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Implications of Wet-Rice Farming on Human Health and Physical Environment in Kenya: A Comparative Study in Mwea Irrigation Settlement Scheme, Kenya

By Samson Wokabi Mwangi
Egerton University

Abstract- This paper examines the implication of wet-rice farming or irrigated agriculture on the physical environment and human health. Environmental problems seem to have increased in the recent past posing a major threat to irrigation development. Several environmental problems created by irrigation development in Mwea Irrigation Settlement Scheme (MIS) could be attributed to improper understanding of the complex processes involved in the irrigation system. The main objective of this study was to examine cases and causes of some environmental and health problems and planning related issues in MIS. An environmental planning and management methodology is suggested which will attempt to minimize or at least mitigate against the environmental and health problems.

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Implications of Wet-Rice Farming on Human Health and Physical Environment in Kenya: A Comparative Study in Mwea Irrigation Settlement Scheme, Kenya

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Abstract- This paper examines the implication of wet-rice farming or irrigated agriculture on the physical environment and human health. Environmental problems seem to have increased in the recent past posing a major threat to irrigation development. Several environmental problems created by irrigation development in Mwea Irrigation Settlement Scheme (MIS) could be attributed to improper understanding of the complex processes involved in the irrigation system. The main objective of this study was to examine cases and causes of some environmental and health problems and planning related issues in MIS. An environmental planning and management methodology is suggested which will attempt to minimize or at least mitigate against the environmental and health problems. 'Fool Proof' method of comparing the situation in an irrigation settlement with a neighboring off-scheme area where irrigation activities were absent, was utilized. The area selected for comparison has been earmarked for rice cultivation through irrigation and no environmental impact studies have been done. The results showed that there has been a dramatic increase in real and potential human health problems emanating from emergence of new diseases, the expansion of the vector base and the ease of spread of water borne-diseases. From the comparative method it was concluded that most of the problems observed were unique consequences of irrigation development since they were absent in the control region. It is recommended that an environmental plan should be instituted in the MIS management structure to ensure that the stress on the irrigation settlement ecosystem is within its carrying capacity. The management plan should incorporate and integrate baseline conditions, planned project activities, impacts anticipated and supportive and assimilative capacities of the system. Future irrigation development planning should therefore be holistic and multidimensional.

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I. Introduction

Out of the Kenyas 44.6 million hectares of land, only 8.6 million hectares are regarded as medium to high potential for rainfed agricultural production (Odero, 1992). Kenyas population continues to increase and this means there is diminishing land per capita and hence the need to increase the arable land. The role of irrigation as a means of expanding agricultural land supply has long been recognized in Kenya and several irrigation schemes have been established. Irrigation and drainage activities which complement the rainfed agriculture continue to augment agricultural production by making arid and semi arid lands productive. Kenyas irrigation and drainage potential are estimated at 540,000 hectares and 80,000 hectares respectively. Presently some 54,000 hectares are estimated to be under irrigation representing only 10% of the potential irrigable land (GOK, 2014: 140). However it has been noted that most of the feasibility studies done before the establishment of the irrigation projects in Kenya tended to consider major engineering, economic and technical aspects but ignored adverse environmental and health related issues associated with irrigation development. Poor performance of irrigation projects has been a major concern for both the policy makers and researchers in the recent past. There are various reasons for this poor performance and factors of Environmental' nature have been prominent in many instances. Many irrigation systems have not provided environmentally sustainable output (Reddy, 1991). Few policy documents and studies have focused on environmental problems such as water logging, salinization, alkalinization, increase in aquatic weeds or water borne diseases which are typical consequences of bad irrigation water management. Irrigation without sufficient drainage disrupts the ground water equilibrium causing a rise of the water table to the plant root zone resulting in water logging. Salts are also brought to the root zone through capillary fringe leading to the buildup of salts in the root zone.

The establishment of an irrigation are not related to irrigation itself but to its misuse, and they may be avoided or alleviated by appropriate management (White 1978). According to FAO (1986), many irrigation schemes, especially those for the extension of agriculture in developing countries, are adversely affected by high prevalence of diseases. Often the prevalence could have been reduced, usually with some extra effort, it certain health and environmental

Author: Associate Professor, Department of Peace, Security and Social Sciences, Egerton University. e-mail: swokabimwangi@gmail.com

safeguards had been taken into account in their planning and construction. For many of these projects restoration of a healthy environment may take considerable time, effort and resources. Failing that, continued degradation of health and environmental quality may largely defeat the very purpose of the project. This may eventually lead to the further decline of the socio-economic conditions of the population involved. Attention is therefore needed at the planning stage of a project to ensure incorporation of environmental and health safeguards. Engineers and managers in frequent contact with irrigation schemes are not specialists in medical or environmental sciences, and environmental and health impacts are frequently outside the scope of their stated responsibilities. As a result, information on environmental and health impacts are generally difficult to obtain and serious impact may go unrecorded and uncorrected. Increasingly, professional engaged in irrigation development and management are recognizing the importance of environmental factors. Agencies engaged in implementing or funding irrigation development are introducing procedures they believe will ensure that serious problems are avoided. The current government policy emphasizes that irrigation, land reclamation by drainage and flood protection are major and attractive alternatives for increased agricultural productivity. The other aims are to expand cultivatable land to meet the ever growing demand for food and restructure the countrys agricultural sector as well as settle people in new lands and create substantial employment opportunities.

II. The Problem

Irrigation development in the Mwea plains has created environmental conditions that are favourable for agricultural production. The same conditions have been ideal for habitants and breeding points of diseases vectors. Environmental and human health problems are some of the unintended consequences of irrigation development in MIS. As an interface between the natural environment and technology, irrigation activities in MIS have some environmental implications which have some adverse consequences on the socio-economic welfare of the supposed beneficiaries. The modification to the environment which usually accompanies rice growing in Mwea tend to create extensive habitants particularly suited for snail intermediate hosts of schistosomiasis and mosquito vectors of malaria. Thus people working in the rice fields and those living near them were often exposed to considerably greater risk from these diseases then those working and living away from the rice fields. There is the incidence of bilharzias and malaria and other water-borne diseases. The high incidence of diseases is not met with adequate health facilities and these diseases can also be attributed to lack of clean water and flood water from the irrigation scheme. Every aspect of an irrigation project has environmentally implications. The problem thus can be stated as: Irrigation development in MIS with inadequate drainage has led to environmental and health problems. Environmental damage associated with irrigation development in MIS is threatening the vitality of the irrigation settlement. Though it is now recognized that irrigation development in MIS have had adverse ecological and health problems, the level of recognition of such implications is still far from satisfactory because of lack of adequate data.

