Chapter 5

REVIEW OF EXISTING RESERVOIRS ON THE TANA

5. REVIEW OF EXISTING RESERVOIRS ON THE TANA

5.1 INTRODUCTION

This chapter summarises the environmental conditions at the existing five reservoirs on the Tana River based on a review of published information. A review was carried out to learn from previous experience of environmental and socio-economic impacts at the existing five dams projects on the Tana River. The focus of the review was on the impact assessments conducted, mitigation measures adopted, and monitoring activities implemented following construction of the dams. Important implications for the current project, derived from shortcomings in previous environmental assessments, are also highlighted.

5.1.1 Methodology

The available literature on the existing five dam projects on the Tana River and on other dams around the world (particularly Africa) was reviewed with the emphasis on the following items:

- Environmental impacts identified prior to the construction, and if any, the mitigation measures and monitoring programs either recommended or put in place during and after the construction.
- The status and impacts of those mitigation and monitoring programs, if any, adopted after the construction.

Additionally, discussions are planned with key staff of TARDA and KPLC to learn more about any ongoing environmental monitoring programs at the project sites. The discussions will be further supplemented by a brief visit planned to the Masinga and Kiambere reservoirs.

5.2 MAJOR "LESSONS LEARNED" FROM THE PREVIOUS EXPERIENCES

Below are summaries of the major lessons learned from experiences with previous EA studies on the River Tana.

1. The previous experience in Kenya indicates that the local population have not derived significant benefit from the presence of the new reservoirs, whether it is in terms of drinking water, sanitary installations and electricity or an increase in food resources and the improvements of housing.
2. Families that were displaced were not properly resettled, and diseases such as malaria have increased rapidly in the regions.
3. The dams have had no significant favourable effects on the plant cover in the surrounding areas, thus leading, in some cases, to the erosion of the banks of the lakes.

4. The experience from the Kamburu Dam ecological survey (Odingo, 1979) indicated that the dam construction led to serious disturbance of vegetation and wildlife.

5. Another big problem was the influx of people into the neighbourhood of the dam. During the construction of the Kamburu Dam there was a workforce of at least 2,000 persons. Random medical surveys among this workforce revealed that there were among them persons suffering from Schistosomiasis.

5.3 IMPLICATIONS FOR THE CURRENT PROJECT

1. Environmental aspects should be considered with regard to the site of the reservoir as well as in the catchment area, both upstream and downstream; and all steps should be taken in relation to the conservation of the environment in the area.

2. The resettlement of the affected persons should be planned carefully, taking into account the opinions and needs of the local populations and adopting measures which would improve the living conditions.

3. There should be consultations with the local communities and NGOs, particularly regarding the environmental and social aspects of the project. Improvements of local communities' living conditions should be an integral part of the project. Reports and other documents concerning the project should be at the disposal of the general public.

4. Full compensation and resettlement schemes, as well as preventive health measures to alleviate increases in water-related diseases, and soil conservation measures, should be carefully considered.

5. The communities living around proposed lakes should have access to the drinking water supply networks; sanitation facilities; electricity distribution networks; appropriate irrigation system using the water from the lakes; and information and training related to the above points.

6. A fish management program should be integrated into the project, including information concerning stocking, restrictions pertaining to fishing, the expected changes in the water quality and envisaged nutritional sources for the fish.

7. Preventive measures with respect to water-borne or water-related diseases should be envisaged, including information and training regarding simple lake water management - action to be taken to eliminate stagnant pool and growth of vegetation, artificial changes in the lakes, etc.

8. Anti-erosion measures should be integrated into the project, particularly:

    (i) Reforestation along the shores as well as on the banks of the rivers and their tributaries upstream,

    (ii) Agricultural activities should be limited in these same areas,

(iii) The communities living in the area should be made aware of the phenomena related to erosion

9. Consideration should be given to the creation of a protected area adjacent to the new reservoirs. *This could be carried out through the creation of a narrow extension of Kijege Forest reserve, with the extension to run between the existing forest reserve and the shores of the new reservoir.* Further scope for protected areas exists on small islands that will be created within the newreservoirs. These will form habitats for a number of waterfowl, and conditions could be managed to provide increased opportunities for breeding birds.

10. Comprehensive water resource planning should be instituted. This will require redefining the objectives of project planning to include considerations of ecological, sociological and hydrological factors, and opening the planning process to give authority to experts in various disciplines.

11. Sound economic analysis of projects should be performed which evaluate reasonable costs of uncertainty, opportunity costs, economic costs of environmental degradation and relocation costs. As project proceeds they should be subject to audit and the results of these audits should be used in assessing possible economic benefits of future projects.

12. The planning process should be open to the public. Planning, environmental and economic analysis should be made to the public in draft form to allow public and scientific community to comment on it.

13. Establishment of watershed management and rehabilitation should be made a priority. This would include making renewable reforestation and soil erosion control projects.

14. The impact of on the local environment and the local communities should be given careful attention in all phases of the project, from the design right up to its management after it becomes operational and particularly in cost-benefit analyse.

15. A thorough environmental analysis should be conducted before the design is finalised. In that way design modifications can be made to the project to minimise environmental and economic losses.

5.4 LOCATIONS, PHYSICAL PARAMETERS AND CHRONOLOGY

5.4.1 Overview

There are five existing hydroelectric dams on the Tana River, commissioned between 1968 and 1988. The five dams are Kindaruma, Kamburu, Gitaru, Masinga and Kiambere. Table 5.1 summarises the main features of the existing reservoirs.

A major part of the country's investment on the development of water resources has been spent in the Lower Tana River Basin area. The Tana River Basin covers over 100,000 km^2 (16% of the national territory). The basin represents a major contributing sector within the Kenyan economy containing some 20 percent of the national population, a major portion of the country's agricultural potential and providing an important source of hydro-electric power generation.

5.4.2 Kindaruma

Kindaruma is the smallest of the lakes with the reservoir surface area of approximately 2.5 km^2. The dam was completed in 1968 and was intended for the production of hydro-electricity (maximum production capacity 44 MW).

Practically no-one lived around this lake at the time of its construction; there was only a small village with traditional huts (mud walls and thatch roofs) at about 500 metres downstream from the dam and 300 metres from the Tana River (Roggeri, 1985).

On the banks the vegetation included bushes which evidently existed well before the building of the dam. The vegetation subsequently became a little thicker than the growth around Kamburu.

Table 5-1 Main Features of Existing Reservoirs & Hydropower Facilities

	Kindaruma	Kamburu	Gitaru	Masinga	Kiambere
Impoundment year	1968	1974/6	1978	1981	1988
Retirement year	2043	2050	2053	2056	2063
Catchment area (km^2)	9,807	9,520	9,520	7,335	11,975
Max. surface area (km^2)	2.5	15.2	3.1	116.0	25.0
Gross storage ($10^6 m^3$)	8.5	159.0	13.5	1,566.0	585.0
Live storage ($10^6 m^3$)	7.5	135.0	12.5	1410.0	485.0
Dead storage ($10^6 m^3$)	1.0	24.0	1.0	156.0	100.0
Mean flow at site (m^3/s)	130.2	129.3	129.3	108.3	136.8
Gross head (m)	37.0	82.0	144.0	50.0	145.0
Max. discharge (m^3/s)	155.9	149.5	120.9	97.2	121.8
Installed capacity (MW)	44.0	94.2	145.0	40.0	144.0
Firm output (MW)	44.0	64.0	145.0	12.9	92.0

Note: Main purpose of all reservoirs is hydropower. Source: Phase 2, Progress Report 1.

5.4.3 Kamburu Dam

This dam, which became operational in 1975, created a reservoir surface area of approximately 15.2 km^2 used exclusively for hydroelectric generation with a firm power output of 84 MW.

During the driest periods the lake only covers an area of 2.2 km^2, causing serious problems for the plant (Odingo, 1979). Masinga dam was built upstream largely in order to insure that Kamburu has a regular water supply throughout the year.

The area surrounding the lake was sparsely populated and, despite the presence of some plots on which traditional crops and mainly maize had been planted, the terrain has evidently developed very little since the establishment of the lake. The Mwea game reserve is to the northwest of Kamburu dam, between the left bank of the Tana River and the right bank of the Thiba River.

5.4.4 Gitaru

The Gitaru Dam, having a reservoir surface area of approximately 3.1 km^2, became operational in 1978, with power generating capacity of 145 MW.

5.4.5 Masinga

Since it became operational in 1981, Masinga has been the largest man-made lake in East Africa having a flooded area of 116 km^2. The maximum production capacity of its hydroelectric plant is only 40 MW since the dam was intended to be a water reserve to ensure constant supply to the Kamburu plant and irrigation projects proposed at that time.

5.4.6 Kiambere

Kiambere Dam with a reservoir surface area of 25 km^2 became operational in 1981 with an installed power generating capacity of 144 MW, and a firm output of 92 MW.

5.5 ENVIRONMENTAL PARAMETERS

A summary of key environmental parameters recommended for consideration of environmental impact assessment of hydro-electric dam projects are given below. These were compiled from: World Bank's Environmental Assessment Sourcebook (World Bank, 1991), World Bank Technical Paper 110 (World Bank, 1989), and publications from the International Commission on Large Dams (ICOLD 1981 & 1985). The environmental parameters are presented under three categories: Dam and Impoundment Area, Upstream Considerations and Downstream Considerations. The following sections provide a brief description of each of the parameters.

5.5.1 Dam and Impoundment Area

Environmental effects of construction:	Specific provisions must be made to eliminate environmental damage in the impoundment area during and after construction. Some of the important environmental considerations related to construction are:
	• Location of borrow areas and borrow pits; eventual conditions of these areas after the construction.
	• Air and water pollution from construction equipment, earth movement, and living quarters.
	• Soil erosion.
	• Destruction of vegetation, siting of contractor facilities and other infrastructure to minimise destruction of the natural landscape.
	• Sanitary and health problems from population influx associated with construction camps. This would require provision for solid waste disposal and screening of labourers for imported water-related diseases.
Dislocation of people living in inundation zone	Reservoir creation would involve inundation of houses, villages, farms and infrastructure such as roads and transmission lines. When people are involved, involuntary resettlement is required. Involuntary resettlement imposes major social and economic

	costs.
Loss of historic, cultural or aesthetic features by inundation.	Inundation of sites or areas of historic, religious, aesthetic or other particular value, and sites of archaeological and paleontological significance requires special attention.
Inundation of agricultural land	This is especially important where highly productive lands are affected.
Inundation of forest land	May mean the loss of valuable timber and species diversity. Salvaging lumbering can recover some of this potential loss and provide other reservoir benefits; species loss may not be replaceable.
Inundation of wildlife habitat	Particularly habitat of threatened species with consequent impact on biological diversity.
Inundation of potentially valuable mineral resources	This has obvious impacts on the ability to utilise these resources.
Inundation of vegetation	Biomass left in reservoir can affect water quality if the water is to be used for potable purposes, reservoir fishing (for example, through interference with nets), operation and longevity of dam and associated machinery.
Proliferation of aquatic weeds in reservoir	Proliferation of aquatic weeds can increase disease vectors, affect water quality and fisheries, increase water loss (through transpiration), affect navigation, recreation and fishing, and clog irrigation structures and turbines.
Deterioration of water quality in reservoir	Depending upon the activities upstream and retention time within the reservoir, water quality may be affected by salt accumulation, eutrophication from weeds and biomass decay, turbidity, pollution from agricultural, industrial and human wastes, and fish processing. By trapping sediment, the reservoir provides better quality water downstream with less suspended matter.
Fisheries	Disruption of riverine fisheries due to flow changes, blocking of fish migration by the dam (although fish ladder may sometimes be practical), and changes in water quality and limnology.
Use of reservoir for fisheries development	Substantial new reservoir fisheries are often possible if carefully planned and managed.
Increase of water-	Establishment of reservoir and associated water management

borne and water-related diseases	structures (e.g., canals and ditches) can create conditions fostering establishment and spread of water-related diseases such as schistosomiasis, onchocerciasis, encephalitis, and malaria. Prevention, where possible, is essential, since treatment to eliminate most disease vectors is difficult (or impossible) and expensive once they become established. In other cases, availability of regulated water supplies for municipal and industrial use can have major beneficial effects
Effects of drawdown regime	A drawdown may create agricultural possibilities, as well as health, recreational, aesthetic, and access problems. However, imposition of an exclusion / buffer zone will severely restrict potential benefits accruing from agricultural possibilities in the drawdown zone
Seismicity	Seismic shocks may be induced by large reservoirs
Groundwater level	Groundwater levels in the surrounding area may be altered
Local climate	Local climate may be modified by the presence of large reservoirs, especially in terms of humidity and local fog.

5.5.2 Upstream Considerations

A variety of upstream considerations can affect the dam and its reservoir. While not directly "caused" by the dam, these effects may be induced or exacerbated by the dam. For example, dam construction and reservoir filling may provide access to a previously remote and inaccessible area. The induced population in-migration may lead to increased agricultural or mining activities with major implications for soil erosion, sedimentation, and water quality. Some of the more important upstream considerations are as follows:

Increased population and poor land use practices:	Increased population settlement and economic development in the upper catchment or watershed usually increase soil movement. This can potentially result in gradual filling up of the reservoir. The timing and ultimate impact of this increased soil movement on the reservoir will vary from case to case.
	In-migration from both downstream and outside the river basin area is often facilitated by the project (improved access due to new roads and sometimes water transport). The resource and environmental effects can include: cultivation of unsuitable sites leading to soil erosion, logging, poaching, loss of wildlands and wildlife habitat, and pollution from settlement and cultivation.
Changed watershed	The changes in land use patterns, if excessive or extensive, may affect the timing and magnitude of runoff, especially during

hydrology	major storm events. Changed vegetative patterns may also influence dry season stream flow
Salt inflows and Pollution	Salts from the watershed may accumulate in the reservoir and affect water quality. Similarly, catchment runoff may carry quantities of agricultural chemicals and fertiliser with resultant impacts on reservoir water quality. Other wastes derived from household and industrial sources within the catchment are also likely to accumulate within the reservoir.

