

EFFECTS OF TECHNOLOGICAL DEVELOPMENT ON RURAL LIVELIHOODS IN DEVELOPING WORLD: A CASE STUDY OF EFFECTS OF A LARGE SCALE MULTIPURPOSE DAM ON MALARIA PREVALENCE IN A RURAL COMMUNITY AROUND KENYA'S LARGEST DAM

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Abstract

This paper examines whether malaria disease prevalence has increased due to the construction of a large multipurpose dam in a rural community by analyzing the distance of the respondents from Masinga dam (the largest multipurpose dam in east Africa) and malaria prevalence. The theoretical basis of the study is the theory of ecological simplification. This theory asserts that, species in any natural ecology tend to be specialized and to be controlled in numbers by competition in their specialized niches. Once the ecosystem is interfered with by human activities, the control feedback mechanisms are broken. Those species (in our case, anopheles mosquitoes) that can survive the impacts caused by changes in ecosystem due to human interference have more opportunity to explode in population numbers since the niche competition has been eliminated. Moreover, the rural community is poorly cushioned from the expected diseases increase since prior preparations in form of medical facilities are not part of the dam preparation.

The paper analyses primary data from a randomly selected sample of respondents from near the dam. The distance of the respondents from the dam was calculated using global positioning system (GPS). Simple Linear Regression and cross tabulation are done to analyze for relationships. The results show that, malaria is the most common disease in the populations near the dam and the disease used to vary with seasons, with high prevalence being experienced in the rainy seasons in the earlier years after the dam construction. However, in later years, this variation disappears and malaria remains high throughout the months irrespective of the season. Prevalence was found to have increased by 47% among the

local rural population. The increase in malaria prevalence can only be attributed to the presence of the dam because this occurrence decreases as we move away from the dam. The paper, further, presents the results to show a spatial relationship of malaria occurrence that can be used for planning intervention measures to reduce the disease in the study area and prevent the disease from devastating impacts on the poor rural community near the dam.

Keywords: Technological development, Rural livelihoods, Kenya

Introduction

Millions of people suffer from infections that are transmitted by vectors- insects or other animals capable of transmitting an infection, such as mosquitoes that breed and live in or near both polluted and unpolluted waters. Such vectors infect humans with malaria, yellow fever, dengue fever, sleeping sickness, and filariasis. Malaria is the most widespread and is endemic in about 100 developing countries, putting some 2 billion people at risk (Chatterjee 1995, World Bank 1993). In sub-Saharan Africa, malaria costs an estimated US\$1.7 billion annually in treatment and lost productivity (Olshansky *et al* 1997).

Lack of appropriate water management, along with failures to take preventive measures, contributes to the rising incidences of malaria. Dam construction projects often increase the mosquito population due to stagnant water (Hunter *et al* 1993). For example, in West Africa, an epidemic of Rift valley fever in 1987 has been linked to the Senegal River Project. The project which flooded the lower Senegal River area enabled the type of mosquito that carries the virus to expand so much that the virus was transmitted to humans rather than remaining in the usual animal hosts (Olshansky *et al* 1997). In Kenya malaria episodes claim high fatality in children and expectant mothers due to low usage of mosquito nets and poorly equipped medical facilities to cope with the situation (GoK, 2002).

Malaria is caused by a parasite called plasmodium, which is transmitted via the bites of infected anopheles mosquitoes. Anopheles mosquitoes breed in shallow fresh waters and are responsible for spreading malaria which is the highest killer of children in Africa (WHO, 2005).

Once the parasite is in the human body, it multiplies in the liver, and then infects red blood cells. Symptoms of malaria include fever, headache, and vomiting, and usually appear between 10 and 15 days after the mosquito bite. If not treated, malaria can quickly become life-threatening by disrupting the blood supply to vital organs. In many parts of the world, the

parasites have developed resistance to a number of malaria medicines. Key interventions to control malaria according to World Health Organization (WHO, 2005) include: prompt and effective treatment with essential malaria drugs, use of insecticidal nets by people at risk; and indoor residual spraying with insecticide to control the vector mosquitoes.