III. A Note on Methodology

In this section the methodological procedures of the study are discussed. These include, the data collection techniques, sampling techniques, and data schedule and the methods used in data analysis, interpretation of the findings. The conceptual-theoretical background of the study is examined and finally, the limitations and problems encountered in the study are outlined. The sampling frame for the study consisted of 3240 farmer households in several villages at the Mwea Irrigation Settlement (MIS). The farmer families are distributed within 36 villages which are located in the 5 sections of the settlement (see appendix V). The distribution of the villages in all the sections is shown on Table 4.1. In each section, for the purposes of a micro-study on environmental and health problems, at least 25% of the villages were sampled for the study. This yielded a number of 10 villages to be studied. All the villages were allocated arbitrary numbers and out of the 36, the 10 villages were selected using Tables of Random Numbers. To determine the number of households to be studied, a pilot survey was conducted. The results of the pilot survey showed that the population in MIS was highly homogeneous and the activities in the community homologous. A sample of 200 respondents was therefore assumed representative. In each of the 10 villages, 20 households were selected and subjected to intensive interviewing. The small sample size of 200 respondents representing 6.17% of the total population was selected on the basis of experience gained through the pilot survey and that from the previous studies on irrigation settlements. Studies conducted by Makanda (1984); Ireri (1986); Omosa (1987); JICA (1988, 1992); Odero (1992); and Hanneke (1993) have indicated the relative homogeneity in the farmer conditions in irrigation settlements which makes it possible to employ the use of small samples. Simple random sampling was used to select the representative sample of 20 household heads to be interviewed in each village selected. Simple random sampling is a method of drawing a sample from a population so that all possible samples of size n have the same probability of being selected from the population *N*. This method is regarded by many researchers and statisticians as the most practical and free of bias. A simple draw at random is unbiased in the sense that no member of the population has any more than one chance of being selected than any other. I the present study, *N* was represented by 3,240 households and *n* by 200 households. The size of the sample selected for the study was limited by time factor, financial constraints and the need to come up with accurate results.

Since the present study utilizes the fool-proof method of comparing the situation in MIS and another neighbouring area where irrigation activities are absent, a control sample selected for this purpose was the neighbouring Mutithi Location. The Mwea plains extend throughout the lower sections of Mwea Division covering Tebere, Thiba and Mutithi locations. These locations have alsomost the same biogeophysical characteristics. It was necessary to select a control region with the same bio-geophysical characteristics with the study area, where irrigation activities are absent. Mutithi area affected such opportunities compared with other alternative like Nyangiti and Murinduko in Mwea Division. Above all other reasons, parts of Mutithi location, about 2,900 hectares, have been earmarked for irrigation development. With the absence of an environmental impact assessment study done during the preparation of the feasibility study, it was imperative to assess the status of this area during this study. It is assumed that the results of this study will form a starting point for the future EIA in the Mutithi area. According to the available information on the area selected, there are 960 households as of 1987. The land is privately owned and therefore the absence of an organized settlement structure like in the MIS. Background information on the area indicates that the area is inhabited by a homogeneous community and the activities taken are also similar from a general point of view. Systematic random sampling was the main technique used in selecting the households to be studied. A sample of 20 households were selected to facilitate comparison with the situation in any one of the villages studied in MIS.

IV. Results and Discussion

In this section, the empirical results of the Mwea Irrigation Settlement (MIS) Field Survey are presented. The findings are based on the interview administered to 200 respondents of the settlement and 20 respondents from outside the settlement, interviews to key informants also generated important data. Data synthesized from field observations and secondary sources are also included. The information presented in this section stems from various sources. Specifically, data inventories in the present study comprised three categories:-

(a) Data collected through the interview scheduled, administered to sampled 200 household heads in 10 villages in MIS and also those administered to 20 off scheme respondents;
(b) Data collected through dialogue with schemes management staff and other selected key informants and
(c) Data collected through the researcher's field observations and secondary information from existing data.

Data collected centred mainly on the various aspects of the physical and human environments. The emphasis was to explain data within the context of environmental and human problems in MIS. Preference in the selection of data has been given to purely quantitative variables and data based on qualitative scales is also considered. Environmental and health problems revealed by these data are exposed and explained in details.

Table 1 : Age of the Respondents in MIS

n=200

Age Group	Frequency	Percentage
0 – 20	0	0%
21 – 40	42	21%
41 – 60	101	50.5%
61 – 80	45	22.5%
81 – 100	11	5.5%
100+	1	0.5%
Total	200	100%

Source: MIS field survey 2014

Most of the respondents were found to be married, a few being widowed, divorced or separated and a small number single as shown in Table 2. The size of the families were found to be fairly large, the majority being more than 6 persons per family (see table 3). It was found out that 57.5% had more than 8 persons per family. The age of the first born was also found to be high, over 35 years, and in most cases, they had their families living together with their parents (see Table 4). the problem associated with this analysis is that the original number of people settled in the scheme has increased by more than 4 fold and need to expand the settlements. From discussions with local elders and leaders this survey revealed that most of the respondents and their families and the families of their children continue to live in confined villages which are now over 35 years old. Majority of the respondents had their first siblings married and staying with them in the same plots. It can be seen from the above that there is population pressure in the villages, basing the argument on this surveys household characteristics. Congestion in the villages can also be seen as an adequate medium for the transmission of communicable diseases like cholera.

Cases and Causes of Environmental and Health Problems at the Household Level

To collect accurate data on these problems, a household survey was conducted by use of an interview schedule. A macro survey was also conducted using filed observations and secondary sources of data. Environmental and health problems identified are presented at these two levels. For purposes of household comparison on environmental and health conditions between MIS villages studied and Mutithi area (where irrigation activities are absent but has the same bio-geophysical characteristics) were compared. The viable compared were: housing conditions, water supply and sanitation systems, energy sources, farmers perceived environmental and health problems unique to irrigation settlement at the household level.