5.5.3 Downstream Considerations

Numerous impacts are felt downstream. Many are positive and are the reason why dams are built-increased irrigation, improved water control, hydropower generation and water supply benefits. There are other environmental and resource impacts that can be both positive and negative. Among these are the following:

Effect on traditional flood plain cultivation	Effect on traditional flood plain cultivation through changes in flow and flooding regime, and loss of annual "top dressing" fertilisation from limited flooding. Control of severe flooding can also yield benefits through reduced crop and property losses
Impact on other water projects	Changes in stream flow and water releases from the dam affect all water and irrigation projects elsewhere in the lower basin. Reduced silt content in water will lower potable water treatment costs (although this is unlikely to be significant since water treatment will still be required). The reduced silt content, particularly the trapping of nutrient rich upper catchment sediments will have long-term impacts on all downstream agricultural activities.
Impact on municipal and industrial water supply	Impact on municipal and industrial water supply downstream can have both positive and negative effects depending on water quantity and quality
Stream bed changes	Streambed changes include the likelihood of increased stream bed erosion below the dam due to reduced silt loads in the water released from the dam. In addition, the course of the river within its floodplain may also be changed.
Salt intrusion	Salt intrusion into estuary and lower river basin areas may result from sustained or seasonal reduction in river flow
Groundwater level changes	Higher groundwater levels due to the higher levels in the reservoir. Downstream, in old flood plain areas, the groundwater level may fall but in irrigated areas, it may rise

Health problems	Health problems are likely to occur, especially from water-related diseases or parasites
Effects on wildlife and wildlands	Effects on wildlife and wildlands through loss of or change in habitat may result in a negative impact on biological diversity

5.6 BEFORE-PROJECT ENVIRONMENTAL ASSESSMENTS

5.6.1 Environmental Reconnaissance

Identification of likely environmental impacts is the first step. Once they have been identified, it is necessary to assess or evaluate which impacts are important and need to be taken into account. Not all impacts are of equal importance and limits on data and resources need to be considered on which impacts to consider further.

This is usually accomplished through an environmental reconnaissance to determine the existence and scope of any environmental problem. Once the environmental parameters are identified and their potential importance assessed, this information is incorporated into the process of analysing options for alternative designs for the project. To the extent that environmental factors can be evaluated in tangible form, they are included in the economic analysis of alternatives.

Only two of the existing five dam sites were subjected to formal, pre-construction environmental impact assessment (EIA) studies: Masinga Dam (Ward, Ashcroff and Parkman, 1976) and Kiambere (African Development and Economic Consultants Ltd., 1984).

There is no indication that any environmental reconnaissance study was conducted for these two dams. In fact, these two pre-construction environmental assessment studies were performed in a relatively short period of time and thus, present limited environmental information on the baseline conditions in the project areas. Furthermore, the studies lack in-depth assessment of the various environmental parameters investigated in the studies. These two studies would be viewed falling far short of the scope of environmental assessment guidelines recommended in the World Bank Environmental Assessment Sourcebook (World Bank, 1991) for hydro-electric dam projects.

Major conclusions and recommendations stemming from the studies are presented below.

5.6.2 Masinga Dam

In February 1974, even before TARDA was created, a feasibility study of potential projects on the Tana River was completed for the Ministry of Water Development. A follow-up study emphasised the technical and economic analyses of alternative dams.

In 1975, a more detailed study recommended construction of a dam at the Masinga site. Engineering design studies for the dam were completed in September 1976.

A study by Odingo (1975) of two other projects (Kamburu and Gitaru Dams) on the Tana River raised questions about environmental impacts that provided the impetus for a Masinga Dam EIA. After completing an ecological study of the two dams under construction on the upper Tana, Odingo (1975) recommended that TARDA conduct a comprehensive environmental assessment of the Masinga Dam project which was then undergoing detailed design. Odingo's study highlighted the need to gather baseline data before construction and raised concerns about the prospect of premature siltation due to erosion in the Masinga Dam catchment area.

In 1976, a short time after it had assumed responsibility for the Masinga Dam project, TARDA obtained financial support for an environmental impact assessment of the proposed dam. Funding was provided by the United Nations Environmental Programme (UNEP), which had opened its headquarters in Nairobi in 1973. The UNEP had no role in supporting construction of the project, and the principal donor, the European Economic Commission, did not call for an EIA.

Ward Ashcroff and Parkman (1976) conducted the Masinga Dam environmental impact assessment study. This study was completed within a period of just two months. A copy of the study report was sent by TARDA to National Environment Secretariat (NES).

The Masinga Dam EIA was one of the first environmental impact assessment studies in Kenya, and thus there was little local precedent for determining what constituted an adequate EIA or what should be done with recommendations resulting from an assessment. For TARDA, the Masinga Dam environmental study provided first lessons on EIA.

The Masinga Dam EIA study concluded that there was 'no environmental reason why construction of the Upper Reservoir on the Tana River near Masinga should not proceed on schedule.' The study did register concerns over the potential for rapid reservoir siltation because of accelerating erosion in the Masinga Dam catchment area. In addition, it recognised potential adverse effects on the downstream areas. In their letter transmitting the EIA to TARDA, the consultants emphasised the need for additional investigations of downstream effects. Construction of Masinga Dam began in 1978 and was completed in 1981.

The EIA study document included two notable points regarding the follow-up work to mitigate environmental impacts.

- The report noted that the reservoir would reduce flood flows and raised concerns over how this would influence downstream areas (e.g., agricultural productivity).

In creating the largest reservoir on the Tana River, the Masinga Dam would reduce the frequency of flooding in the Tana River delta, and this could decrease the crop yields for farmers practising 'flood recession cultivation'.

The Authority did not act on the EIA's call for studies of downstream effects (Hirji and Ortolano 1991).

- A second follow up called for by the EIA study concerned land use. There was a concern that the viability of the project would be threatened by upstream erosion that would lead to rapid siltation of the reservoir. The EIA study called for land-use planning to control erosion in the Masinga Dam catchment area.

  The Authority did not act to control erosion until ten years after the EIA was completed. In 1986, after the predicted problem with reservoir siltation had become apparent, the Authority undertook a soil and water conservation study of the Masinga Dam catchment area and developed a soil conservation program (Hirji and Ortolano, 1991).

Considering the Authority's lack of response to the EIA's recommendations for additional studies and mitigation measures, the influence of the environmental impact assessment on decision making process was judged to be insignificant.

Some of the remaining key conclusions documented in the EIA study were as follows:

- The principal impacts were inundation of 5,300 ha. and the displacement of 5,800 people.
- Water supplies for the people and livestock of the area surrounding the reservoir would not be significantly affected. However, the construction of a rural water supply in the affected area was recommended to improve the situation markedly.
- The study expected that there was little risk of deterioration in public health as a result of the reservoir provided certain precautions were taken.
- Water turbidity and sedimentation in the reservoir were not expected to constitute environmental hazards. These would affect mainly the build up of aquatic weeds and algae, the productivity of any fishery and the aesthetic appearance of the reservoir.
- The wildlife in the area was already sparse and would be little affected by impoundment.
- Problems with aquatic weeds were not anticipated.
- If bush clearance was carried out in the reservoir area, useful fishing industry could be produced.

- The downstream floodplain was thought to be under greater permanent threat from land misuse upstream and on the plain itself than from the effects of hydroelectric development. There was a real danger that the Pokomo people would suffer further reduction in the plains flooding on which they depended for their food supplies, especially in a cycle of dry years.

Some of the important recommendations resulting from the study were as follows:

- Resettle the affected population to land outside the study area that has the productive capacity to meet requirements without suffering deterioration. This was believed to help relieve pressure on the overstocked range in the study area.
- Implementation of a land use plan involving the co-operative ranching, with cultivation confined to the most suitable soils, was desired as the most appropriate land use. Full co-operation of the affected people was considered essential for the necessary reduction in stock numbers, grazing control and soil conservation measures.
- A rural water supply should be undertaken in the context of an overall land use plan.
- Bush clearance throughout the area to be inundated in order to establish productive local fishery.
- A field inventory of property requiring demolition within the inundation area in order to assess the cost of compensation.
- Initiation of a program to record flood events in the Tana plains and their relation to river stages at Garissa. This was essential from the viewpoint of assessing effects of future extension of river utilisation and regulation. In particular, this was to be used in considering resettlement of the Pokomo people.
- Introduction of a moratorium on charcoal burning throughout a zone peripheral to the reservoir.
- Fuelwood plantations developed just above reservoir retention level on the lighter and better-drained soils where moisture retention would be most favourable.
- Provision for improved health services in accordance with the medical survey report for the area.

The study also recommended an environmental monitoring program to be conducted by a small co-ordinating unit in TARDA, by either obtaining relevant data from other organisations already operating in the area and/or filling any gaps in the data coverage by others. The key elements of the recommended monitoring program consisted of:

- Aquatic weed: presence and growth.
- Fish catch records in the reservoir.
- Screening of immigrant labour for the assessment of disease transmission.
- Check for the formation of stagnant pools around the reservoir waterline during the retreat stages in the first few years after construction of the dam.
- Sediment sampling upstream and downstream of the dam to assess the reservoir's sediment retention capacity and also to assess the fisheries programs and build up of aquatic plants and public health condition. Periodic hydrographic surveys were also recommended to determine the distribution of the sediment in the reservoir.
- Population census, cultivation and grazing habits and public health statistics of people within the vicinity of the reservoir, as a basis for land use planning.
- Obtain (before and after the completion of the reservoir) and maintain satellite images of downstream floodplain grassland, forests and crops spanning the complete river flood cycle.

5.6.3 Kiambere Dam

In 1980, the Engineering and Power Development Consultants (EPDC) completed a feasibility study on a hydroelectric power project of Kiambere Gorge. By early 1982, the process of pre-qualifying for a World bank loan was well underway. TARDA was given the responsibility of the project in July 1982.

An appraisal mission of the World Bank visited Kenya in 1982 and recommended that the loan for the Kiambere Dam project be granted. However, it indicated that TARDA had to conduct an EIA as one of several conditions for obtaining funds. The Authority first argued that the Masinga Dam environmental study could serve as the required EIA for Kiambere Dam since the proposed project was in a similar geographic and climatic region to the Masinga. The World Bank rejected this argument. TARDA followed by proposing a combination of past two studies could serve as the required EIA: the Masinga Dam EIA and the EPDC 1980 feasibility study. The latter addressed questions related to resettlement, a major concern of the World Bank's appraisal mission. The World Bank rejected this proposition also. Soon thereafter, TARDA agreed to fund an EIA to meet the World Bank's conditions.

The Authority retained the African Development and Economic Consultants (ADEC) to conduct the environmental assessment based on generic terms of reference (dated 1972) specified by the World bank. The draft environmental assessment report was submitted to TARDA in July 1983, and two months later a copy was sent to the World

Bank headquarters in Washington DC. However, it was only in September 1986, three years after TARDA submitted the draft assessment and at a time when the Kiambere Dam construction was well under way, that the World bank began raising questions about the number of people to be displaced by the project. The information generated from field surveys about the number of people to be resettled was challenged frequently. So were figures related to appropriate levels of compensation for relocated families (Hirji and Ortolano, 1991).

The Kiambere Dam EIA was conducted just prior to project construction, and its utility was limited to proposing mitigation measures and monitoring programs. Although the EIA identified five archaeological sites that would be affected by the project, only one was fully restored; the other four were only partially salvaged. Other actions in response to the EIA included programs for compensating individuals to be relocated; TARDA also provided funds to relocate two schools.

The EIA also recommended measures to prevent rapid siltation of the reservoir. For example, the environmental study called for a program to monitor sediments in the proposed reservoir, and it proposed that a greenbelt be created to prevent rapid siltation. However, as of 1988 (at which time the project was still under construction), no steps had been taken to implement the recommended greenbelt.

The EIA was useful in offsetting archaeological impacts and in structuring compensation programs. However, because the EIA was conducted just prior to construction and because of a lack of follow up on the part of TARDA and the World Bank, the EIA had only a moderate influence on decision making.

The EIA study for the Kiambere Dam (ADEC, 1984) highlighted serious impacts to be the loss of 32 km^2 of inundated land and 100 km^2 of buffer zone, displacement of 3,000 people (which subsequently turned out to be much higher number), and increased incidence of malaria and bilharzia.

Some of the key conclusions and recommendations documented in the study are as follows:

- The physical effects of the project were not expected to be extensive but 24 km of riverine environment would be destroyed leading to changes in vegetation and wildlife populations.
- Further investigation was recommended to validate indications that the previous estimates of sedimentation yield from the upper catchment had been grossly underestimated.
- Soils on hills were to be left under protective cover. The project was not expected to result in loss of significant areas of good soils for cultivation.
- Development of afforestation program involving tree planting in areas vulnerable to erosion and enrichment where the vegetation biomass could be increased. Programs dealing with selective felling and replacement, and fuelwood production were also recommended.

- Clearing of the impoundment area to enhance safety for navigation and fishing activity.
- Development of commercial fisheries in the reservoir.
- Provision of improved water supplies and sanitation, and increased community awareness of negative health effects due to living in the vicinity of the reservoir.
- Provide an access to the reservoir waters for human and livestock consumption and permit use of land for grazing and bee-keeping.
- A detailed program to investigate the valuable archaeological sites in the project area before reservoir inundation.

The study recommended monitoring of the following items:

- An on-going monitoring in the project area with respect to resettlement and employment of displaced people, community health, land use, erosion and sedimentation, vegetation changes, wildlife, and the aquatic environment.
- Monitoring of nutrition, water-borne diseases and mortality of the people in the resettlement area.
- Aquatic environment to include physiochemical and biological analysis.
- Terrestrial ecology for changes in species composition and abundance in the downstream areas.
- Wildlife counts in the area acquired for resettlement.