Ecological simplification theory

The study on relationship between the dam and malaria increase is based on the theory of ecological simplification (Odum, 1978). This theory asserts that species in any natural ecology tend to be specialized and to be controlled in numbers by competition in their specialized niches. Once the ecosystem is interfered with by human activities, the control feedback mechanisms are broken. Those species that can survive the impacts caused by changes in ecosystem due to human interference have more opportunity to explode in population numbers since the niche competition has been eliminated.

According to Odum (1978), one of the most profound human influences on earth has been ecological simplification. People create the simplest possible ecosystem for agriculture and other land uses. The simple, young ecosystems that people create through land uses are ideal for human health epidemics. When arthropods or disease agents inimical to human health are present in a simple ecosystem, they exist in large, explosively growing numbers with few controls. In a natural vegetated environment there may be several species of anopheles mosquitoes capable of transmitting malaria, but they are competing with many other species. When trees are felled, fields cleared for agriculture and dams are built for human activities, conditions similar to a young ecosystem are created. The species of Anopheles that breed in those conditions have large numbers of individuals to reproduce rapidly, and so take blood meals frequently, have few controls, and create epidemic malaria. Thus, the development of Masinga has created a simplification of the original ecosystem and hence a young ecosystem that provides better opportunity for anopheles mosquitoes to multiply unhindered and hence causing malaria increase.

It is also important to note that insect disease vectors have a well established flight range (WHO 2005). This range, given in Table 1 was the basis of analysis. The health risk to community is therefore influenced by both ecological characteristics of the dam region and vector movements of pathogens within the region.

Table 1: Flight range of insect vectors that spread waterborne diseases

Vector	Local movement (km)	Migration (km)
Simuliid blackflies	4.0-10	400
Anopheles mosquitoes	1.5 – 2.0	50
Culicine mosquitoes	0.1 - 8.0	50
Tsetse flies	2.0 – 4.0	1

(Source WHO: 1999)

Study area

The study area is the Masinga Division, which is part of Machakos District, in the Eastern Province of Kenya. The district stretches from Latitude 00 45'S to Latitude 1031'S. From east to west and it is located between Longitude 360 45'E and 370 45'E. The dam reservoir straddles across the Districts of Machakos and Mbeere in the river Tana in Kenya (Figure 2). The dam is by far the largest reservoir of the five impoundments along the upper Tana River. It is a part of a cascade of dams and power stations on the Tana River (Kenya's largest river), called the Seven Forks Falls. The dam and the reservoir called Lake Tana (or Masinga reservoir), borders the Mwea National Reserve on the eastern side. Masinga dam is managed by Tana and Athi River Development Authority (TARDA). The mandate of TARDA is to advise the government on all matters pertaining to the development of the river Tana basin especially in relation to utilization of water resources. Other major stakeholders are the Kenya Electricity Generation Company (KenGen) and the Tana Water Services Board (TWSB). The latter came into being after the implementation of water reforms by the Ministry of Water and Irrigation (GoK, 2005). Kenya Power and Lighting Company supplies the electricity generated by KenGen. While the Tana River Water Service Board Licenses the Water Services Providers (WSP) who supply water to households and urban centres in the region.

Human activities have immensely influenced the ecology of the study area. The distribution of vegetation has been greatly influenced by vegetation clearing due to small scale farming and agro-pastoralism activities. This has led to areas once covered by bush land to become open grasslands with scattered bushes. However, in areas where the original vegetation has remained, thick acacia species are evident.

Population density around Masinga dam is estimated at 74 persons/km² by 2004 (GoK, 2002). The population growth rate is about 3.09% (CBS 2001). Most of the population

is young comprising mostly of school going children. The rural community is about 63,000 people with a household number of 15,700 (GoK, 2001).

Crop production is mainly done at the subsistence level. The main crops grown are maize, beans, peas and cow peas. The major cash crops grown are cotton, citrus, coriander, chicken peas, French beans and green grams. The community also keeps indigenous varieties of livestock for household use. These are cattle which provide cash on sale and milk for household use. Other types of livestock kept are goats, sheep and poultry. The farmers therefore practice mixed agriculture, where subsistence farming is done and livestock are kept by the same household as well. Health facilities are not are scanty with only one health centre and five dispensaries dispensary which are poorly equipped with medicine to fight malaria. It is therefore important to note that, among the authorities, who have stake on the dam, none has been mandated to deal with issues of public health caused by the dam and no health facilities have been developed to mitigate waterborne diseases anticipated after the completion of the dam.