Environmental problems related to demographic and family characteristics of the respondents interviewed

For the purposes of this study, a household refers to a group of persons living together in the same home and or sharing the same housekeeping arrangements. A household therefore includes a husband, wife or wives and children living together. From the data collected, it was found out that the respondent ages varied between 20 and 100 years, the majority being between 40-60 years (50.5) as shown in Table

Table 2 : Marital status of Respondents in MIS
n=200

Marital Status	Frequency	Percentage
Married	164	82%
Widowed	24	12%
Single	2	1%
Divorced	7	3.5%
Separated	3	1.5%
Total	200	100%

Source: MIS field survey 2014

Table 3 : No. of children of the respondents
n=200

No. of children	Frequency	Percentage
0 – 2	5	2.5%
3 – 5	12	6%
6 – 8	68	34%
9 – 11	83	41.5%
12 – 14	14	7%
15 – 17	6	3%
18 – 20	8	4%
21+	4	2%
Total	200	100%

Source: MIS field survey 2014

Table 4 : Age of the First Born living with their parents (the respondents)
n=200

Age of first born	Frequency	Percentage
0 – 5	5	2.5%
6 – 10	8	4.0%
11 – 15	19	9.5%
16 – 20	15	7.5%
21 – 25	24	12%
26 – 30	30	15%
31 – 35	85	44.4%
36+	23	11.5%
Total	200	100%

Source: MIS field survey 2014

Environmental problems related to housing conditions

(a) MIS villages

All the respondents interviewed were allocated a 50ft by 80ft plot of land on the higher grounds for purposes of building residential houses. The results of the household survey shows that majority of the respondent, 73%%, live in brick iron-roofed houses and 90.5% of the respondents noted that the housing had 1 to 4 rooms (Table 5.5 and 5.6). Most of the respondents noted that the housing units owned were not enough for the entire family but could not build others because of lack of space. Almost all types of houses used by the tenants are characterized by factors which contribute to poor health. The interview survey showed there was the presence in the human environment of pathogens because of lack of basic infrastructure and services such as sewers, drains or services to collect solid and liquid wastes and safely dispose of them. There is lack of safe and sufficient water supply. Overcrowding and cramped living conditions as observed in all the villages can be said to increase the risk of transmission of airborne infections and increase the risks of accidents. Many diseases such as tuberculosis, influenza and meningitis are easily be transmitted from one person to another.

Global Journal of Science Frontier Research (H) Volume XVI Issue III Version I Year 2016

Table 5 : Type of houses in studied villages

Type of House	M I S Villages		Mutithi	
	Freq. n=200	%	Freq n=20	%
Mud grass-thatched only	25	12.5	0	0%
Mud iron-roofed only	8	4	0	-
Brick (earth) grass-thatched only	20	10	1	5%
Timber iron-roofed only	9	4.5	11	55%
More than one type	18	9	4	20%
Total	200	100%	20	100%

Source: MIS field survey 2014

Table 6 : Number of rooms per house of the respondents

Number of rooms	M I S Villages		Mutithi	
	Freq. n=200	%	Freq n=20	%
1 -2	75	37.5	0	-
3 – 4	106	53	4	20
5 – 6	14	7	11	55%
7+	5	2.5	5	25%
Total	200	100	20	100%

Source: MIS field survey 2014

Implications of demographic characteristics and housing conditions in nucleated settlements

Housing conditions are seen to be determined by the number of rooms and the household size. The results of the field survey revealed that most of the tenants still live in houses which were built during the inception of the settlement. There has been a dramatic increase in the population of the scheme since its inception in 1958. By 2014, when this survey was undertaken there were 3240 farmers families with an average family size of 9.6 which is very high. This implies that the housing structures which were originally meant for two persons have an additional 7 members. Because the size of the plots remain fixed (50ft x 80ft) the implication is that tenants have to squeeze in the little room available with their children and grandchildren. There were reasons given as to why there was a high birth rate in the scheme though it was also noted that the average was not very far from the national average which was by 1993, 6.7 children (GOK, 1993). There were two reasons given by the tenants:

(i) The high labour demands required by rice growing activities and the high costs of hired labour demanded reliance on the family labour and hence need for large families and
(ii) That since most of the tenants were formally detainees and landless, when they were freed and resettled, they found consolation in having children.

The validity of these arguments is debatable but these were from the tenants' point of view (today the medical and nutrition department of NIB includes family planning activities as part of the community health education to the tenants). The exclusive concern by the management of the scheme for a high level of technical achievement has led to neglect of the problems of human welfare. As a result, housing is unsatisfactory, overcrowded, smoke filled, and lacks privacy. Nutritional standards are low and this has severe health implications. The physical expansion of the scheme appears to have reached a limited and the management should seriously look into the welfare standards of the tenants. Apart from its social and health implications these conditions can be economically harmful, discouraging full participation in the scheme and commitments to long term investments and this may lead to poor performance of one of the successful irrigation settlement in Kenya.

(b) Housing conditions in the control area

The housing conditions of the farmers reflect their living standards. All the farmers live in their own houses. Data was collected on the number of rooms and whether there is provision of a separate kitchen and bathroom.

Most of the respondents had over 5 rooms in the Mutithi area (80%). This could be attributed to the fact that the land in the area is privately owned and there is no limited building space like in MIS villages. Housing units in this area are highly varied in type and nature. It was the feeling of those interviewed that the housing units were sufficient for the whole family. Majority of respondents owned at least o separate kitchen and bathroom. The average number of occupants in a room in MIS villages was 6 persons while in Mutithi area was 2 persons per room. This shows that people are more congested in MIS villages than in the control areas.

Environmental problems related to water supply and sanitation systems

(a) MIS villages

The results of the interview survey revealed that a greater majority of the respondents, 53% got their water supply from the nearby canals. Some chemical analysis of water quality showed that canal water was of poor quality and was contaminated with pathogens. The poor quality of water can be attributed to subsurface flows from the irrigated fields. It was also found out that 50% of the communities aged between 5 to 19 years defecate at the water points within the scheme. Considering that his water is used by residents for bathing and domestic use, these residents become extremely vulnerable to water-borne diseases. The results showed that 12% of the respondents many of whom were from Haraka and Kwihota villages from Thiba and Karaba sections get their water supply from boreholes. It was observed that in these villages some NGOs had assisted in construction boreholes. It was not possible to establish how many of these boreholes were actually functional but the respondents said that the supply from boreholes was sufficient throughout the year and was of good quality. Nearly 18% of the respondents got water for domestic uses from rivers and stream. Though the water was enough for their uses throughout the year, most respondents noted it was of poor quality because of subsurface return flows from the irrigated paddy fields. Only 7.5% of the respondents had the piped water supply. Respondents from Gathigiriri village of Tebere section had access to piped water supply which was in GOK's Gathigiriri Prison. However the supply was not guaranteed. It was noted that 9% of the respondents had more than one source of water. Within the scheme, improper human waste disposal can also be said to be responsible for water-borne diseases. All the respondents interviewed had pit latrines as the only method for excreta disposal and a large percentage, 83.5%, had shallow pit latrines were only 5-10 meters away from the houses because of the sizes of the plots as shown in Table 9. there is the absence of drains and sewers to take away waste water and rain water from the settlements and this leads to stagnated pools which harhour mosquitoes. There is therefore lack of sewerage connections and garbage collection and this may lead to critical environmental problems.