5.7 PRESENT ENVIRONMENTAL CONDITIONS AND MITIGATION MEASURES ADOPTED AT THE EXISTING DAMS

The following dam sites were visited to ascertain the present conditions:

- Kindaruma
- Gitaru
- Kiambere
- Masinga

Kindaruma and Gitaru hydroelectric power plants are operated by KPLC while Kiambere and Masinga Hydroelectric power plants are operated by TARDA. The third power plant, Kamburu, operated by KPLC, was not visited because the environmental conditions expected at this dam site ate believed to be similar to those at the Kindaruma and Gitaru dams.

The field visits were primarily conducted to observe the environmental settings at the existing dams. In addition to driving and walking around the reservoirs, informal discussions were held with local residents, field staff of KPLC or TARDA, and person(s) in charge such as a resident engineer or afforestation officer, etc. No information was forth coming from TARDA officials in Nairobi. The discussions were aimed at firstly confirming some of the items reported in the preconstruction EIA studies and secondly to learn more about post-construction mitigation measures and ongoing monitoring programs (if any) adopted for the dam sites.

The field observations and discussions were focused on the following environmental issues.

- Extent of buffer zone around the reservoir
- Population distribution around the reservoir and its immediate surroundings
- Local activities (i.e. agriculture, fishing, bee-keeping, etc.)
- Access to reservoir water or availability of piped water for the local people
- Availability of electricity for the local people
- Prevalence of water-borne diseases among the local people
- Afforestation scheme for the reservoir surrounding areas including the borrow pits used during the construction period and the upper catchment areas
- Promotion of tourism at the reservoir site

Below is a summary of the observations at each of the four dam sites

Kindaruma

- KPLC has created an adequate buffer zone of approximately 150 m from the reservoir mean water level. The local inhabitants are restricted from building any structures or cultivating crops within this buffer zone. However, the locals and their cattle are allowed an access to the reservoir water. Grazing of their cattle is also permitted. Fishing from the reservoir is also permitted. These measures (which may not be part of an official policy) have not proved to be a problem. This is because, as the local foreman indicated, there are relatively few people living in the area and their activities do not interfere with the operation of the dam. The area was sparsely populated even before the construction of the dam.
- The foreman indicated that the local residents were given a small compensation for evacuating their homesteads during the construction period. There was no systematically planned resettlement program.
- A small water intake exists at the shore of the reservoir. This supplies water to the KPLC staff camp, located some distance away from the reservoir. There was no indication of any water supply scheme for the few remaining local residents.

- There are both crocodiles and hippos in the reservoir area. The local foreman indicated that the hippos eat trees planted along the shore as part of the afforestation program to restore vegetation along the reservoir.
- There is no agricultural activity adjacent to the reservoir (unlike at Masinga dam). This is most likely due to lack of any irrigation scheme and the low population density in the area.
- A tour of the plant area indicated that the plant staff have successfully planted and nurtured trees around the office building. This program seems to have been undertaken to improve the aesthetics around the office building area. Elsewhere, the afforestation program has not been successful except at a location near the top of the reservoir. In spite of the afforestation programme, according to the local official, the siltation of the reservoir remains to be a serious problem. The great majority of this siltation is caused by erosion (associated with poor land use) in the upper catchment area and has very little to do with erosion in the vicinity of the reservoir.
- There has been no attempt to use the reservoir for any recreational activities, though the setting could possibly be used to promote tourism. However, with the stiff competition offered by the large number of established tourist facilities with significantly greater attractions elsewhere in Kenya, the likelihood of attracting tourism to this area is considered remote.

Gitaru

- Similar to Kindaruma dam, this area was also sparsely populated during the construction period, and as a result only a few households had to be compensated. The area still remains at relatively low population densities. Thus, the situation does not create incentives for KPLC to develop the area.
- Locals are allowed an access to the reservoir for domestic water supply, grazing and fishing. They are not permitted to construct any structures or cultivate in the buffer zone area.
- There is no irrigation scheme in the area, thus no irrigated agricultural activities exist.
- An afforestation program is in place but not pursued to the same extent as a similar programme at Masinga. Afforestation may not be successful because the trees planted are not indigenous to the area. They possibly require more water than the local rains can support. It was surprising (to the consultant) that there does not appear to be a co-ordinated afforestation scheme for the various reservoirs. Considering that Masinga has a major effort underway on afforestation, other dams can learn and adopt the more successful elements of this programme.
- Evidence of lot of post-construction debris (e.g. concrete slabs, pipes, broken down construction equipment, oil barrels) was observed in the

field. Contractors apparently abandoned the construction camps without bothering to clear up the construction camp area.

- Borrow areas were not filled up and trees/plants have not been planted to restore those sites. The resident engineer indicated that a child had drowned in an abandoned quarry (used during the construction period) which is filled with water during rainy periods.

Kiambere

- TARDA officials indicated that the resettlement program involved relocation of some 20,000 people. This figure seems much higher than the number reported in the EIA for this site. The people were compensated and were left to find land on their own. However, most people squandered the money instead of buying alternative land. The official indicated that monetary compensation was not a good idea. Instead, the people should have been helped to find alternative land.
- A livestock development program is in progress at the site. TARDA is active in running a goat ranch, though one official mentioned that it had not been very successful mainly due to the breed of goats introduced. There was a plan to introduce a new breed of goats.
- An irrigation scheme design is underway but no further details were available. There is a plan to grow fruit under irrigation.
- Construction is ongoing for a water supply scheme to serve parts of Mwingi District adjacent to the Dam. This project scheduled for completion by early 1997.
- Plans are also underway for a similar water supply project to serve parts of Embu District adjacent to the dam.
- TARDA's advertisement brochure indicated that a tree nursery is in existence to help with the afforestation of the upper catchment area.
- The Consultant visited TARDA's crocodile farm. The crocodiles are kept in buildings which at one time were part of the construction camp. There is a population of about one thousand, crowded in groups of 15 to 20, inside a metal rectangular tank with only a limited water supply. The crocodiles at present are about 4 to 5 years in age. The farm provides employment to local people and also gives them a sense of participating in the project. The primary motivation though seems to be commercial. TARDA plans to sell crocodiles after they have matured for their meat and skin which can fetch a high price in Nairobi. It was not clear how the locals would share in this seemingly profitable scheme.
- Next to the crocodile farm, the consultant saw a bee farm.
- The locals suffer from malaria (which is seasonal). There is a clinic in the area run by the Ministry of Health. A drive past the clinic did not show an indication of any activity.

- Fishing in the reservoir has not been successful. No explanation was offered for this. One reason could be that TARDA, unlike KPLC, has not encouraged fishing for fear of interference with the operation of the dam. This is somewhat disappointing because with some effort on part of the authority, locals could gain an alternative source of nutritional food supply. This activity would require monitoring by the authorities.
- A squatter camp (Ngiri Market) exists near the dam site, which is a remnant of a market from the construction era. The problem is further compounded by the fact that the squatter camp is now a gazetted market centre, thereby making its eviction legally difficult.

Masinga

- This reservoir was found to be in a different setting than the other reservoirs visited by the consultant. The scenery is spectacularly beautiful. There is a tourist lodge (Masinga Tourist Lodge) which provides a view of the reservoir. A picnic site with a lot of trees also exists near the lodge. A boat was seen at the beach probably available for rent. The lodge is owned by TARDA and leased to a private company, but is kept poorly. The swimming pool appeared to be like a cesspool. The menu in the restaurant was very limited, the service was poor and the food unsavoury. Whilst the site provides an excellent setting to promote tourism, no one has bothered to provide quality facilities.
- The local official noted that the rains in the area seem to have improved, possibly due to the presence of a large lake. Large size maize farms were seen off the main tarmac road, but the maize crop appeared to have failed. However, a TARDA official indicated that the crop had already been harvested.
- Private farmers cultivate very close to the shoreline of the reservoir. Farmers use portable pumps for irritating their plots. Apparently, the buffer zone mandated by TARDA is either not enforced or is just a very narrow strip (about 10 m).
- TARDA has built a school. Previously there was no school in the reservoir area,
- A clinic that existed during the construction period no longer exists, having been turned into a police station.
- Along the higher slope of the reservoir area, TARDA has been successfully running an irrigation scheme since March 1988. About 80 ha is under irrigation and grows vegetables (onions, green peppers, eggplants, tomatoes etc.). A TARDA horticultural expert explained that this was a pilot scheme and there is plan to irrigate an additional 200 ha. The future emphasis would be on horticultural crops for export. One limiting feature of the irrigation scheme is that sometimes when the water level in the reservoir recedes, the water intake pipe is exposed and the water drawing

operations have to be discontinued. No indication of a water storage facility which would alleviate water supply problems was evident

- Small-scale farming is practised by locals along the shore, in some areas fairly close to the shoreline itself. They draw water by portable pumps, feeding via short pipelines. They seem to have received little benefit from the larger-scale farming practised by TARDA. It was again not clear as to who would benefit from this scheme. The scheme appears to be commercially driven, rather than intended to set up an institution which, through demonstration of a pilot scheme encourages private farmers to do the same.
- Echo sounding is performed to monitor the water depths to assess the sedimentation problem.
- Stone slabs from the foundations of the construction camp still exist.
- There is a tree nursery near the reservoir which is active in planting trees around the reservoir area, especially those areas affected seriously during the construction period. The attendant at the nursery indicated that some trees have been planted at distances as far as 17 km upstream of the reservoir. This is to alleviate the problem of sedimentation of the reservoir caused by erosion upstream.
- Fishing is discouraged unlike at the three dams operated by KPLC.
- There is an ongoing construction of a water project to serve parts of Masinga constituency adjacent to the dam as well as parts of Kitui District.

Conclusions

- As institutions, TARDA and KPLC appear to have done very little in their respective regions to improve the environment or living conditions of the people who remain in the reservoir areas.
- Local people up to now have not benefited from a large water storage available in proximity to their homes. However, two water supply schemes are now underway and one is being planned.
- Locals are not provided with electricity.
- Except at Kiambere and Masinga, no schools or clinics for the use of local people exist in the other three dam areas. Such facilities are, however, provided for the staff and their families.
- Fishing activities have not been encouraged. Fishing is discouraged at Masinga and Kiambere reservoirs. However, fisheries statistics do exist from these dams and some fishing does take place.
- The surrounding areas are sparsely populated, arid, and due to poor soil conditions support very little agricultural activity.
- The few activities such as crocodile farming, irrigated vegetable farming, goat breeding, etc. appear to be more commercially motivated rather than using such projects to set up pilot demonstration schemes to promote and develop such trades at other dam sites.

- Opportunities to develop reservoir sites for tourism or recreational activities have not been exploited.
- Post-construction debris have not been removed from many of the dam sites.
- Other than an afforestation scheme at Masinga the consultant did not see any evidence of environmental monitoring or rehabilitation at any of the dam sites.

5.8 POST CONSTRUCTION ASSESSMENT AND MITIGATION MEASURES

A study related to post construction assessment entitled, "The Kamburu/Gitaru Ecological Study" (Odingo 1979), was performed to assist the Government of Kenya and other developing countries in becoming aware of the ecological, social, and economic consequences of poorly planned water projects. This study found that it was not possible to establish a baseline study of the area, because by the time the study began, the construction of the Kamburu Dam was already far advanced.

Another study entitled, "African Dams" (Roggeri 1985) documented a post construction assessment of the three dams - Kindaruma, Kamburu and Masinga. This study focused on the dams' impact on the immediate surroundings and local populations. The study involved observations of the reservoirs and their surroundings, surveys among the local communities, information gathering on number of pathological cases treated in the hospitals and dispensaries in the study area, and chemical and bacteriological analysis of water samples taken from the reservoirs.

The above two studies contain useful information pertaining to the various shortcomings in the previously conducted environmental assessments and associated follow-ups for the Tana River reservoirs. The studies also draw several useful conclusions and recommendations for implementation of future water resource development projects.

The post-construction environmental assessments for the Tana River dams are discussed below under the following topics. The conclusions are believed to apply to all the five existing reservoirs on the Tana River.

5.8.1 Impact On Displaced Populations: Reservoirs Elsewhere in Africa

One of the inevitable consequences of flooding an area is that those who previously lived there have to be resettled. The relocation of people from the inundation zone is often one of the most costly and complex aspects of man-made lakes (Linney and Harrison 1981). In some cases, such resettlement has involved the movement of vast numbers of people. Ghana's Volta Dam, for example, saw the evacuation of some 78,000 people from over 700 towns and villages; Lake Kainji in Nigeria displaced 42,000; the Aswan High Dam, 120,000; and the Kariba Dam, 50,000 (Goldsmith and Hildyard 1984).

While such relocation inevitably result in disruptions, this opportunity could also be used to improve housing and social amenities for the resettled population, as well as for job creation in the resettlement area (Roggeri 1985).

Careful and intricate planning is however necessary in order to cater for the needs of the newly displaced persons. Moreover, resettlement is a long-term operation requiring significant financial and human resources. Previous studies on resettlements have shown that the three vital factors to be considered (cost, duration and human resources), have been grossly underestimated during the planning stages (Linney and Harrison 1981).

Several scientific studies have been carried out on problems related to resettlement and have shown that physiological, psychological and socio-cultural difficulties arose among persons who had been relocated against their will. (Scudder and Colson 1982).

In Africa, the creation of dams for hydropower has often had an adverse effect on the economic basis through which communities sustain sound family life. The effect has been to remove people from their familiar and predictable environments in which the clan and family relationship carries out important social and economic obligations. These lost benefits have not successfully been replaced in the resettlement areas (Mburugu 1994).

Resettlement operations in the past have suffered from deficiencies of policy, organisation, implementation and resources (Cernea 1994). Cernia states that:

- Resettlement planning focuses on removing people from the site of the project, and only marginally address re-establishment.
- Estimates of the population to be displaced tend to be undercounted.
- Resettlement components tend to be prepared hurriedly and superficially.
- Resettlement components are underfinanced.
- Assistance to resettled families / persons is typically confined only to short-term relief.
- The productive capacities and incomes of those displaced are not restored within a reasonable transition period. The result is lasting impoverishment.
- Resettled families / persons and hosts are not invited to join in planning, negotiation and execution.