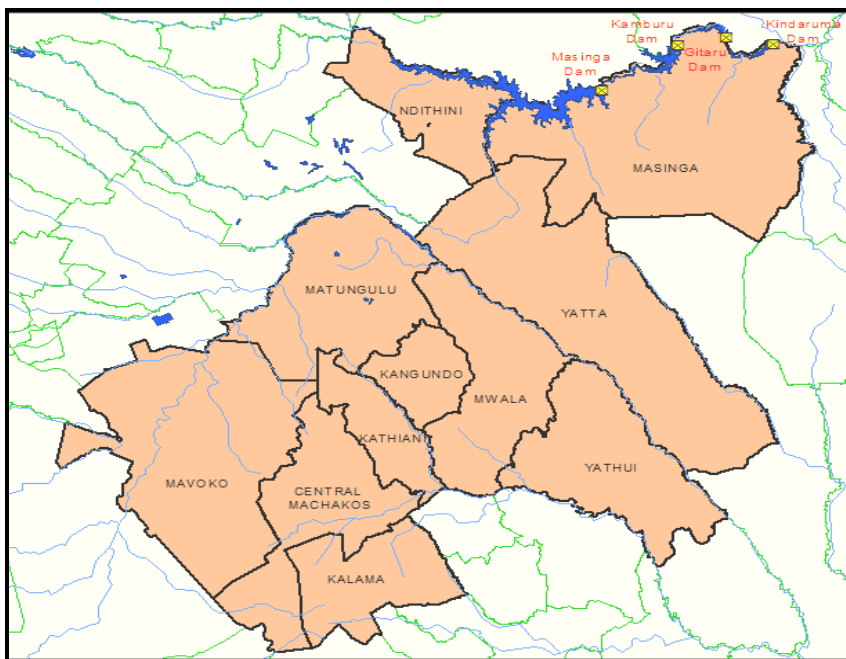


Figure 2: Study area

Environmental characteristics of the dam area

The Dam area lies at an average altitude of 1000 metres above sea level. It is part of the foreland plateau experiencing a semi-arid climate. Evaporation demand is high due to the high temperatures that can rise to above 30⁰C during the dry season (Table 1). The implication of these high temperatures is that a lot of water is lost through evaporation in the open reservoir reducing the lifespan of the dam. The high temperatures are also conducive for

breeding of anopheles mosquitoes which breed on the shallow waters in the dam. The annual rainfall amounts received in the area ranges between 500 mm and 750 mm (Odingo, 1979), thus making the area a semiarid environment and prone to frequent droughts. The lack of food security makes the local community more vulnerable to malaria due to poor diet.

Table 1: Long-term monthly rainfall (37 year average) from Kiritiri Chiefs Camp (near masinga dam)

Month	Mean monthly rainfall (mm)	Std. Deviation	Coefficient of variation	Max. Temp. (°C)	Minimum Temp.	Mean Temp. (°C)
January	21.9	28.5	130	27.8	13.4	20.6
February	20.7	28.2	136	27.3	16.1	21.7
March	108.4	69.8	64	27.6	16.3	21.9
April	217.0	95.3	44	28.8	16.8	22.8
May	69.6	59.6	86	28.2	17.2	22.7
June	4.7	9.2	196	26.9	16.2	21.5
July	3.3	6.4	194	25.5	16.3	20.9
August	4.0	6.4	160	26.1	15.5	20.8
September	7.3	17.5	240	29.2	16.3	22.7
October	79.2	72.4	91	30.6	17.8	24.2
November	272.9	141.5	48	28.1	17.4	22.8
December	78.4	94.9	121	27.5	14.9	21.2
Annual average	907.4			27.8	16.2	22.0

Source: Kenya Meteorological Department (2008)

Study methods

Firstly, the population most likely and directly affected by the dam was extracted from the 1999 National Population Census using the proximity of the administrative region to

the dam. There are thirteen frontlines administrative zones in the study area; out of these 6 were selected randomly. It was assumed that, selection of six sub-locations out of the 13 was representative because the population distribution, culture, livelihoods and other demographic characteristics are homogeneous (“normal” in statistical sense) in the frontline locations.