Table 7 : Sources of water for domestic use

	M I S Villages		Mutithi	
Sources of water	Freq. n=200	%	Freq n=20	%
Canal only	107	53.5	0	-
Boreholes only	24	12	2	10
River/stream only	36	18	3	15%
Pipe borne only	15	7.5	12	60%
More than one source	18	9	3	15
Total	200	100	20	100%

Source: MIS field survey 2014

Table 8 : Depth of pit latrines in the villages studied

	M I S Villages		Mutithi	
Depth of pit latrines	Freq. n=200	%	Freq n=20	%
0 -2	80	40	0	-
3 – 4	75	37.5	0	-
5 – 6	12	6	1	5
7 – 8	24	12	17	85
9+	9	4.5	2	10
Total	200	100	20	100%

Source: MIS field survey 2014

Table 9 : Distance of the pit latrine from the houses

	M I S Villages		Mutithi	
Distance in metres	Freq. n=200	%	Freq n=20	%
0 -5	108	54	0	-
6 – 10	76	38	0	-
11 – 15	16	8	0	-
16 – 20	0	-	1	5
21 – 25	0	-	15	75
25+	0	-	4	20
Total	200	100	20	100%

Source: MIS field survey 2014

i. *Implications*

A lack of readily available treated drinking water, of sewage connections or other systems of disposing of human wastes hygienically, of garbage collections and basic measures to prevent diseases and provide primary health care can result in many debilitating and easily prevented diseases becoming endemic. These include diarrhea, dysenteries, typhoid, intestinal worms and food poisoning. Many health problems are linked to water, its quality, the quantity available, the ease to which it can be obtained and the provisions made for its removal after use. The results revealed that the majority of respondents fetch their water from canals which were found to be contaminated by the irrigation subsurface return flows which is responsible for several waterborne diseases.

(b) Water supply and sanitation systems in the control area

Water Supply

Table 7 presents a summary of the major sources of water for domestic supply in the control area studied. Majority of the household heads interviewed said they got their water supply from piped water (60%) and a minority from boreholes (10%) as security since the tap water was not readily available during dry seasons. In all, 15% of the respondents get their water from rivers or streams. While respondents in MIS noted the water quality from canals and nearby river was of poor quality, those in Mutithi area said water used was of satisfactory quality. This was ascertained through water quality assessment at the government chemist and the results are summarized in Tables 16 and 17. It was noted that majority of the respondents in MIS villages have no pipe borne water supply and they rely on water from canals as shown in Table 7.

Sanitation

In Mutithi area, most of the respondents had their pit latrines with a depth of 8 meters (90%) and a distance from the house of over 9 meters (100%) away. The reason for the difference in depth was that most respondents in MIS villages found ground waste at a depth of 4 meters and therefore could not dig deeper than that depth, this was an absent hindrance in the Mutithi area. As regards the location of the pit latrine away from the house, it was observed that the size of the land was the determining factor. Respondents in Mutithi area owned large expanses of land as compared to 50 ft by 80 ft plots allocated to respondents in MIS villages studied. In both areas the method used for excreta disposal is pit latrines. It was observed that the major difference were in the depth and the distance of the pit latrines from the houses. In the villages studied in MIS, the majority of respondents had their latrines with a depth of up to between 2 – 6 meters (83.5%) and the distance from the house was 6 meters (90%).

Environmental problems related to energy sources and uses

(a) MIS villages

The major sources of energy mentioned by the respondents were firewood, paraffin, charcoal, animal dung, ad crop residues. Majority of the respondents interviewed, 49%, mentioned firewood as the only main source of energy and 22% combined it with other sources. It was observed that firewood used in the villages studied was either brought from a local market or from the surrounding off-scheme reserves. Informal interviews with the firewood and charcoal sellers revealed that these energy sources were supplied by dealers outside the scheme. Plates 5.1 (a) and (b) show heaps of firewood in the market awaiting consumers. Plate 5.2 shows cyclists coming from the off scheme reserves to buy firewood. Attempts were made to enquire the approximate daily firewood requirements. The average daily household requirement for fire wood was found to be 3 bundles of 15 kilograms of wood each. It is noted here that such high demand of wood fuel may lead to deforestation outside the scheme. Kerosene was used by all the respondents for lighting and only a minority, 2.5%, used it for cooking. Charcoal was used for cooking by a minority of the respondents, 4.5%. animal dung, it was revealed by the results o the interview survey was used by 16.5% of the respondents in almost all the villages studied. This was because animal dung served both as a source of energy and a repellent to mosquitoes in the houses. 5.5% of the respondents used crop residues (see Table 10 below).

However it was observed that there was a general shortage of wood fuel in the scheme and most of the respondents saw this as a major problem in the scheme. Other major problem area revealed by the survey was indoor pollution. This was caused by smoke from open fires from firewood, animal dung and crop residues and other biomass fuels. Relatively inefficient lamps used for indoor lighting were also a source of smoke and fumes which may be dangerous. As seen earlier, the small housing units necessitated the use of one room as both a kitchen, store and also as a bedroom. Many respondents knew that smoke and fumes from wood, animal dung, crop residues, effective and inefficient lamps and other biomass fuels can lead to serious respiratory problems.

Implications of environmental problems related to energy sources and use

Major sources of energy used in the study area were firewood, animal dung and crop residues. These sources of energy make open fires used indoors for cook and they produce fumes and smoke which can cause or contribute to serious respiratory problems. The other problem identified in the study area as far as the energy sources were concerned was the fact that these energy resources were not readily available. Omissions at the planning stage of the energy requirements of the tenants have lead to depletion of the few bushes in the settlement. These has been further depletion of forested areas in the hinterland of the scheme. The results showed that much of the fuel wood requirements is met by supplies from outside the scheme. The results of our field studies revealed that this is a looming problem it the trend is not reversed.

Table 5.10 : Major energy sources of households studied

	M I S Villages		Mutithi	
Sources of energy	Freq. n=200	%	Freq n=20	%
Firewood	98	49	5	25
Charcoal	9	4.5	6	30
Kerosene	5	2.5	5	25
Crop residues	11	5.5	0	-
Animal dung	33	16.5	0	-
More than one source*	44	22	4	20
Total	200	100	20	100%

Source: MIS field survey 2014

*firewood was mentioned by all the respondents who had more than one source of energy in both the MIS villages and the Mutithi area.