A review of past several case studies (Cook and Mukendi 1994) to assess the consequences of resettlement in World Bank financed projects resulted in the following findings:

- It was not possible to evaluate the impacts of resettlement, either on the affected population or on the physical environment, based on quantitative field data and quantitative analytic techniques. In many of the cases studied, resettlement was not identified as an issue until well into project implementation. Pre-project baseline data could not be accurately reconstructed. In other cases where adequate baseline studies were conducted during project preparation, either no provision was made for monitoring and evaluation of impacts on the project, affected population and much less on the physical environment, or in a few cases, funds intended for monitoring and evaluation were diverted to other project purposes during implementation.

- The most successful projects in terms of establishing a solid data base were those that utilised local consultants or co-operating agencies, rather than the implementing agency itself, to carry out monitoring and evaluation.
- Project-affected populations were systematically underestimated.
- The project implementation was most successful where governments entered into dialogue with the affected population at an early stage in the project design.

Past studies on involuntary resettlements have revealed:

- that they bring out a departure from known and tested ecological norms for natural resource use;
- it alters long established social norms by placing the displaced people in new and alien social environments;
- it uproots people from stable economic traditions with vistas of unfamiliar markets and commodities.
- It places the resettled people on a long path of evolving and adapting to conditions in the new environment, full impact of which only gradually unfolds over a very long period (Magadza, 1994; Tamakloe, 1994).

In the past, planning for resettlement was rarely initiated at an early enough stage, sometimes not until dam construction has begun (e.g. the Volta Dam in Ghana and the Aswan Dam in Egypt). When planning is started late, the opportunity for an orderly resettlement is lost (Linney and Harrison 1981).

Another problem results from the government underestimating the complexities of resettlement. Not enough money or personnel is allocated to resettlement, causing the program to fall behind schedule. At the Kariba Dam, the government assigned resettlement to the Federal Power Board, which was only interested in the economic generation of electricity. The board did not view the lake basin as a priority, but rather as an expensive nuisance (Linney and Harrison 1981).

The damming of the Volta lake which was created in 1964 by Akosombo Dam in Ghana resulted in several serious problems. The resettlement of some 80,000 people in the area inundated by the lake turned out to be a disaster. Originally, the people were to be resettled on a self-help basis 3-4 years before the flooding. In reality, only 2 years were available because of financing problems. The physical movement of the people was carried out successfully in 1964; 67,000 people elected to move into the official settlement, the rest elected to receive cash compensation. By 1968 (i.e., 4 years later), only 25,000 of the original settlers had remained in the planned settlements. The failure of the agriculture program was the major cause of the 42,000 original settlers (Linney and Harrison 1981).

Tamakloe (1994) reported that the Volta River Project policy on compensation became obsolete for the following reasons:

- It was discovered that the cash compensation envisioned was not adequate to enable the affected people to build replacement houses.
- Most of the property had not been valued and the time for valuing the remaining property was not sufficient to allow the people to make their own arrangements before flooding.
- The affected people expected the Government to resettle them in better conditions than they had before.
- It was found that suitable land for farming was limited. Thus, the traditional system of shifting cultivation had to be changed to a more intensive technique to sustain the increased population.

Tamakloe (1994) noted several long-term problems associated with the Akosombo Dam which are highlighted below:

- Programs designed to improve the living conditions of the resettled population were not always culturally sensitive. The people were overcrowded in standardised housing which led to socio-cultural problems and increased stress.
- A few years after resettlement, rainfall began to decline resulting in ecological changes on flora and fauna. The formation of the lake was attributed as one of the reasons for the ecological changes. The environmental changes led to the loss of soil cover, soil erosion, and destruction of agricultural land, drastically affecting crop yields.
- The construction of the dam resulted in flow changes in the Volta river below the dam. Aquatic weeds and snails proliferated as a result of the slow flow of the river which caused an increase in the incidence of schistosomiasis and malaria.
- The farming program failed because of inadequate planning in terms of providing the people resources for labour, equipment, and financing. The policy of mechanised clearing of farmlands near the settlements led to the destruction of the topsoil.
- The failure of agricultural production due to climatic changes and poor organisation started a process of migration.

Tamakloe (1994) concludes that in the case of the Akosombo Dam resettlement, planners overemphasised the national interest of the Volta River Project, as against the local interest of the resettled families / persons.

Based on the Akosombo Dam experience, Tamakloe (1994) recommended that:

- The feasibility study be broadened to address both immediate and long-term effects.
- A high-level co-ordinating body of representatives from the government, sector agencies, researchers and scientists, local people, and the dam authority is essential.
- It is necessary for all development agencies to have a proper perspective on the possible impacts of the project.

The above recommendations are very important in this issue of involuntary resettlement. Grove (1989), Manga (1994) and Magadza (1994) have revealed problems associated with involuntary resettlement are as result of poor feasibility studies carried out in planning for resettlements.

The flooding of the Kariba Gorge in the Zambezi River basin in 1958 caused the displacement of more than 50,000 Tongo Tribes people. The people violently protested, and struggled to keep their homelands. In the end they were forced to abandon their alluvial valley for generally less fertile areas. These areas were already occupied by other tribes, resulting in conflicts and resentments because of tribal differences. It took two years to clear enough land for farming after the resettlement. During that time free grain, food concentrates and powdered milk had to be provided (Linney and Harrison 1981).

According to Magadza (1994) there was little pre-project feasibility studies related to the life and culture of the Tonga people in case of the Kariba Dam project. Not only did the Kariba Dam project interfere with the cultural norms of the Tonga people, but the study revealed some other impacts. These are:

- The Tonga people were suddenly thrust into a commercial environment, although they had previously been treated as a non-commercially minded people. Due to crop failures and other exigencies, they had to buy food and other basic commodities in an environment that had little income generating capacity.
- Due to the long neglect of the general area by colonial administrators, health and education were little developed. This led to an increase in endemic diseases among the Tonga who had limited access to medical care.
- After the inundation of the Gembwe Valley, the Tonga people were translocated to semiarid lands with a high risk of crop failure. The Tonga, formerly using seasonal rains and flood pattern of the Zambezi River to raise crops throughout the year, then became a food deficit people.

The Cabora Bassa Dam was completed in 1974. This was the creation of a second major impoundment on the Zambezi (the first being the Kariba Dam, which was closed in 1958). The idea of constructing a dam at Cabora Bassa had been suggested possibly as much as a hundred years earlier, although it was not until 1956 that the first direct measures were taken to implement the idea. Despite the size of the project and extent of the preparation for the dam itself, few people outside Portugal (which at that time, controlled Mozambique) had heard about the project. During the planning stages, the project was intended to be of multi-purpose benefits. However, it was constructed primarily as a hydro-electric scheme which at present brings little benefit to the people of Mozambique (Bolton 1984).

It was estimated that approximately 25,000 people were displaced by the reservoir. The relocation was undertaken by the armed forces involving a high degree of coercion. Furthermore, the new lands were often inadequately prepared and the choice of village locations was frequently unsuitable. It was therefore not surprising that, after Independence, most of the villages were abandoned and those who could returned to their original homes (Linney and Harrison 1981).

The Kainji Lake experience in Nigeria is an example of a successful resettlement (Ayeni et al. 1994). About 44,000 people displaced by formation of the lake were resettled near its shore. Some of the reasons for a successful resettlement were:

- Only minimum pressure was used to ensure people would leave their homes. Having agreed to leave, no further demands were made to interfere with their social, economic, and cultural traditions. Some central services, water supply, market structures, and mosques were built in many villages.
- Tourism developed an unforeseen beneficial impact.
- Agriculture was and still remains the major occupation of the inhabitants of the Kainji Lake area.

However, it should be noted that the nomad Fulani pastoralists suffered the greatest loss of resources. The grazing land was frequently burned too early in the dry season and in any case, the grazing reserves proved inadequate with succession of dry years and overstocking. It has also been revealed that in the original concept the Kainji Dam with its diverse objectives was perhaps over ambitious, involving a measure of political prestige rather than detailed planning. Furthermore, at the time Kainji Dam was planned, little attention was paid to environmental impacts (Ayeni et al, 1994).

Tshabalala (1994) with respect to the Lesotho Highlands Water Project, states that, in addition to direct compensation for lost income and assets (which was short-term), the resettlement plan also allowed for detailed design and implementation of rural development The rural development program included increasing production crops and fodder, horticulture, range and livestock management, community forestry, and fisheries. Infrastructure development included rural electrification, rural roads, cross-reservoir transport, water supply and sanitation, and settlement planning.

It is, therefore, seldom realised that displacements, such as those caused by the Akosombo or Kariba Dams have affected a much higher proportion of the respective country's population than the displacements caused by even larger dams in Asia. Thus they have strained the site's resources and affected those African nations in a much profound way, notwithstanding the benefits eventually yielded by those projects (Cernea 1990).

5.8.2 Impact On Displaced Populations: River Tana Reservoirs

The fundamental objective of the Government of Kenya's policy in human settlement is to enhance the quality of life for all the people by ensuring their social, maternal and spiritual well being (Republic of Kenya 1976). Construction of large dams in previously sparsely populated areas has caused rapid unforeseen accumulation of population; many associated problems have arisen. Kenya's experiences of involuntary resettlement are not different from those of Africa in general. Some of the relevant findings are summarised below:

5.8.2.1 Kamburu & Gitaru

Muga (1979) in his study about the social characteristics of the residents of the Kamburu and Gitaru dam areas found many social and health problems. He asserts that before the dam was built, Kamburu had a population of less than 100 families, which quadrupled after the completion of the dam. The influx of people to Kamburu area led to overcrowding and associated social problems. In Gitaru area the problem of housing of large number of labourers became problematic.

Odingo (1979) carrying out an ecological survey of the Kamburu and Gitaru dam areas found that people who had been displaced and compensated eventually returned and squatted in the buffer zone which was intended to protect the reservoirs.

The resident of Kamburu dam area complained of reduction in land available as a result of increasing population; soil erosion due to semi-arid conditions and over-stocking; and disturbance of wildlife. As a result of the human settlement, the larger species of wildlife faced threat of elimination; and birds and aquatic life increased due to new favourable environmental conditions.

5.8.2.2 Masinga

The pre-construction EIA study had estimated that at full supply level, an area of 12,100 ha. will be inundated. This was estimated to displace about 1,000 families, comprising about 5,800 people living within the area to be flooded.

The EIA study had recommended that the affected people be transferred to land outside the study area having the productive capacity to meet requirements without suffering deterioration.

With the beginning of the construction of the Masinga Dam, the government moved families which were cultivating land on the left bank of the Tana River in Embu district (which was the Government trust land) to new land, and particularly in the Mwea Irrigation Scheme in the northern part of Embu district. The transfer involved all families, whether their land was to be covered by the lake or not. An evaluation was made of the crops in the field and the improvements made to the abandoned land and families were given compensation. Since the land itself belonged to the State, there was no compensation for its value. No records were available regarding how much land the displaced people lost and how much land they were given in exchange.

On the other side of the river, in Machakos district (which was the freehold land), the families were given compensation for their land, at a rate of US$100 (1980) per acre, which was the average price for an acre of land used for subsistence farming at that time. The displaced people also received compensation for any improvements they had made as well as for crops in the fields at the time of their departure.

However, the search for and purchase of new land as well as for new housing was entirely the responsibility of the displaced families. According to the Masinga village chief, the move did not cause insurmountable problems, because of the region's sparse population (Roggeri 1985).

5.8.2.3 Kiambere

This project was processed by the World Bank without any query being raised about the project's compliance with the Bank's resettlement policy, which had been issued some years earlier (Cook and Mukendi 1994).

At Kiambere, an estimated 737 households with a population of 6,500 people were displaced. Consistent with the policy in Kenya, the displaced people were given cash compensation to enable them to buy land and resettle in the surrounding area, or in any other place of their choice (Mburugu 1994).

The results of a resettlement survey taken after the dam construction showed that the resettled people suffered great hardship in the process of settling down. Compared to the non-settlers in the new areas, the resettled families / persons fared rather badly on all counts. The money the resettled families / persons were paid for loss of their land in the project area could not buy equivalent land elsewhere. Only a small minority (less than 20%) spent their money to buy land. Some important facilities for a well-functioning community such as schools, shops, roads, and markets, were not easily accessible to the resettled families / persons. (Mburugu 1994).

Mburugu (1994) concludes with respect to the Kiambere experience that planning and implementation of future resettlement projects in Kenya should include (i) review of existing government laws relating to displacement and land compensation; (ii) ensuring the availability of land to resettle displaced persons; (iii) involving resettled families / persons in making decisions on resettlement issues; and (iv) devising ways of handling the host population.

Mburugu (1994) notes further that in the Kiambere case, only a minority of the displaced people used their compensation to buy land. Cash compensation in agriculturally-oriented countries such as Kenya results in impoverishing many families, especially when irresponsible heads of households fail to buy land to resettle their families. The dissatisfaction expressed by the resettled families / persons may have been partly due to the fact that they were not further assisted in deciding where to resettle..

Horta (1994) while evaluating World Bank's projects on Kenya's Tana River shared the same sentiments with Mburugu (1994) on the Kiambere Dam experience. According to Horta, a central problem of the Kiambere Dam was the fate of the people who once farmed the fertile valley were forced to leave when the dam reservoir had moved. Horta (1994) further noted that:

There was no resettlement plan, no timetables and no evaluation of the adequacy of compensation. The villagers went from poor to destitute. People lost their land, access to water and pasture for their cattle. Threatened by hunger, many found refuges in the surrounding villages, vastly increasing pressures on the land. Reduced fallow periods for arable land and overgrazing of pastures created environmental stress. As result, people in the communities that absorbed population also became poorer. The families displaced lost 82% of their money-equivalent income due to resettlement.

