stress-related problems are also likely to be experienced among Lower Tana communities during months of water scarcity. The communities already blame upstream activities, e.g., the damming of the Tana for the disappearance of the regular annual floods and the subsequent economic deterioration of their areas (AIC 1995). By extension of this line of reasoning, expanded irrigation in the upper Tana area is likely to be blamed for downstream water shortages and is a potential source of conflict between the downstream and upstream communities.

Risk Management and Mitigation Measures

In selecting mitigation measures for a development project, higher priority should be given to interventions with a positive impact on the general health status than to disease-specific interventions (Konradsen et al. 1997; Verhoef 1996). In the case of expansion in irrigation activities, general poverty is obviously among the more serious fundamental problems facing the stakeholder communities. Thus, a strengthening of production and marketing systems aimed at economic empowerment would rank high among measures for health improvement and the general well-being of the communities.

For malaria and schistosomiasis, a community-based health education program for promoting awareness about the diseases and available control options should be implemented at the start of expansion of irrigation activities in a given area. In the case of malaria, screening the eaves and windows of houses with mosquito-proof mesh wire could be a cost-effective method of reducing mosquito-person contact. Both the government and the NGOs should support communities in setting up sustainable systems for provision of insecticide-treated mosquito nets and antimalarial drugs. These measures are especially important if increased mortality is to be avoided among the high-risk groups including pregnant women, and children under 5 years. As regards schistosomiasis, swimming by children in infected water is considered to be the most important factor continuing or increasing disease transmission (Renshaw et al. 1998). It would be of benefit if villages along the Tana river were provided with snail-free bathing areas. These should be centrally sited, concrete-lined and protected from snail colonization. Latrine provision is also an essential element in the control of schistosomiasis. Therefore, there is a need for the promotion of improved and long-lasting latrines.

Conclusion

The present HIA shows that an increase in irrigation along the Tana river basin will enhance agricultural production systems and contribute to improved human nutrition and well-being among downstream communities. However, there will also be an increase in the risk of a number of communicable diseases including malaria and schistosomiasis. Safeguards against the negative impacts should be incorporated at the earliest opportunity to maximize their effectiveness.

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