(b) Mutithi area

Table 5.10 summarizes the sources of energy, the proportion of the respondents using each type and the corresponding percentages have also been given. There was abudance of fuel wood in the Mutithi area. This was attributed to the large expanses of land in the Mutithi area and the land tenure system. The average size of land owned in the Mutithi area was high – 8 acres per household and most respondents had woodlots within their farms. The indoor pollution caused by fumes from biomass sources was seen to be low in the Mutithi area than in MIS villages where crop residues and animal dung were major sources of energy.

Environmental problems related to human health

(a) MIS villages

A total of 200 interviews were conducted. The study population consisted of household heads who were tenants in the scheme and owned paddy fields. Most of them were aged between 20 – 80 years.

(b) Malaria

The proportion of people bitten by mosquitoes was higher in the morning and evening in houses. The frequency of bites increases during the wet rice growing season (April to December). People use repellents but a low percentage use mosquito nets which showed that the consciousness of mosquito control was not high. In all, 75% of the respondents mentioned malaria as one of the common diseases they suffer in the course of the year. this shows that malaria is endemic at MIS. Secondary information from Mwea Mission Hospital's medical records supported our field surveys by showing that malaria is endemic and the cases increase after the flooding of the paddy fields.

(c) Schistosomiasis

It was observed that 95% of people live near water such as canal, river or ponds and use water for domestic affairs and for body hygiene. All the tenants work in the paddy fields without any protectors. They knew that the snails are the intermediate host of bilharzias but no control was progressing. A survey carried out by the African Biodiversity Institute (ABI) revealed that up to 70% of the inhabitants of the scheme are infected with schistosome, a bilharzias-causing worm. This is among the highest figures in the country. Our field surveys in 10 villages revealed that 58.5% of the respondents mentioned schistosomiasis as one of the common disease affecting human beings in the scheme.

(d) Amoebic dysenteries

In all 62% of the respondents listed amoebic dysenteries as one of the common diseases that they had suffered at least in the last 6 months. Most of these respondents were of the opinion that these dysenteries were as a result of poor water quality used for domestic supply.

(e) Typhoid

In the course of the study period there was an outbreak of typhoid in at least 5 villages I the settlement. In fact in one of the study village, Bahati, there was an outbreak as confirmed from a local health centre and had claimed at least four lives. Typhoid is transmitted direct by water ingestion. Most respondents noted that the disease was more severe because there were no drugs in the government aided health centres and they had to rely o private clinics which were expensive. It was observed that 54% of the respondents interviewed said typhoid was one of the common diseases they had suffered from.

(f) Cholera

Also related to the above, cholera was also mentioned as a common water borne disease at MIS. Official records showed that there had been at least an outbreak of cholera in some villages. Because of poor sanitary systems and congestion in the villages plus the poor quality drinking water, the spread of cholera was noted to be high in the villages where there was an outbreak. In all, 55% of the respondents said they had suffered from the disease in the last 6 months.

(g) Others

Other diseases mentioned as common in the scheme were: Hepatitis (infectious) which is transmitted through ingestion of contaminated water; bronchia pneumonia, cardiac failure, meningitis was also mentioned by quite a large number of respondents and finally, intestinal worms. About 3.5% of the respondents at least mentioned one of the above diseases.

In general, all the respondents noted that these diseases affected their working schedules seriously and finally affected the final yields.

Results from doctors and medical staff

A total of six doctors and two MIS medical staff were interviewed in order to cross check the information given about the common diseases by the tenant. They were asked to briefly comment on the three major diseases treated throughout the year. The information obtained was supplemented by secondary information about the diseases in MIS obtained from Mwea Mission Hospital's medial records for the years 1990-94 as shown in Figure5.1.

(a) Malaria

Almost all doctors had treated more that 200 patients in the last 6 months of the year. Principal medicines for treatment were chloroquine, fancidar, metakelfin and quinine. In all, 66% of doctors answered that there had patients who did not respond to medicine, which means drug resistant malaria was prevalent there. During the long and short rains and throughout the times when rice fields were flooded, the number of patients increased. This was also shown by the medical records from Mwea Mission Hospital and presented in figures5.1 and 5.2. In 2014 there was a sharp increase in malaria cases and this was due to continued rise in drug resistant malaria.

(b) Schistosomiasis

Almost all doctors had treated patients for bilharzias. The number of patients treated were less than malaria, with the number being the highest during the growing season when tenants frequently are in the flooded fields as presented in figures 5.3 and 5.4. The parasite species were both *Schistosome mansoni and S. haematobium.* Praziquantel was used for treatment.

(c) Amoebic dysenteries

More than 50% of the doctors interviewed noted that there was an increase in incidence of amoebic dysentery cases at the MIS. Over 66% of the doctors interviewed had treated more than 100 cases if amoebiasis and related problems of intestinal worms. The patients treated were responding well to medicines but because of the poor quality of water used, the cases continued to increase. The two medical staff from MIS interviewed agreed that the above mentioned disease were endemic at MIS and they were caused by the presence of disease vectors like mosquitoes and snails propagated by the flooded rice fields and the poor quality of canal water used by tenants as sources of domestic water supply. They acknowledged that community health education could help reduce incidence of these human diseases. They noted that since the NIB stopped spraying canals or treating the water, the farmers have been exposed to malaria, bilharzias, amoebic dysenteries, typhoid and other water borne diseases.

(d) Mutithi area

Table 5.11 shows the common human diseases in the control area. The interview schedules revealed that malaria was endemic in both the Mutithi and MIS villages with the latter recording that 100% of respondents had at least been attacked by malaria. However, 65% of respondents from Mutithi area also said they had suffered from malaria. This is because malaria transmitters, mosquitoes have been known to affect populations who are not necessarily within the boundaries of the breeding points. Malaria was the only disease which was mentioned by both the respondents from the study and the control area, Schistosomiasis was another vector borne disease found in rice growing areas was found to be endemic in the MIS villages. In the control region only 5% of the respondents had contracted bilharzias. It was found that this particular respondent had to be absent in non irrigated lands. Water-borne diseases like, Amoebic dysenteries, typhoid, cholera, diarrhea, intestinal worms and hepatitis were found to be endemic in MIS villages and absent in the control region. This could be attributed to the presence of treated pipe-borne water supply and uncontaminated water from borehole in the control area.