The dam's electrical transmission lines pass over nearby villages, but not a single volt helps the lives of the local people (Horta 1994).

5.8.3 Impact On Displaced Populations: Conclusions

1. Although the areas in which the dams were built were sparsely populated, the number of people displaced was significant. About 1,000 families were displaced with a population of 4,000 to 6,000 in the case of Masinga Dam, and for Kiambere Dam, the number of displaced households was 737 with a population of 6,500 people. In spite of this, the construction of the dams did not make provision for a systematic resettlement program.

2. Although the number of persons affected by the establishment of these lakes is very small compared to the number of displaced people for other large African dams, greater care should have been exercised during the preliminary study on the movement of the people.

3. The resettlement process should make it possible for the displaced community to fully participate in the resettlement decision and be able to control their situation in the new environment.

4. There is a general failure to recognise that resettlement disorganises the displaced population and breaks up long established networks, destroys productive assets, causes severe environmental effects and the loss of valuable resources, besides being subjected to increased stress and heightened morbidity and mortality rates. (Mburugu 1994).

5. Squatters who had been compensated have returned to the Kiambere buffer zone. Experience from the above lessons indicates that compensation for the displaced population should be based on land for land.

6. Cash compensation in agriculturally oriented communities results in impoverishing many families, especially when irresponsible household heads fail to buy land to resettle their families.

7. There is urgent need for short, medium and long term monitoring and evaluation of resettlement with a view to making adjustments where necessary.

5.8.4 Impact on Agriculture & Local Food Supply: Elsewhere in Africa

Reservoir impoundment submerges vast areas of land. 400,000 hectares disappeared beneath the waters of Lake Nasser, for example, whilst 848,200 hectares were lost to the Volta River project; and 510,000 hectares were flooded by the Kariba Dam.

5.8.4.1 Impact on Agricultural Land

In many cases, the flooded area contained thousands of acres of good agricultural land. Figures for the total, worldwide loss of farmland to dam projects are not available. Nonetheless, the very number of people who have had to be resettled as a result of the productivity of the lands they previously occupied and which now have been flooded. In India, for example, the Srisailam Hydroelectric Scheme near Hyderabad flooded some 107,000 acres of farmland - land that, until the dam was closed, had provided a livelihood for some 100,000 people. The 'Fact Finding Committee on Srisailam Project Evaluations' notes: "The agricultural economy of the region was considered to be highly prosperous. The lands, both dry and wet, situated along the Tungabhadra and Krishna Rivers were highly fertile and the cropping patterns adopted by the farmers were both remunerative and profitable. The level of food production in these areas was quite high as the soil and the climate were very favourable to agriculture. Thus, the submersion of 107,000 acres caused an enormous amount of loss and hardship to the local villagers" (Goldsmith and Hildyard, 3 Volumes, 1984).

The agricultural program for the resettled population displaced as a result of the creation of the Volta Lake in Ghana failed mainly because of a lack of good land. The siting of the settlement had taken into account and located the towns on their traditional lands, but there was already a high pressure on the land from other people. Only 6,000 ha. of new land was cleared, and half of this was required for the actual town sites (Linney and Harrison ,1981).

5.8.4.2 Impact on Fisheries

When a large reservoir is filled, there is likely to be a dramatic rise in the population of those fish species which are favoured by the new lacustrine conditions - although, those fish which are adapted to a riverine environment will tend to disappear. The release of large quantities of nutrients from rotting vegetation and soils which have been submerged by the reservoir - together with the increased populations of those micro-organisms favoured by the new conditions - will encourage the expansion of fish populations.

The expansion in fish numbers, however, is likely to prove a short - lived bonanza. In the case of Lake Volta, for instance, a very considerable fishing industry was indeed developed immediately after inundation. In fact, at one time, there were as many as 20,000 fishermen on the Lake, using some 20,000 canoes and catching up to 60,000 tonnes of fish a year. However, catches rapidly fell off, as the submerged vegetation below the lake rotted away and nutrients became less readily available (Goldsmith and Hildyard Vol. 1, 1984).

The experience of fishermen on Lake Kariba is similar. Thus, five years after the lake was formed, some 2,000 fishermen were landing some 3,700 tonnes of fish per annum. Ten years after closure of the dam no more than 900 tonnes of fish were caught and the number of fishermen fell off correspondingly. Efforts to restock the lake with new species proved a dismal failure: 26 tonnes of juveniles were introduced in the lake but very few survived. By 1978 fish catches had fallen so low that only a small part of the human population along the shores of the lake was engaged in fishing.

The trapping of silt by the Kariba Dam had caused the recession of the delta 80-100 km below the dam. Migratory fish in particular have been affected by blocking of their breeding grounds.

The patterns of fish yields at Lakes Kariba and Volta appear to be fairly typical of those at other man-made lakes.

Fisheries program planned for the reservoir created by the Cabora Bassa Dam in Mozambique also was not successful. At first, because of expected extra nutrients (compared to Lake Kariba), it was concluded that the Lake Cabora Bassa would be more productive in terms of fisheries. The low fish productivity was largely due to the required drawdown of the dam resulting in large fluctuations in the water level in the reservoir that prevented the establishment of stable fishing communities. This was also partly due to the remoteness of the reservoir that made it difficult to export high-value fish products (Bolton 1985).

Goldsmith and Hildyard (1984) noted that dams disrupt river ecosystem and, in particular, its fisheries in the following way:

- Dams tend to reduce the catch of migratory fish by preventing them from reaching their spawning grounds. In California, for example, catches of salmon have fallen by 90 percent because dams now make it almost impossible for the salmon to travel upstream in order to spawn.

- The creation of vast storage reservoirs tends to reduce the flow of rivers - largely because the stored waters are drawn off for domestic, agricultural or industrial use. The fall in water levels in the lakes has been partially blamed for the reduced catches in the rivers.

- The building of storage schemes have led to an increase in the salinity of many rivers. The high salt contents of the lower reaches of many rivers no longer provide suitable habitats for riverine fisheries.

- The dam traps silt that was previously washed downstream as the river flowed unimpeded to the sea. The trapped silt contains nutrients that are vital to the survival of fisheries in the lower reaches of a river and in the sea beyond.

- Invasion of reservoirs and their associated waterways by aquatic weeds has seriously reduced fish yields both upstream and downstream of dams. The weeds interfere with riverine ecosystem by increasing water losses to evapotranspiration and thus reducing the water level. Their sheer mass reduces the effective capacity of the reservoir, and by diminishing the sunlight in the waters below which reduces the biological productivity of a reservoir. In addition to their adverse effect on fish life, weeds also interfere with fishing activities.

- Aquatic weeds lead indirectly to the loss of fish life as a result of herbicides which are used to eliminate them - albeit temporarily.

- Finally, various pesticides applied to reservoirs to control the habitats for the vectors of water-borne disease also pollute the reservoir water, which leads to destruction of fisheries.

Even without considering the reduction in fish catches attributable to the various types of ecological disruption discussed above, it seems doubtful whether the fisheries provided by man-made lakes can compensate for the food resources lost to flooding Goldsmith and Hildyard 1984).

5.8.4.3 Irrigation

Since a dam makes it possible to irrigate land in which there is inadequate water, it can have an important effect on agriculture, hence it can lead to increased agricultural production, which in turn improves the food resources of the region.

But irrigation can also be a source of problems. Biswas (1987) in his report with reference to Lake Nasser (Egypt), states the following for one of the largest irrigation projects in the world:

- The slow rate of flow of water in the canals encouraged the spread of bilharzia throughout the irrigated areas.

- The infiltration of the water from these canals into the neighbouring soils resurfaced due to poor drainage causing them to be waterlogged. This renders the soils useless for any agricultural activity.

5.8.4.4 Impact on Soil Fertility

A dam can also lead to the impoverishment of soils situated downstream. With respect to Lake Nasser, before the construction of the Aswan dam, the Nile floods spread a total of 100 million tonnes of sediment over a surface of a million hectares. These indispensable nutrients are now infused into the soil in the form of fertilisers, at a cost of US $100 million per annum (Goldsmith and Hildyard 1984).

Before the Kariba Dam flooded the Guembe Valley of the Zambezi River, it had high potential in crops and animals. The protein of the wild animals could have yielded same amounts as the fish in the new lake.

Linney and Harrison (1981) with respect to the creation of the Kariba Dam, assert that the promises of large irrigation schemes, high fish production, and other benefits were never fulfilled.

The building of the High Aswan Dam changed Egyptian culture dramatically, since it put an end to the flood cycle, which not only flushed out the salts that would otherwise have accumulated in the irrigated soil, but also replenished both ground and surface waters (Lavergne 1985).

Egypt is an arid country and its agriculture is almost totally dependent on the use of Nile waters for irrigation. When traditional agriculture was practised, the land was submerged during the Nile's annual floods. As the level of the river fell, the waters would recede; but the land retained its moisture and this permitted the cultivation of winter crops which grew and matured without the use of fertiliser. So long as this system of irrigation was practised, the land maintained its fertility-which it did for thousands of years-but when it was replaced by perennial irrigation, conditions changed drastically.

The Aswan Dam resulted in the following adverse secondary effects:

- The steady deterioration in the fertility of Egypt's soils occurred. A few years after the completion of the dam, the signs of waterlogging and soil salinisation began to appear.
- The erosion of the bed of the Nile and degradation of its banks downstream from Aswan started to occur.
- The systematic retreat of the coastline in the Nile delta.
- The danger faced by the local population in various regions of being poisoned by the vast amounts of chemical fertilisers and insecticides that were used on the land. In the past, such dangerous substances would have been flushed out by the annual floodwaters of the Nile.
- The loss by evaoptranspiration of a large volume of water as a result of the proliferation of aquatic weeds in the irrigation canals and in the Nile itself.

5.8.5 Impact on Agriculture & Local Food Supply: River Tana Reservoirs

Neither the area downstream of the three dams nor those around the lakes are irrigated in Masinga, Kamburu and Kindaruma. Roggeri's (1985) investigation revealed that on the banks of Lake Masinga, around the Riakanau village, the planted maize dried up prematurely only 80 meters or so away from the water. This indicated that (during the time of the field trips), the water table was not high enough for the plants to reach.

The area of land surrounding the lakes did not indicate significant differences as compared to areas further afield, neither did they show any signs of developments since the construction of the dams. It would therefore seem that the groundwater most likely was constantly at levels well below they reach

Roggeri's (1985) field investigation showed that in a matter of only one year, the quantities of fish caught at Kamburu, decreased significantly (37%). Since there was no significant change in the fishing activities in Lake Kamburu or in the number of fishermen, this decrease in production seemed to indicate that the fish in the lake diminished in corresponding proportions.

The main reason, according to Roggeri, for this decrease was improper and uncontrolled fishing. The fishermen in the region, operating totally independently, used very fine nets and even poison to increase their catch, according to the Fisheries Department in Embu. This was also the reason why the authorities prohibited any fishing at lake Masinga where such practices almost depleted the fish stocks which were limited to start with because the project had just been launched. Subsequently, the authorities restocked the lake and a system of official registration of each boat operating on the lake and organising the fishermen into co-operatives was considered.

There was no fishing at Kindaruma (at the time of Roggeri's field investigation) where crocodiles, which even attacked nets loaded with fish, have discouraged the few fishermen in the area.

Although fish production had increased in the Kiambere reservoir since the construction of the dam, it was however limited due to the insufficiency of food for the fish. The rate of flow of the waters and the numerous variations in the levels of the lakes were not conducive to the increase of plankton (ADEC, 1984) which, together with insects and other organisms living at the bottom of the lakes, are basic food types of fish.

5.8.6 Impact on Agriculture & Local Food Supply: Conclusions

1. One would expect that the areas around a lake should be well provided with water so that crops can grow normally, irrespective of seasonal changes. Furthermore, when water is stored, it can sometimes make it possible to irrigate areas downstream of the dams, thus increasing the total surface area cultivated in a region and increasing its agricultural production. In case of the Tana River lakes, their development appeared to have insignificant impact on the increased availability of water for irrigation and hence the food supply.

2. Even though the conditions were unfavourable for the development of fish stock, no control and no serious management was considered when the lakes were established, so the local fishermen had free reign.

3. Later on, the authorities had the difficult problem of restocking Lake Masinga and were obliged to take such unpopular measures as prohibiting fishing activities altogether.

4. Fisheries development plans should be incorporated into the project from its inception.

5.8.7 Impact on Water Supply & Sanitation: Elsewhere in Africa

The lack of drinking water distribution facilities, adequate sanitation and information campaigns for local people (on simple water treatment methods, banning the use of lake water for animals, and hygiene), can lead to the deterioration of water quality and proliferation of various diseases (Goldsmith and Hildyard 1984).

The farming settlements and fishing communities around the Volta Lake, according to Linney and Harrison (1981), were not provided with adequate drinking water supply. The centre of each small community had only one water tap or hand pump. The women did not like queuing for water and would go back to the original source, the river or lake. This increased human contact with water causing an increase in the infection rate.

5.8.8 Impact on Water Supply & Sanitation: River Tana Reservoirs

The Kamburu and Kindaruma Dams are used for the production of hydro-electricity while Masinga's role is to maintain the quantity of water necessary for the regular supply to the electricity plants downstream as well as its own plant. On the sites of these three lakes, no drinking water supply network was constructed (Roggeri 1985).

The rural communities living around the lakes therefore use water drawn directly from the lakes for their drinking needs and all domestic activities.

The results of the analyses performed as part of the previous study (Roggeri 1985) indicated that the bacteriological characteristics of the waters of each lake were similar:

- The rate of turbidity was found to be high.
- The population of coliform bacteria were highly developed and presence of *E. coli* indicated the existence of faecal pollution
- The oxygenation rate indicated that the organic decomposition activity was low. This is because the vegetation covering the flooded area was to a large extent destroyed before the flooding.

- There was no indication of any traces of industrial pollution and the content of toxic elements was found to be at an acceptable level.