Secondly, the population was weighted based on the number of people in each particular region. The administrative zones with higher weights had a higher probability chance of being chosen for sample extraction. This provides a proportionate representation of the population for sample selection. The research randomly selected 35 respondents from each of the 6 sampling location (strata) making a total sample size of 210 respondents.

Results and discussions

The respondents were asked to name the disease that they had suffered in the recent one year period and the data recorded. The study also recorded the distance of the respondent from the dam against the prevalence of malaria as shown in Table 2.

Table 2: Distribution of the malaria with distance from the dam

Distance from the dam (in Km)		0 - 0.5	0.6-1.0	1.1- 1.5	1.6- 2.0	2.1- 2.5	2.6- 3.0	3.1- 3.5	Ove r 3.5	Tot al	
Disease prevalence	Malari a	Count	26	14	5	7	0	7	0	7	66
		Percent	39.4	21.2	7.6	10.6	0	10.6	0	10.6	100

Source: Researcher

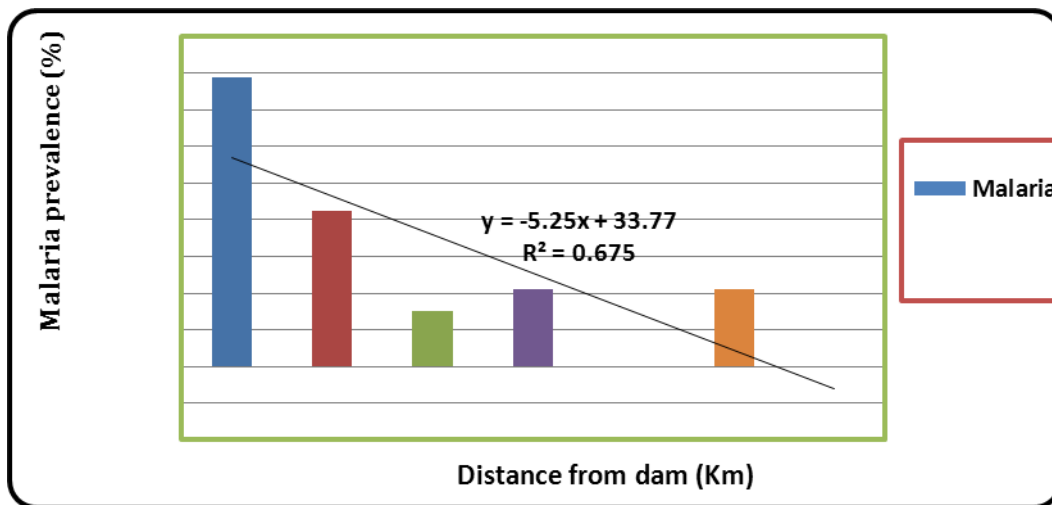
Relationship between malaria prevalence and distance of the respondents from the dam

i) Regression Test

The study was based on the hypothesis that malaria prevalence is randomly distributed and does not vary with distance from the dam. To achieve this, Linear Regression test was done to establish whether the relationship between malaria occurrence and the distance of the respondent from the dam is significant. The coefficient of determination (R^2) was calculated to determine the strength of the relationship and the direction of this relationship (negative or positive). The results show that, there is a strong linear relationship between the distance of the respondent from the dam and malaria prevalence. The

relationship is a strong negative relationship as shown by the equation ($Y = -5.25x + 33.77$). The coefficient of determination value $R^2 = 0.6755$ (or approx. 68%), which indicates that, 68% of the total variation in y can be explained by the linear relationship between x and y as described by the regression equation. This implies that malaria prevalence varies with the distance from the dam with most cases occurring within the population nearer to the dam and decreasing as we move away from the dam. The results were further plotted to indicate this relationship as seen in Figure 2.