Table 11 : Major Diseases Mentioned by the Respondents in both areas

	M I S Villages		Mutithi	
Disease	Freq. n=200	%	Freq n=20	%
Malaria only	46	23	13	65
Schistosomiasis only	13	6.5	1	5
Amoebic dysentery only	20	10	0	-

Typhoid only	4	2	3	15
Cholera only	6	3	0	-
Malaria, Schistosomiasis, Amoebic dysentery, Typhoid and Cholera	104	52	0	-
Other diseases	7	3.5	3	15
Total	200	100	20	100%

Source: MIS field survey 2014

Table 12 : Causes of major diseases as given by the respondents

	M I S Villages		Mutithi	
Reason given	Freq. n=200	%	Freq n=20	%
The presence of many disease vectors and poor water quality	112	56	19	95
Poor sanitary conditions and congestion in the village	50	25	1	5
Poor housing and people's interaction with waters	38	14	0	-
Total	200	100	20	100%

Source: MIS field survey 2014

Implication of environmental problems related to human health in MIS

The disease associated with rice growing, and those identified in MIS, can for convenience be divided into three as seen from the results.

(i) Diseases transmitted by vectors or intermediate hosts living in the rice fields or associated irrigation canals i.e. malaria and schistomiasis,

(ii) Water related diseases such as dysenteries contracted through drinking contaminated waters, i.e. amoebic dysenteries, typhoid, cholera, intestinal worms, diarrhea and food poisoning, and finally,

(iii) Those related to insanitary housing conditions and overcrowding, i.e cholera, tuberculosis, influenza, meningitis and pneumonia since they can be transmitted from one person to the other.

In MIS, vector borne diseases were seen to have the greatest socio-economic impacts on the community. They affect large populations and in fact cause high mortality, especially among the infants and adolescents or to be more chronic and debilitating. These diseases can reduce working ability of those infected as well as reduce the quality of life. The most important of these diseases is malaria transmitted by mosquitoes and schistosomiasis, which has various aquatic or amphibious, snails as its intermediate hosts. Schistosomiasis is in fact the most important and widespread disease after malaria in the study area. Despite the vigorous anti-malarial efforts in MIS, malaria continues to be a major disease. Malarial infections in MIS are brought about by different malaria parasites of the genus plasmodium of which the most common are *P. falciparum and P. vivax*. Schistosomiasis ranks among the most important occupational and public health problem in MIS. Rice cultivation does not invariably lead to schistosomiasis problem. For example, collaboration between NIB and the MOH prevented snails becoming established at the Ahero Pilot Scheme; this action was prompted by the disastrous rise in the schistosomiasis prevalence in MIS. It was noted that environmental changes due to irrigation development transformed seasonal and moderate malaria into a permanent hyper-endemic situation currently in MIS.

Data generated from MMH's 2012 and 2013 annual reports reveal overwhelming effect of malaria on MIS population mortality. The seriousness of this disease is only partly reflected in the morbidity and mortality (it was top of 10 disease for both adults and children). Malaria peaks are found in March/April and August/September especially when fields are flooded with water. In 2012, 2752 in-patients and 1855 out-patients were treated for malaria while in 2013 the number rose to 3075 in-patients and 2279 out-patients respectively.

The economic consequences of ill health are difficult to assess. Economic loss through absenteeism caused by Schistosomiasis, was estimated at US$8,640,000 annually. Extrapolating from studies elsewhere, the production loss due to ill health was estimated at 10%, which in the case of schemes under NIB means an annual loss of US$818,700 (WHO/FAO/ UNEP, 1988, quoted in WHO/FAO/UNEP, 1990). Though the present study did not calculate the economic costs of ill health, it can be seen from the results that farmers in Mwea suffer a number of debilitating illnesses which if the economic loss is estimated it could be enormous. It is therefore observed that to ensure the timely considerations of health in the planning of irrigation development especially in Mutithi area, the opportunities for inter-sectoral cooperation have to be utilized at the crucial movements during the project cycle. It can be said that malaria, schistosomiasis and other water borne diseases identified in MIS have caused great damages since considerations for public health effects have been neglected by the NIB and MIS management in particular.

Farmer's perceived environmental problems

(a) MIS Villages

The interview survey revealed that the major environmental problems perceived by respondents were of two kinds: those that are social in nature and those that are physical. Human environmental problems as perceived by the respondents are: Human health problems and poverty among others while physical environmental problems are: diseases in aquatic weeds, salinity and alkalinity in the fields and waterlogging. Table 5.15 (a) gives a summary the perceived social environmental problems and percentages. It was the feeling of many respondents, 48%, that human health problems were the main problems in the social sphere in the settlement. 41% of the respondents however noted that poverty among other problems was the most important social environmental problem facing the settlement. The problem is discussed below. The remaining respondents, 9%, noted other social problems other than the above two as important. Among the ones mentioned which are of interest to this survey were seen as causes of the above two rather than problems on their own.

Poverty and its implications

In this context poverty is defined as lack of assets to pay large expenses or to meet contingencies and to powerlessness. It was indicated by malnutrition and high birth rates, high infant mortality, vulnerability to diseases, physical weaknesses and indebtedness. According to Chambers, R. (1991:112 in his book *Rural Development: Putting the Last First,* diseases like cholera is an indicator of poverty. Crowded conditions plus inadequate water and sanitation are ideal conditions for it. This disease seldom strikes those in upper socio-economic groups, even in region point of view, poor living standards and conditions, is the major cause of their ill health in the scheme. During the planning stage of the settlement the planners were preoccupied with the main objective of increasing agricultural productivity and farmers welfare was peripheral to this goal. A high degree of control of tenants activities is exercised by the management. The overall system of control is very strict based on irrigation rules (cap 347) and the success of Mwea has largely been attributed to the close supervision which has protected tenants from failure. However this type of control have made tenants apathetic and they now tend to mistrust the board and see themselves as slaves. The complete control over tenants activities, the far reaching sanctions, the absence of legal rights to holding, or the assurance of the inheritance of the holdings – all these led to tenants insecurity. The regime under which the scheme is managed, and to which most of its success is attributed, is probably its most disquieting feature. Much depends upon whether the present situation is considered a traditional phase, and it has taken too long, during which the tenants are educated towards becoming independent farmers, or whether this discipline is a built-in feature of the scheme, without which it would eventually breakdown, as has happened in other irrigation settlements in Africa. Its continuance would inevitably perpetuate the apathy and dependence of tenants lacking initiative, and drive others to search outlets for their initiatives and enterprise outside the settlment.

(b) Mutithi area

Table 5.15 gives a summary of perceived environmental problems in the control area. The major environmental problem which was found in the control area and not mentioned in the study area was soil erosion especially in the red soil area. This was completely absent in the MIS area since the agronomic practices presently in use do not aggravate soil erosion.