5.8.9 Impact on Water Supply & Sanitation: Conclusions

1. The establishment of the lakes did not appear to have helped to improve the water supply to the local communities.
2. Due to lack of analysis of water quality before the dams were built, it was not possible to determine whether their quality had deteriorated.
3. The chemical analysis results indicated that water chemical content in the Masinga reservoir had slightly increased but was remaining acceptable.
4. The waters in Lakes Masinga, Kamburu, Kindaruma were found to be unfit for human consumption.
5. The use of the water for domestic purpose was judged to be risky which was being increased by the lack of adequate sanitary installation.

5.8.10 Impact on Water Related Diseases: Elsewhere in Africa

The spread of water-borne and water-related diseases is one of the most spectacular consequences of large dam and irrigation projects in tropical countries. Predictably, measures to mitigate the spread of diseases associated with water development have not been pursued as vigorously as the development itself. One finds that the health hazards of water development projects continue to be either played down or (worse still) ignored (Goldsmith and Hildyard Vol.1).

The construction of the Aswan Dam (Lake Nasser, in Egypt), for instance, was followed by a significant increase in the number of persons attacked by bilharzia in the local community.

Around Lake Volta in Ghana, the increase in bilharzia cases was even more dramatic. There had been no budgetary provision for the control of spread of such diseases, and, subsequently, a program involving more than US$ 100 million was launched in order to eradicate bilharzia in the area. Despite the epidemic of schistosomiasis and river blindness which followed the building of the Volta Dam - plans were announced to build a further 120 relatively small dams in the area, in addition to rehabilitating 100 older dams which had silted up. This program was undertaken without any accompanying measures to prevent water-borne diseases - led to a predictable escalation in the rate of schistosomiasis infections, the incidence of the disease tripling in the area.

Ghana's experience is by no means unique. In water projects after water project, one finds that no efforts are made to control disease until too late, in fact, the dam and associated irrigation schemes have been built and all the problems created (Goldsmith and Hildyard Vol. 1, 1984).

Goldsmith and Hildyard observed that the authorities appear blind to the crucial part played by rivers in everyday lives of those who live on their banks. Children are constantly in the water; traders swim out to passing boats in order to sell their wares, and housewives rely on the river to wash the family's clothes.

Other parasitic diseases also frequently spread around man-made lakes and these include malaria, elephantiasis and river blindness. They spread by "hosts" or "vectors" within which the parasite has to spend part of its lifetime before it can be transmitted to man. In most cases, the hosts are snails (bilharzia), mosquitoes (malaria) or flies.

The construction of a dam can lead to the spread of parasitic disease in the surrounding areas because it creates conditions favourable for the development of one or several organisms. The change in the rate of flow of the waters can for example lead to:

- The establishment of egg-laying areas for mosquitoes in the stagnant surface waters of the lakes and pools of water which collect alongside the lakes when the level falls;

- The presence of snails (bilharzia carriers) in calm or slow-moving waters, encouraged by the growth of aquatic plants on which they live.

Another element of the spread of diseases around a man-made lake is linked to sanitation facilities: the lack of control of human excreta in the proximity of a lake can cause water pollution. When humans subsequently drink this water, it can cause diseases such as diarrhoea, dysentery, cholera or typhoid fever.

The effect of waterborne diseases spread by water projects is to lessen the increase in food production that the projects are hoped to realise. Bilharzia is debilitating, if seldom fatal disease, and human labour productivity in endemic areas is vastly reduced by bilharzia-induced lethargy. Reservoir fishery harvests often fail to meet expectations partly for the reason that disease prevalence prevents establishment of human populations on the shores.

Even in 1959, the World Health Organisation (WHO) had warned Egypt that Aswan Dam would bring a severe bilharzia problem. WHO had outlined sanitation measures that needed to be undertaken in the areas to be irrigated, to prevent the spread of the disease; Egypt did not act on these proposals.

Intense disease problems frequently accompany dam construction. Workers entering the area bring new parasites and become exposed to local ones. On-site water and sanitation facilities are frequently poor. Constant human contact with water insures maximal disease transmission.

Population relocation prior to reservoir infilling is frequently not planned adequately. Linney and Harrison (1981) note, " Populations relocated as the reservoir is filled are frequently not planned for, thus, they end up in refugee-camp circumstances, which are notorious for causing epidemics. Many of the 50,000 Tonga tribesmen dislocated by the Kariba Dam caught influenza as they queued up for relief supplies."

In Zambia, those who were resettled to make way for the Kariba Dam - mainly Tonga tribesmen - were located in an area infested by the tsetse fly (Goldsmith & Hildyard 1984).

The flooding of the breeding grounds of the *Simulium* blackfly, the vector of the river blindness on the Volta River, did not bring the expected decrease in the rate of infection. Some communities simply moved back from the lake to tributaries that contained more breeding grounds for the vector. Below the Volta Dam, the treatment of the river with insecticide was unsuccessful both in 1968 and 1969.

Initially, the infection rate of bilharzia increased around the Volta Lake. Aquatic weeds became abundant with nutrients released from the soil and provided a habitat for the vector snails. Also, fishing people, many of whom were already carrying the disease, migrated to the lakeshore. The infection rate reached 70% in some cases.

The waterborne diseases (schistosomiasis and malaria) were considered to be the principal health problems facing those planning the development of the lower Zambezi basin. While the relatively large drawdown helped reduce the risk of schistosomiasis transmission, it had a detrimental social impact (Bolton 1984).

Another problem brought about by the predominance of single men among migrant population has to do with giving rise to prostitution and the sexually transmitted diseases.

5.8.11 Impact on Water Related Diseases: River Tana Reservoirs

Roggeri (1985) the new reservoirs were the most probable cause of the increased incidence of diseases in the surrounding area. It was also confirmed that no steps were taken to minimise their effects on public health.

The interviews held with the local medical officers during the field visits and at the Embu district hospital by Roggeri (1985) indicated that the authorities concerned were aware of the spread of these diseases and its relation to the presence of the man-made lakes.

Odingo (1979) reported that bilharzia had not been a problem around the Kamburu Dam because of an absence of abundant aquatic vegetation in the reservoir. Large seasonal variations in the level of the reservoir were given as the reason for this. These fluctuations were expected to be eliminated by construction of the Masinga Dam. The study therefore recommended that the fluctuations be maintained artificially to discourage vegetation for the bilharzia-carrying snail. It was further recommended that the settlements around the new Masinga Dam be planned with adequate sanitary facilities to minimise the spread of water-borne diseases.

Another problem associated with dam construction on River Tana has been an increase in waterborne diseases in the area of associated irrigation schemes. A survey conducted in the Hola irrigation scheme revealed that 70 percent of the population suffered from bilharzia (Linney & Harrison 1981).

5.8.12 Impact on Water Related Diseases: Conclusions

1. Health aspects are seldom considered in advance in water development projects. Even where health agencies have come up with detailed anti-disease programs, as in Egypt, water development agencies have often failed finance them. The additional funds are not available from donor sources, and political pressures to go ahead with construction are too great to resist. Furthermore, previous examples indicate that the expenses incurred in providing health care to patients suffering from water-borne disease have not been considered as part of the final cost of a water resources management project.

2. Mitigation of health impacts is usually a matter of launching a sanitation program to accompany the project. Education and facilities for sanitary waste disposal can break a link in the life cycle of waterborne disease organisms. Health inspectors can check on the conditions at work camps. Clean water supplies can keep workers away from sources of infection.

3. A few simple modifications in the design may also be helpful. For example, sloping channels to keep water moving, and lining them with concrete, prevents them from becoming snail and mosquito habitat. This is easy matter if it is planned for in the initial design phase of the project.

5.8.13 Impact on Plant Cover & Sedimentation: Elsewhere in Africa

Sediments containing nutrients and transported by water which then deposit them in the plains downstream. The sedimentation helps the soil to renew itself and this is essential for agriculture. On the other hand, sediment accumulation in reservoir reduces the economic life of a dam and furthermore, impoverishes soils situated downstream, which would need to be remedied by costly use of fertilisers.

Quite apart from ecological devastation it causes in the area drowned by a dam's reservoir, impoundment also prevents a river's silt from being carried to the sea. The silt - which generally contains large quantities of feldspar, clay and organic matter - often has a high nutrient value. Before building of the Aswan Dam, the River Nile deposited 100 million tons of sediment a year on nearly one million hectares of land in the Nile Valley. Today, the Nile deposits only a few tons of sediment per year on the Delta - and much of that comes as a result of river bed scouring (Goldsmith and Hildyard 1984).

With its silt trapped behind the High Dam, the once muddy - brown waters of the Nile are now green. To compensate - and very partially at that - for the Nutrients which were previously provided free by the river's annual flood, but which are now prevented from flowing down the river, Egypt must apply artificial fertilisers on an ever increasing scale. The annual cost of fertilisers now required by Egypt is in the region of 100 million dollars a year.

A further problem caused by depriving the waters downstream of a dam of their silt content is the erosion of land which results in the Delta. Before the High Aswan Dam was built, the Nile deposited vast quantities of alluvia in the Delta at a rate which exceeded that of coastal erosion by the normal action of the sea. According to Mohmood Kassas (1987), "the Delta shoreline that had obviously been advancing throughout the history of the Delta is now retreating."

Sooner or later, the dam gets filled up with silt and other detritus that the dam prevents from flowing downstream. And when that happens, the dam must be decommissioned. Clearly, the rate at which a reservoir silts up depends on the amount of silt carried by the rivers that feed it - and that, in turn, depends on the rate of soil erosion in the river's catchment area. The premature sedimentation of reservoirs seriously affects their economics.

5.8.14 Impact on Plant Cover & Sedimentation: River Tana Reservoirs

The problem of sedimentation in the Tana River reservoirs, over and above rates of sedimentation that could be expected to occur naturally, is due to the following causes:

- Farmers upstream have cut away forests and cultivated to within a foot of the streams without terracing.
- After the independence of Kenya, the farmers cleared the banks of the river in order to increase the available land. Previously, cultivation of riverbanks was prohibited. These areas are still cultivated today.
- No reforestation or embankment policy was established in the areas through which the river and its tributaries run.

Clearing of land for cultivation and burning of charcoal, leaving poor and impermanent grass accompanied the increase in human settlement in a formerly uninhabited area (around Kamburu reservoir). The study (Odingo 1979) recommended implementation of afforestation or revegetation schemes to prevent soil erosion and increase wildlife. The study also recommended that the Kamburu and Gitaru areas be declared as protected areas to preserve vegetation and wildlife which were being threatened by human population and poaching.

All four dams were constructed without considering the watershed and its effect on the life and performance of the dam, causing serious economic consequences. In the past, long periods of electrical shortages were due to the heavy silt load on the hydroelectric turbine (Linney and Harrison 1981).

5.8.15 Impact on Plant Cover & Sedimentation: Conclusion

1. The severe sedimentation of the River Tana lakes has threatened the capacity of the dams to produce initially planned and anticipated levels of hydropower.

2. The development of the Tana River reservoirs did not use an integrated river basin development approach, which would include the protection of the catchment area.

3. There was no afforestation program or efforts to limit agricultural activities in the vicinity of the river in place to prevent erosion.

5.9 MONITORING ACTIVITIES FOLLOWING DAM CONSTRUCTION

According to information currently available, the impacts of the existing dams on the Tana River have not been monitored. As a result, there is no existing database on impacts for environmental auditing purposes.

Section 2

RESERVOIR POPULATIONS & RESETTLEMENT

Chapter 6

SETTLEMENTS & POPULATION: RESERVOIR AREA

6 SETTLEMENTS AND POPULATION: RESERVOIR AREA

6.2 INTRODUCTION

Village level population statistics and map data from the Central Bureau of Statistics were used, together with field surveys and extrapolation of 1989 national census information to produce estimates of the number of people and households that would be affected by the proposed reservoirs. GIS tools were used to determine population numbers and densities within the project area.

6.2 HOUSEHOLDS & POPULATION AFFECTED BY THE RESERVOIR

Population and household numbers were estimated for each village in the surveyed area through field survey and by extrapolation from the 1989 national census data (CBS). These data are presented in Table A6.1 in the Annex.

Part of the study area would be directly impacted through inundation of the proposed reservoirs. Parts of the remaining area would be indirectly impacted through resettlement of families/households forced to move out of the reservoir area.

The study area as a whole, defined by the affected sublocations, included an area of 1656 km^2 with a population of 59,799 at the time of the 1989 national census. Within the areas that would be directly affected by the combined reservoirs, an area of 106 km^2 supported a population density of 34.5 at the time of the 1989 census and a population estimated at 43.2 per km^2 at 1996 levels. It is estimated that, by the year 2005, this directly affected population will have increased to 57.7 persons per km^2, or a total of 6,125 people in both of the proposed reservoir areas, Mutonga and Grand Falls (LGF).

Areas that will be directly impacted by the proposed reservoirs include the area of inundation of each reservoir and the surrounding buffer zone. Areas of inundation were calculated on the basis of the reservoir full supply levels (FSL). The 550 metre contour was used to define the FSL for Mutonga. In the case of Grand Falls (LGF) the FSL of 512 metres was calculated from the available contours by creation of a digital terrain model. Buffer zones were estimated as 100 metres from the FSL. People would be excluded from both of these areas and the buffer zone can be described as an "Intensive Management Zone". In addition to the 100 metre intensive management zone, an area adjacent to and surrounding the proposed dam structures was added to enable the development of housing, offices and other structures required for the operation and management of the reservoirs. These areas, termed the "Operations Zone" were defined as being a 1 km buffer surrounding each dam to the eastern (Mutonga) or southern (Grand Falls) side of the Tana River. Although people would be living and operating within this area, it represents a special case since existing residents/farmers would be required to move.

Surrounding the proposed reservoirs and the 100 metre buffer zone, it is proposed to develop a Special Management Zone (SMZ), within which land use would be managed to support the management of the reservoir, but where settlement and farming would not be moved. It is within this zone that the major parts of resettlement activities are proposed. As a baseline, this SMZ was defined as a 3 km wide zone surrounding the 100 metre buffer zone. Village areas falling within or being part of this 3 km zone were considered as being within the SMZ.