Figure 2: Malaria prevalence versus distance of the respondent from the dam

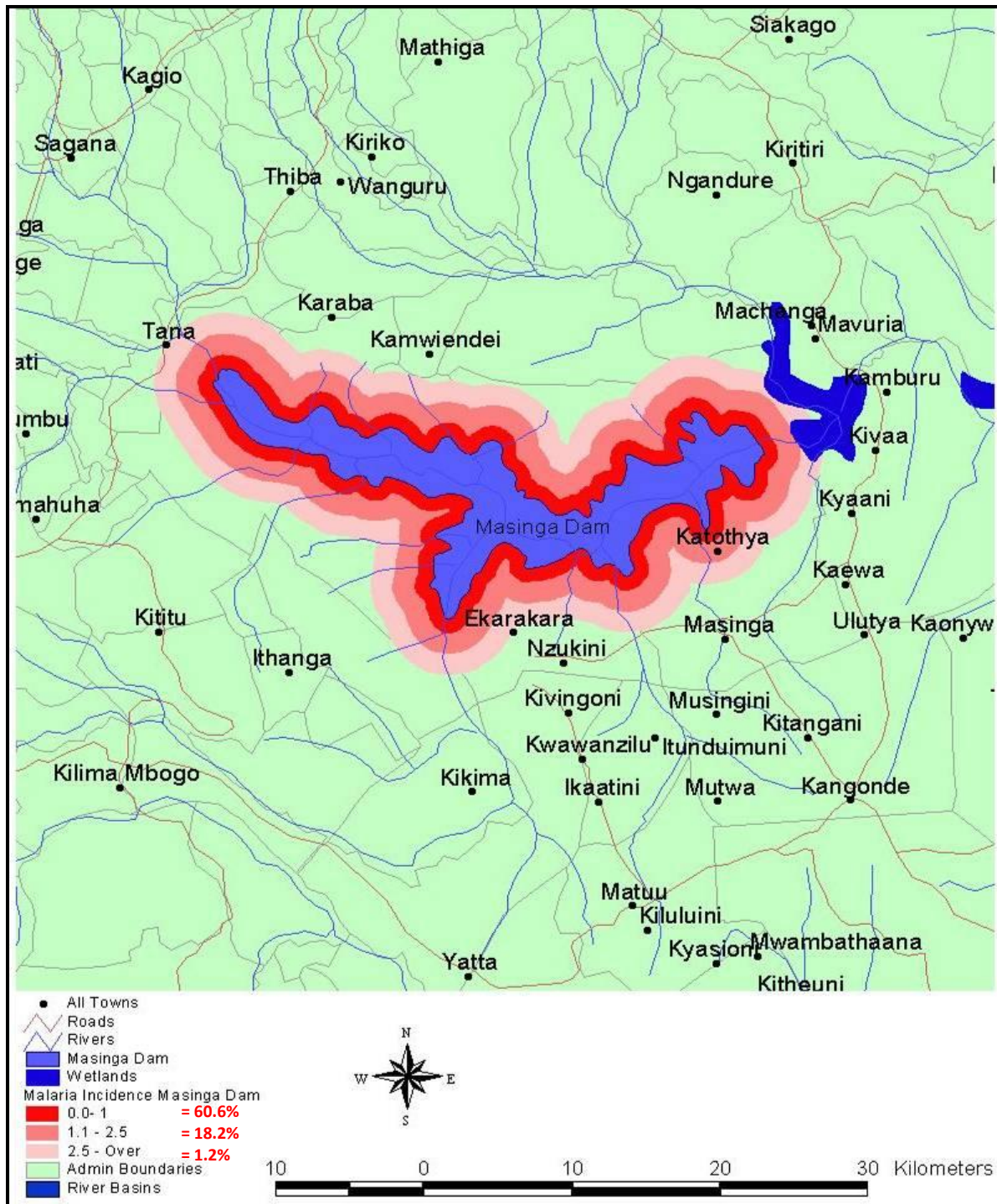


(Source: Researcher)

Spatial distribution of Malaria prevalence

The research presented the spatial distribution of malaria prevalence with distance from the dam as shown in Fig. 3. It is clear from the map that the intensity of malaria prevalence decreases as we move away from the dam. This diagram is of high significance for planning purposes in order to reduce malaria incidences. The research concludes that, anopheles mosquitoes find a good environment for breeding in the shallow waters of the dam, and along the dam estuaries where they can breed and transmit malaria to the nearby populations.