Table 15 (a) : Farmers perceived Environmental Problems in MIS and the control area – Social Environmental Problems

	M I S Villages		Mutithi	
Environmental problems	Freq. n=200	%	Freq n=20	%
Human health problems	96	48	5	25
Poverty	82	41	4	20
Others	11	22	11	55
Total	200	100	20	100%

NB: Respondents were asked to mention the most important social environments problem faced.

Source: MIS field survey 2014

Table 15 (b) : Farmer's perceived Environmental Problems in MIS and the control area: Pysical Environmental Problems

	M I S Villages		Mutithi	
Environmental problems	Freq. n=200	%	Freq n=20	%
Increase in aquatic weed	92	46	0	-
Water contamination	69	39.5	0	-
Salinity and alkalinity	27	13.5	0	-
Waterlogging	12	6	0	-
Soil erosion	0	-	20	100
Total	200	100	20	100%

Source: MIS field survey 2014

NB: Respondents were asked to mention the most important physical environments problem faced.

Environmental problems observed at the Macro-level MIS irrigation fields

Water Contamination

When water is not in conformity with the water quality standards, either existing or intended, the water is said to be polluted. Water is contaminated when there exists a real health hazard or damage risk from using that water for some specific purposes, and in this case drinking water. From this field survey and the results of the interview schedule, most respondents used canal water for domestic purposes. Samples were collected at Thiba Headworks (the incoming irrigation water) and other samples were collected from subsurface drains near exit. Thought only 10 sampling sites were selected in each category, the following results show that there was an increase in coliform count per 100ml of water. This is an indicator of the presence of disease causing pathogens in the water which eventually drains into the canals used as sources of domestic water supply. Table 5.16 presents a summary of the parameters measured in order to ascertain the changes in water quality of water after irrigation. There was an increase in hardness of water indicated by increase in calcium carbonate ($CaCo_3$) from 44 to 138 mg/l, dissolved salts as indicated by increase in conductivity, from 80 to 263 mmhols/cm, showing the surface drain was near exist is highly polluted. This was also indicated by increase in Chlorides, Nitrates, Calcium, Magnesium, Sodium, Potassium and Sulphates as shown in Table 5.16. when this irrigation drain water finally enter receiving water bodies this eventually affects the water quality and pose danger to aquatic life, animal and man. Water quality from the control region was of satisfactory quality as shown in Table 17.

Implications of Water Contamination

Adverse effects of irrigation on water quality have been seen and identified as increased salinity, turbidity, colour, taste, temperatures, nutrients, bacteria and viruses (indicated by increase in coliform count). These effects can cause economic losses and deterioration of the environment. The rise in total salts due to irrigation normally has effect of increasing hardness. Part of the irrigation return water flows gets back into the canals and rivers which are used as sources of drinking water. Ingestion of this contaminated water leads to the widespread of waterborne diseases in MIS. Pollution of eventual receiving water bodied is equally important as it poses real danger to aquatic inhabitants, animals and man downstream.

Table 16 : Water Quality of Constituent Applied Irrigation and Surface Drain Water near exit of Irrigation Water: Irrigation Season

Average for 10 Sampling Sites

Constituent for characteristic	Applied Water	Surface Drain Next Exit
Temperature °C	18.0	21.4
Dissolved Oxygen	10.2	8.0
pH units	7.62	8.5
Hardness as $CaCo_3$	44	168
Turbidity units	32	146
Conductivity mmhols/cm	80	263
Chlorides as mg/1	0.98	9
Nitrates as mg/1	0.25	6.5
Calcium as mg/1	9.8	33.2
Magnesium as mg/1	4.6	18.7
Sodium as mg/1	4.6	18.7
Potassium as mg/1	1.4	4.6
Sulphates mg/1	3.6	24.6
Total Dissolved Solids (TDS)	121	470
Coliform per 100 ml	150	1,079

Source: MIS field survey 2014

Global Journal of Science Frontier Research (H) Volume XVI Issue III Version I Year 2016

Table 17 : Water quality assessment for tap water in Mutithi area: Averages for 5 sampling sites

Constituent for characteristic	Amount
Temperature °C	17.4
Dissolved Oxygen	12.6
pH units	7.44
Hardness as $CaCo_{3(mg/l}$	32
Turbidity units	23
Conductivity mmhols/cm	73
Chlorides as mg/1	0.68
Nitrates as mg/1	0.05
Calcium as mg/1	6.2
Magnesium as mg/1	2.9
Sodium as mg/1	2.9
Potassium as mg/1	0.39
Sulphates mg/1	1.81
Total Dissolved Solids (TDS)	91.5
Coliform per 100 ml	46

Source: MIS field survey 2014

Increased aquatic weeds

Irrigated rice farming in MIS is a part of a complex practices comprising management of available water resources, controlled distribution of this water over the cultivated land, and withdrawal of excessive water through drainage. The ecological consequences of this complex systems include the radial modifications of ecological systems of the terrestrial habitat to aquatic habitats. Aquatic weeds immediately find a conducive environment where they thrive and compete with the rice crop. Of big concern in MIS in the *Typha latifolia species*, found in areas of high water table and other species of aquatic weeds. Early and continuous weeding is he only way of controlling these aquatic weeds. From the field survey, tenants complained of reduced production in areas with intense aquatic weeds.

Water logging

According to field surveys water logging was only mentioned as an environmental problem by 6% of our respondents. Field observations and the results of the key information interviews confirmed that there were only isolated cases of water logging and occurred in lower unit of Tebere section. Over six and a half (6½) acres had been abandoned because of water loggig according to official records from MIS. However field observations showed that there was an additional eight acres which were under cultivation and affected by the water logging problem. Waterlogged plots were identified by the presence of *Typha laifolia* species and where the rice seedling was observed to turn yellow while still in water. Waterlogged soils in the present study means a soil saturated with water or having excess water in the root zone. It may be temporary, seasonal or permanent. In this study permanent waterlogged conditions which could lead to abandoning the rice fields are the only ones observed because of the conditions under which wet rice is grown. Soils having permanent groundwater near the surface are considered waterlogged. In the areas the condition was observed in Tebere's T.19 and T.20 units, water logging was as a result of:-

- The low relief which make the area receive water from surrounding lands and thus become waterlogged,
- Introduction of an intensive network of irrigation canal system causing canal seepage that affect the water balance within the region with more incoming than outgoing. It was the observation of the irrigation officers interviewed that the problem of water logging was caused by poor drainage. The objective of drainage is to evacuate excess water from the soils. Plate 5.3 presents an abandoned paddy field because of water logging problems. The presence of *Typha latifolia* species indicated the high water table. Plate 5.4 presents a waterlogged plot which a farmer is tring to reclaim and *Typha latifolia* species can be clearly identified. Plate 5.5 shows a farmer leveling a partly reclaimed plot and in the background, plots which are not problematic have rice seedlings already transplanted and growing. Plate 5.6 presents a plot in the same unit where there is no waterlogged soils with the rice crop doing very well.