Accordingly, population estimates are presented for the area of inundation and the 100 metre buffer zone, as well as for the Special management Zone (SMZ).

Figure 6-1 indicates the boundaries of the study area and administrative divisions, whilst Figure 6-2 shows the boundaries of administrative locations. Although a number of changes may have occurred subsequently, the 1989 national Census boundaries are used as a baseline. Figure 6-3 shows the village areas used during the study. This figure also indicates the boundaries of Forest Reserves. Since there are no permanent settlements within these forests and since many of them overlap with one or more village areas, these forest areas were cut from the village areas and the population densities reassigned to the remaining village areas using GIS techniques. Population densities are indicated by Figure 6-4.

Figure 6-1 Boundaries of the Study Area indicating the Proposed Reservoirs and Administrative Divisions (1989 Census)

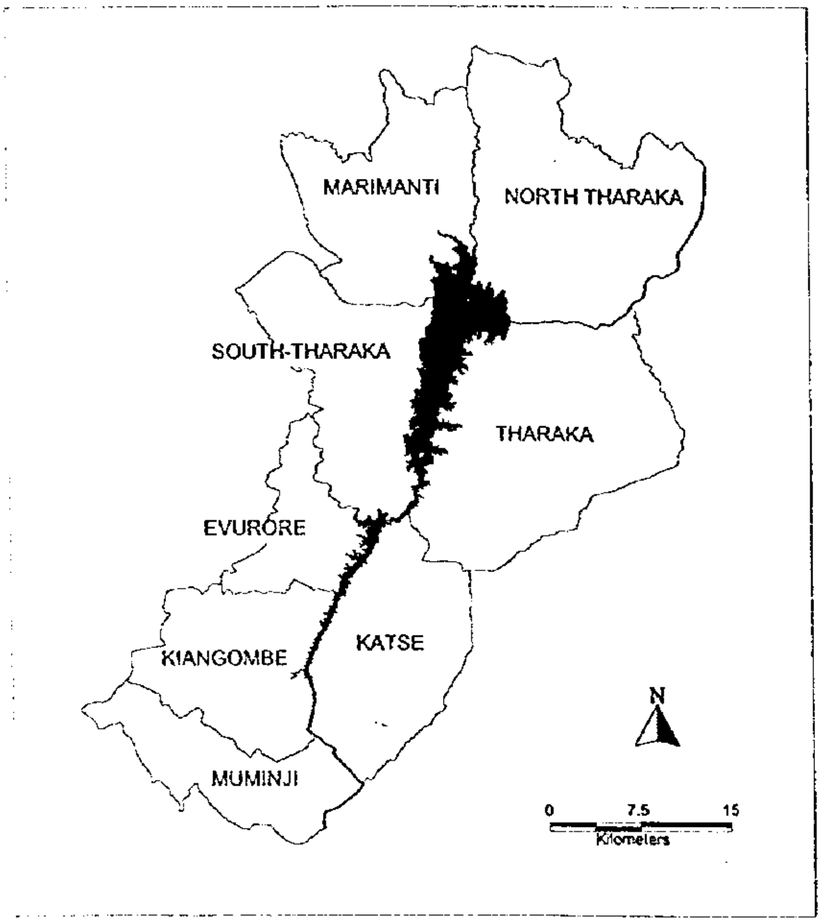
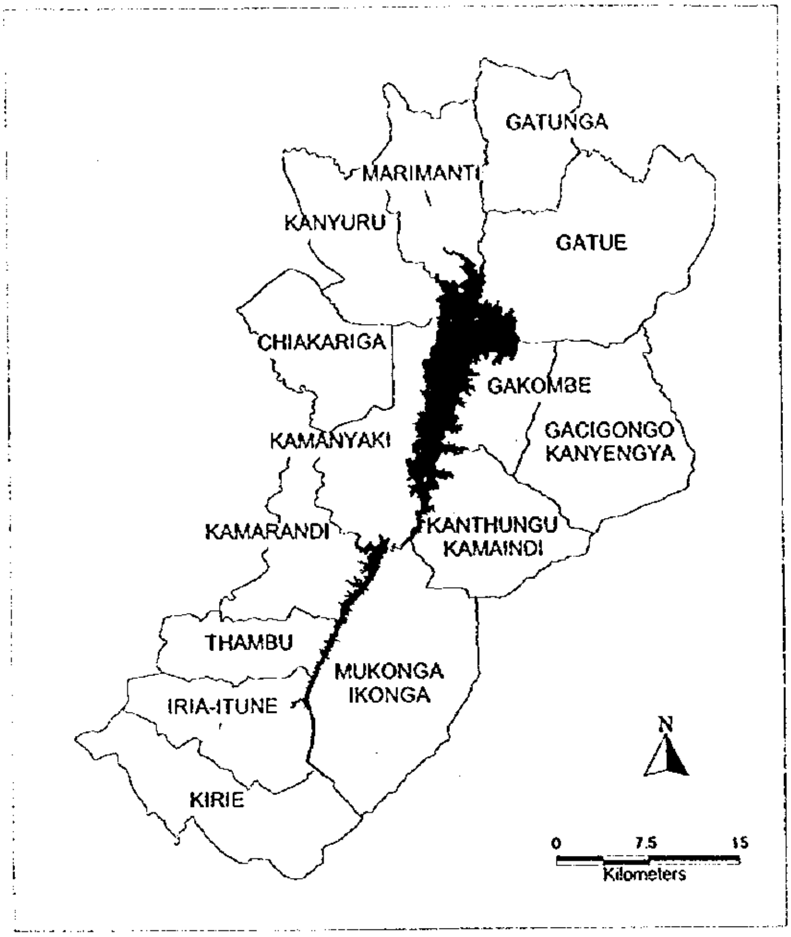


Figure 6-2 Boundaries of the Study Area indicating the Proposed Reservoirs and Administrative Sublocations (1989 Census)

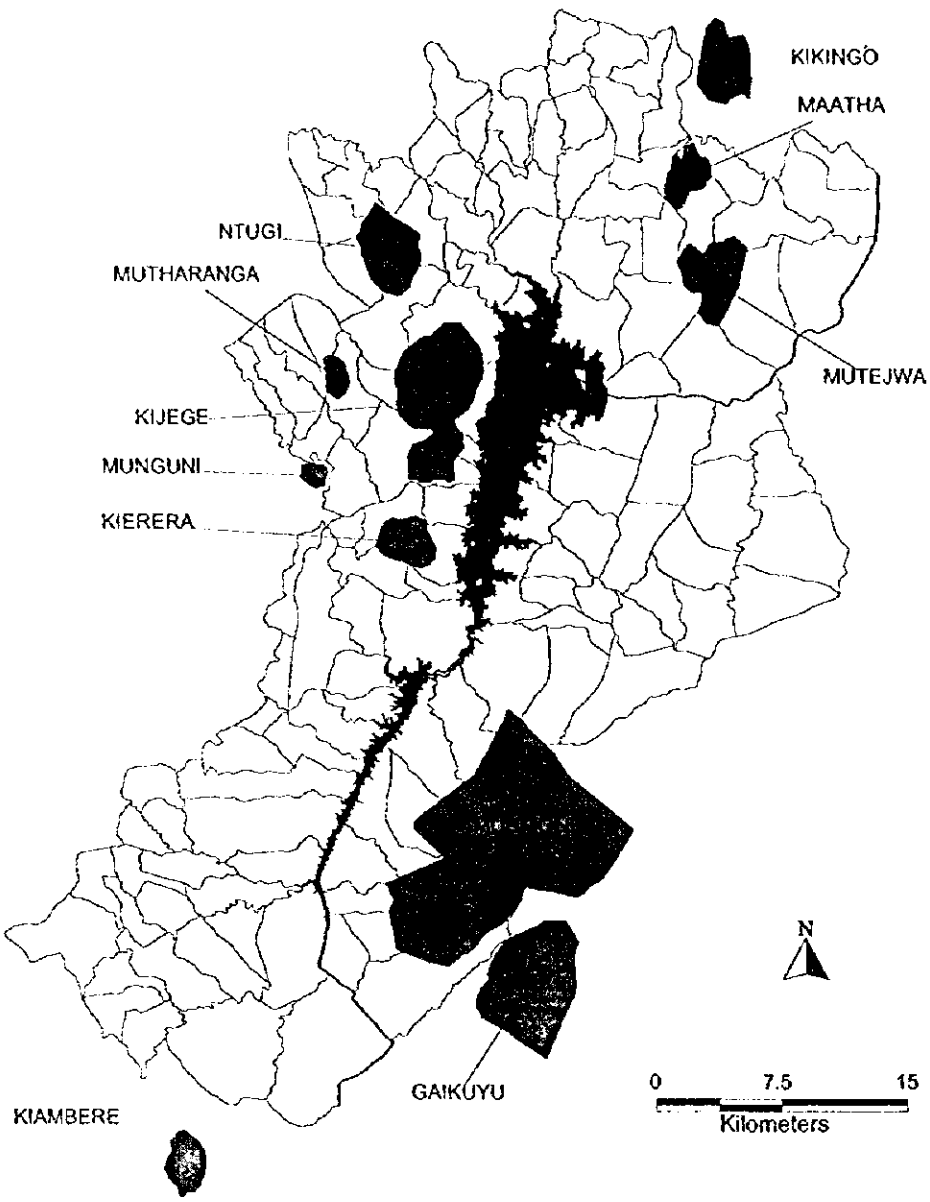


1989 Population numbers and projected figures for affected sublocations

1989 Sublocation	1989 Households	1989 Population.	2000 Projection
Kamarandi	762	4,264	6,090
Iria-Itune	590	3,118	4,460
Thambu	687	3,658	5,230
Kirie	1,097	4,625	6,610
Mukonga-Ikongo	611	3,738	5,340
Gaciongo-Kanyengya	504	2,950	4,220
Gakombe	281	1,772	2,530
Kamaindi-Kanthungu	464	2,843	4,060
Kanyuru	703	4,053	5,790
Marimanti	1,097	5,826	8,330
Gatue	743	4,359	6,230
Gatunga	603	3,533	5,050
Chiakariga	1,148	6,386	9,130
Kamanyaki	738	4,389	6,270
TOTAL	10,028	55,514	79,340

Figure 6-3 Boundaries of the Study Area indicating Proposed Reservoirs and the Village Areas used during the study.

Forest Reserves within and adjacent to the area are indicated and named.



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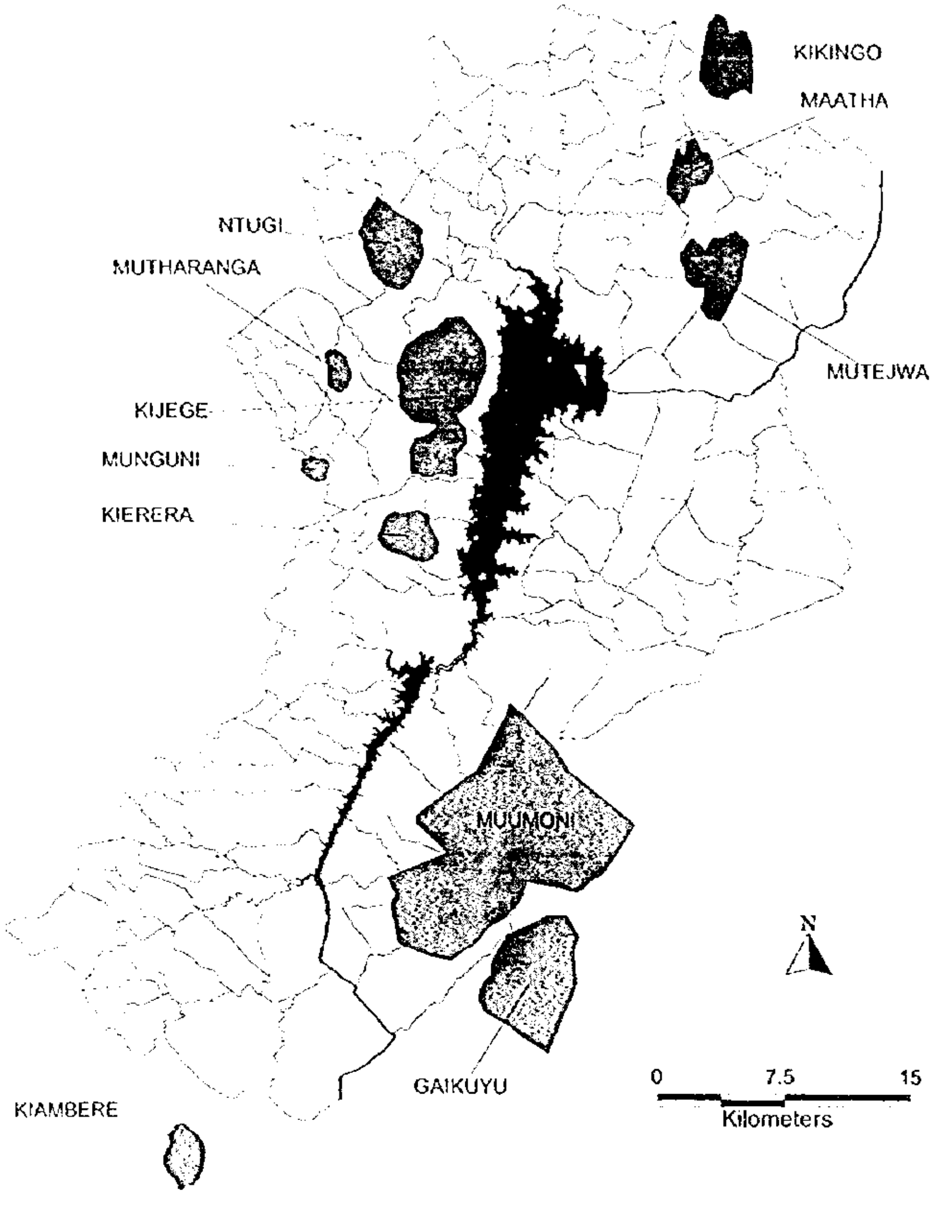