Figure 3: Distribution of Malaria prevalence relative to proximity from Masinga Dam



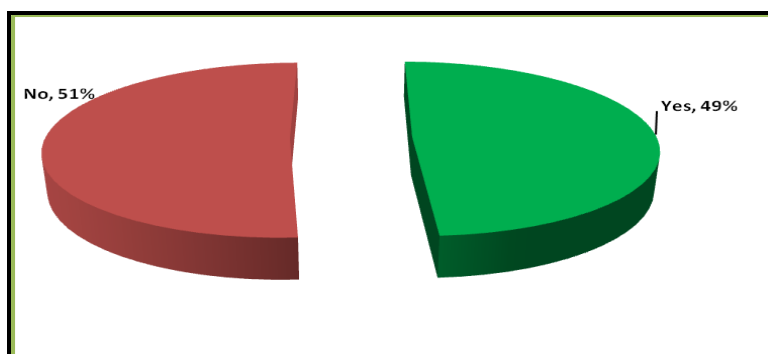
Source: Researcher, 2008

Interventions to mitigate malaria in the study area

This research investigated the interventions that are or may be taking place to abate the ill effects of the dam to public health. To achieve this goal, the respondents were asked to state the satisfaction level and types of external intervention to improve public health in the study area. The results are shown in Figure 4; they indicate that 51% said no external interventions have taken place while 49% were in the affirmative.

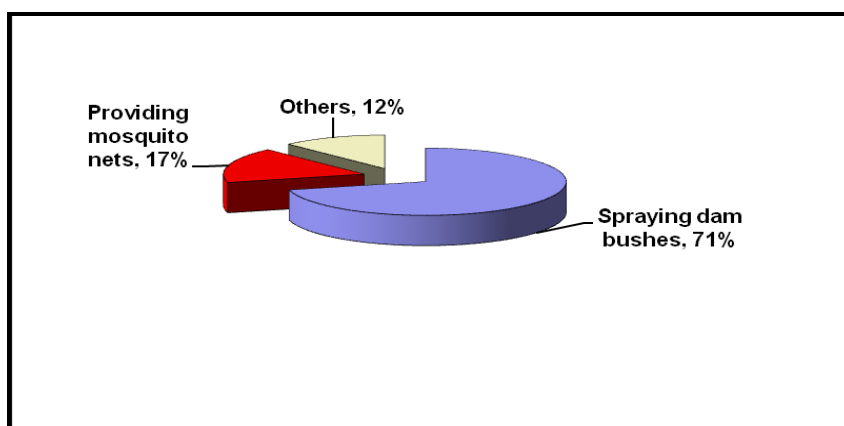
On types of intervention used, the research found out that the method that has been used in the past to control malaria was spraying the surrounding bushes around the reservoir with insecticides (71%). This method according to the respondents has been abandoned. The data also shows that the use of mosquito nets as a means of malaria control is not common (17%). This is worrying because it shows the use of mosquito nets in the dam community not popular yet this is one of the highly recommended method of fighting malaria spread.

Figure 4: Adequacy of intervention measures according to the respondent



(Source: Researcher)

Figure 5: Public opinion on interventions to reduce diseases prevalence in the study area



Source: Researcher

The majority of people felt there is no adequate external intervention to improve public health illnesses related to malaria caused by the dam presence. The most common type of intervention has been spraying the dam fringes with insecticides. This is not environmentally friendly method of disease control, as the insecticides could also kill non-targeted insects and pollute water resources and result in adverse effects on fisheries and public health. However, this method has since been abandoned.

Conclusion

The concept of sustainable development entails that the external costs of an activity should be factored in the benefits accrued from the activity. It is only then when planners of a project can estimate whether a project was beneficial. Thus, it makes sense for those who initiate development projects to also take care of the external costs including the costs to public health that are manifested through ill health effects affecting negatively sustainable community livelihood. This lies at the heart of the concept of “the polluter pays principle” (Hughes, 1992). Thus the management of Masinga Dam should also have factored in the costs of abating ill health that were expected to arise from the construction of the Dam.

The study concludes that, due to the dam’s presence, malaria has now become endemic in the study area throughout the year. This disease is most prevalent within the people residing nearer to the dam and decrease as we move away from the dam.

On external intervention, the results show that the majority of people feel that the level of intervention is not adequate to improve public health that is deteriorating due to the presence of the dam. The most common type of intervention has been spraying the dam fringes with insecticides. This is not environmentally friendly method of disease control as the chemicals could also kill non-targeted species and could also pollute the water resources and have negative effects on fisheries and public health. This mitigation method however has been abandoned in recent years.

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