Salinity and Alkalinization of soils

The migration of salts in water, accumulation through evaporation and deposition are responsible for salinization of soil. Dissolved salts migrate with artesian waters through tectonic cracks and re-migrate to the surface and then salinity may develop as a result of evaporation during very dry or hot conditions. Secondary salinization often results following irrigation as a result of rising water table above the minimum level. The concentration of soluble salts in the soil solution increases as water is removed from the soil by evaporation and transpiration. Alkalinization may result from the evaporation of water containing low concentrations of sodium salts. As observed in some areas, the white accumulation of bases were obvious in some units. The concentrations sometimes were above critical levels as in Thiba units 6 (see Table 5.18). The damages caused by accumulation of bases are divided to 2 types:

- High total concentration of bases, Calcium (Ca) is a major base i.e. salinity. This causes the inhibition of water uptake by plant because of high osmotic pressure. The measure of conductivity is a way of estimating soil salinity in general. The higher the conductivity, the higher the level of salinity.
- High pH because of sodium (Na) is an indication of alkalinity. Where (Na) is high, pH becomes high in fact >8.5. The alkalinity causes the deficiency in some elements of which availability of low in high pH., (Na) inhibits Potassium uptake. Alkalinity can be proved by pH and sodium concentration. The accumulation of bases on surface is caused by poor drainage.

Table 18 : Soil Characteristics in selected areas in MIS

Parameter/Station	K2	W7	H6	M13	T19
pH- H_2O (1:2.5%)	7.94	5.79	8.29	6.68	7.72
Hcl Reaction (10%)	X	X	oo	X	oo
CEC (ml/100g) pH 7.0	61.0	68.0	76.0	70.0	68.0
Exch. Ca. (me/100g)	45.5	36.0	136.9	34.2	52.6
Exch. Mg. (me/100g)	19.9	15.3	29.9	20.2	31.2
Exch K (me/100g)	0.5	0.3	0.1	0.1>	1.0
Exch Na. (me/100g)	1.0	0.5	6.8	3.5	3.4
Avail. P ppm	15.3	25.3	24.9	22.7	94.8

Horizon 0-15 cm

Source: MIAD Soil Labs Feb. 1992

K2= Karaba Unit K2

W7= Wamumu Unit W7

H6= Thiba Unit H6

M13= Mwea Unit M13

T19= Tebere Unit T19

X= no reaction at all

oo= slight reaction

NB. The units where soil analysis was done were selected as problematic soils with the assistance of Irrigation officers in charge.

Table 19 : Soil Characteristics in selected areas of Mutithi area

Parameter/Station	Mut. 1	Mut. 2	Mut. 3	Mut. 4	Mut. 5
pH- H_2O (1:2.5%)	7.65	7.25	6.30	6.45	6.46
Hcl Reaction (10%)	6.05	5.50	4.25	4.90	5.20
CEC (ml/100g) pH 7.0	78.5	65.4	25.2	29.2	38.7
Exch. Ca. (me/100g)	32.2	27.5	10.6	11.5	11.2
Exch. Mg. (me/100g)	22.6	13.9	1.6	4.8	4.8
Exch K (me/100g)	0.1	0.1	0.1	0.6	2.1
Exch Na. (me/100g)	2.0	0.8	0.8	1.0	4
Avail. P ppm	77	75	80	120	112

Horizon 0-15 cm

Source JICA 1988.

Mut.1= Mutithi station 1

Mut.2= Mutithi station 2

Mut.3= Mutithi station 3

Mut.4= Mutithi station 4

Mut.5= Mutithi station 5

Implications of Waterlogging, Salinity and Alkalinization

The most important factors causing waterlogging, salinization and alkalinization is MIS are aridity of the climate together with geomorphology, topography, physiochemical characteristics of the soils and soil and water management practices. The presence of high water table and high evapo-transpiration sometimes alkalinization of soils. The development of waterlogged soils is mainly associated with low-lying lands of poor soil physical conditions and internal drainage. As a result of intensive and continuous application of water in the paddy fields in MIS, with the absence of efficient drainage systems or good internal drainage in some units, waterlogging may become a serious problem in the scheme. Quantitative data on the extent of the present and potential salinity, alkalinization and water logging was not available and this should be a research priority in MIS. However from the examples given in the results, it should be noted that these problems, though at low magnitudes, should be mitigated against to avoid future deterioration of the schemes soils. The reclamation of the already affected soils will depend among other things on the proper selection of them method that best suits the specific conditions in the field. In order to reach such a decision, field and laboratory works are required to indicate the extent of the problem.

Comparison at the Macro level (MIS irrigation fields and the Mutithi area)

At the macro level, the variables compared are water quality, waterlogging, soil characteristics (salinity and alkalinization) and vegetation characteristics in MIS and the Mutithi area. Tables 5.16 and 5.17 show the water characteristics in MIS and the Mutithi area could be said to be as a result of irrigation activities. It was observed that there was a high number of coliform in water from MIS than the samples analyzed from the control area. This may be the prime cause of many water borne diseases in MIS than in the control area. The interpretation of soil analysis from MIS (Table 18) and the control area (Table 19) indicates some degree of salinization and alkalinization in MIS. These are absent in the Mutithi soils which are not irrigated (see Tables 18 and 19). Water logging was found to be isolated in some units of MIS as revealed by field observations. This phenomenon was found to be absent in the control area. Soil erosion was found to be serious problem in the control region especially in the heavily cultivated red soils of the Mutithi area. It was established through interview schedules, informal interviews, interviews with key informants, literature survey and interpretation of aerial photographs that the Mwea Plains, which now supports rice paddy fields and villages were once open grasslands with isolated shrubs. However this type of vegetation has been modified to suit wet rice cultivation. In the Mutithi area, areas with black cotton soils were also found to be devoid of intense vegetation though it supports isolated vegetative cover. In the red soil areas in MIS we find nucleated settlements while in the Mutithi area these areas were cultivated and support thick vegetation. In both areas, attempts have been made to regenerate vegetation and now the MIS villages support thick *Grevillea robusta* species. These species were also observed in the control area. Interestingly the reasons for planting trees in both areas were different with the respondents in MIS acknowledging that they have planted trees to provide fuel wood. Respondents in the control area said they had participated in three planting to improve the soil quality and present soil erosion.