Figure 6-4 Population Density within the Study Area (1989 census data)

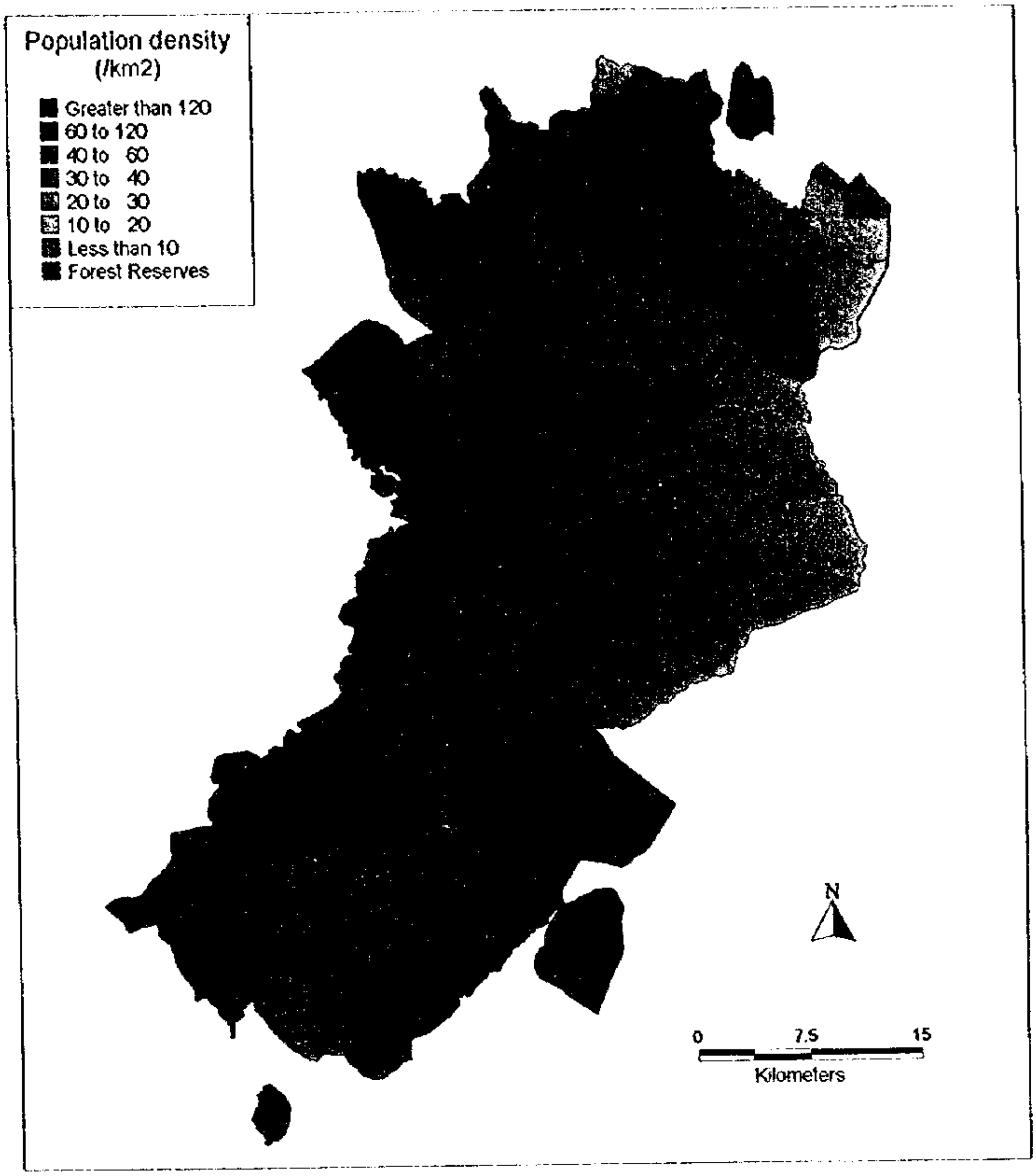
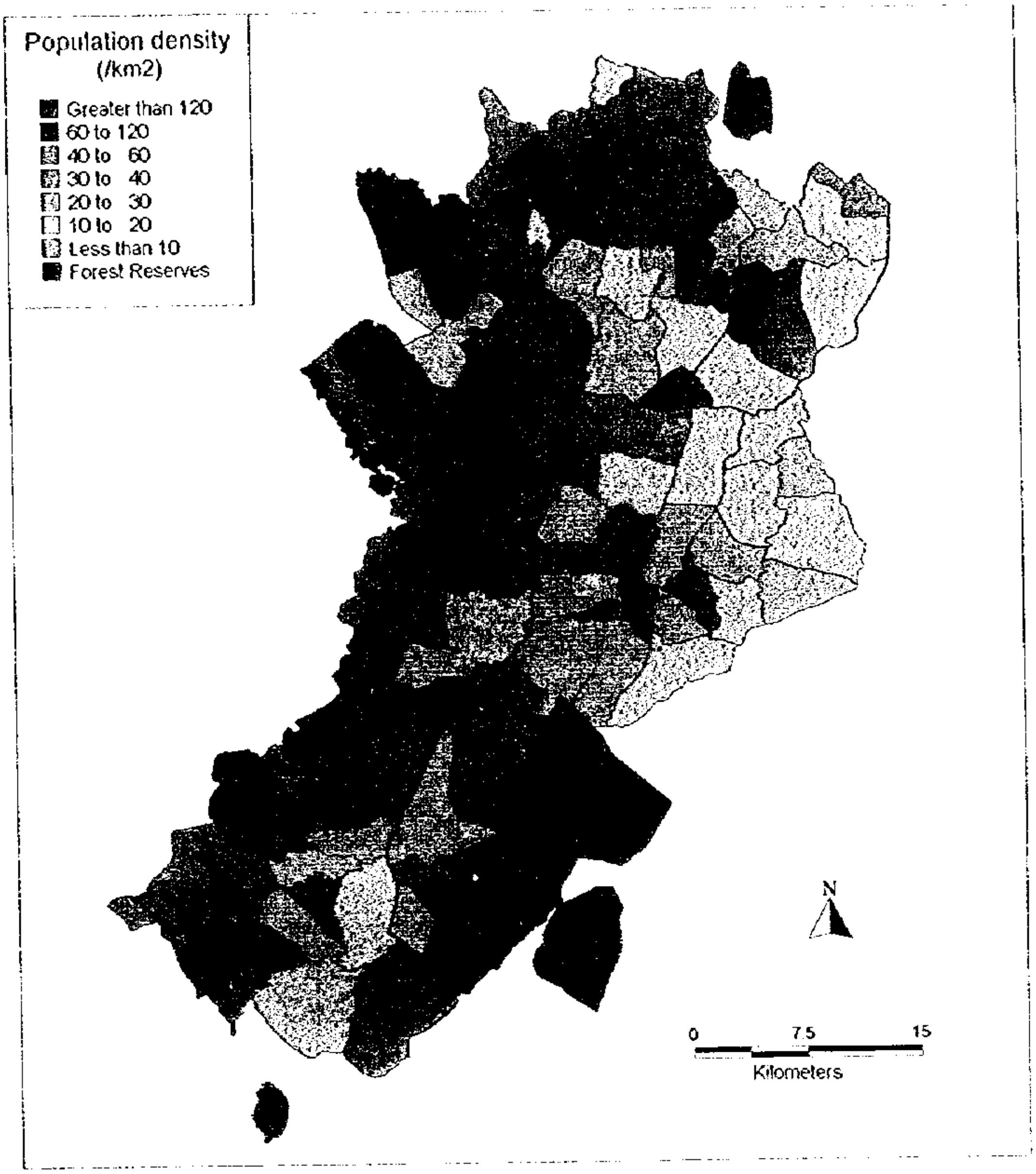


Figure 6-4 Population Density within the Study Area (1989 census data)



6.2.1 Population affected by the proposed Mutonga Reservoir

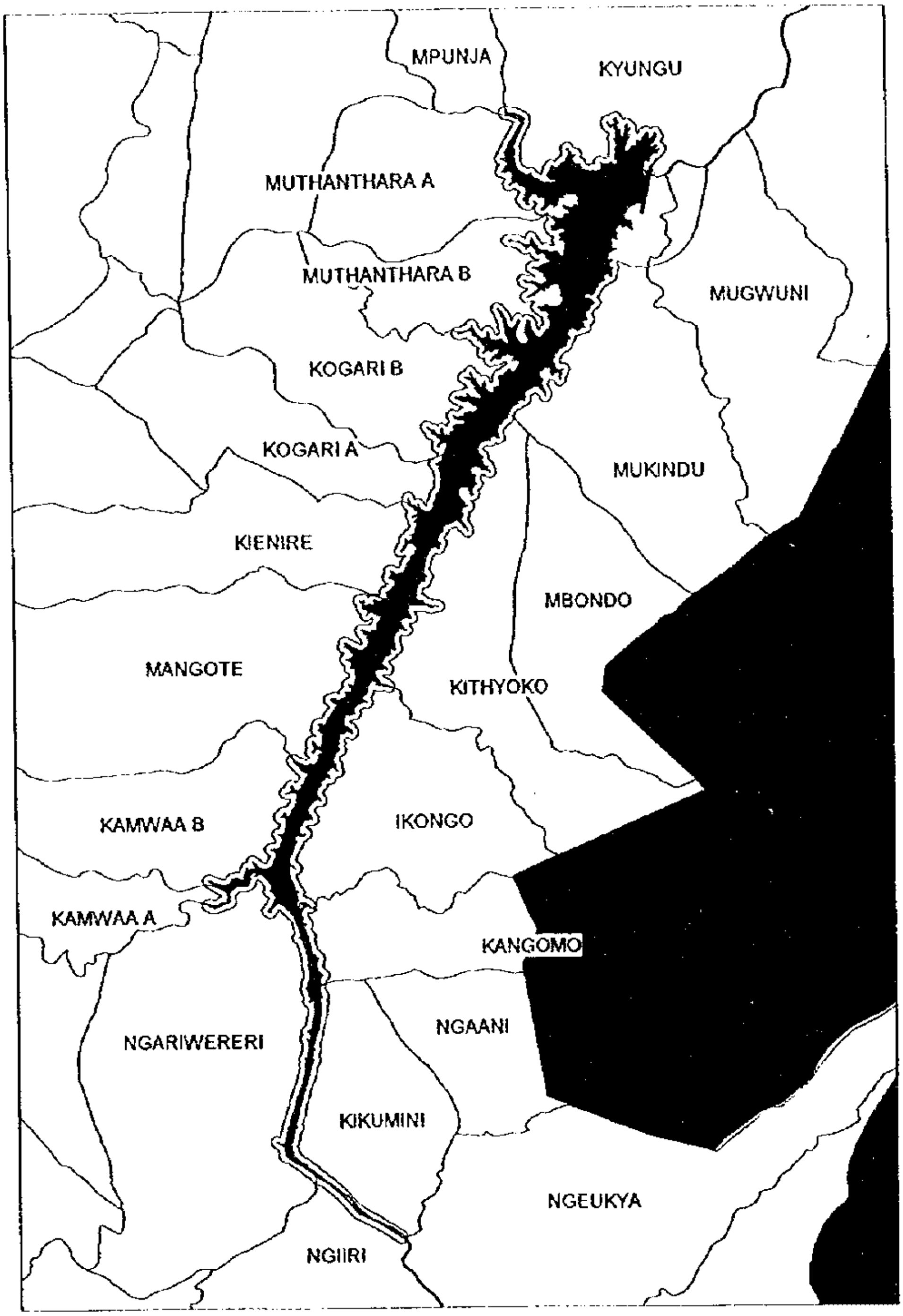
The flooded area impounded by the proposed dam at Mutonga, together with an adjacent 100 metre buffer zone and land set aside for use by management and dam operations, will occupy an area of 21.82 km². This land forms part of 18 villages (see Figure 6-5) On an area proportional basis, the impounded and buffer zone land was utilised by an estimated 722 people in 127 households at the time of the 1989 census (Table 6-1). For 1996 population levels the total was estimated at 838 people in 140 households

Table 6-1 Estimated Population impacted by the proposed Mutonga reservoir, including 100 metre buffer zone and the operations zone.

Census ID	Village	1989 Pop	1989 H/h	Area (km²)	1996 Pop	1996 H/h
1989 Census District: EMBU, Siakago Division						
41311011	Ngiiri	9	3	0.28626	7	1
41322011	Kienire	42	7	0.75446	32	5
41322021	Mangote	46	9	1.53377	37	6
41323021	Kamwaa A	2	0	0.08589	5	1
41323031	Kamwaa B	20	4	0.98017	24	4
41323041	Ngariwereri	20	4	1.36138	30	5
41332031	Muthanthara A	27	4	0.99429	42	7
41332041	Muthanthara B	166	27	2.74424	173	29
41332051	Kogari B	56	11	1.65073	80	13
41332061	Kogari A	23	5	0.54028	33	6
1989 Census District: Kitui, Kyuso Division						
43464011	Mugwuni	39	6	0.89180	48	8
43464021	Mukindu	120	22	3.43765	113	19
43464041	Kithyoko	63	11	2.17211	81	14
43464051	Ikongo	32	5	1.41188	49	8
43464061	Kangomo	17	2	0.31107	20	3
43464081	Kikumini	18	3	0.67857	22	3
46332071	Kyungu	21	4	1.96751	41	7
46332081	Mpunja	1	0	0.01766	1	1
	Total:	722	127	21.82	838	140

Source: CBS, 1989 Census; Field Survey 95/96 data

Figure 6-5 Villages impacted by the proposed Mutonga reservoir, including 100 metre buffer zone and the operations zone



6.2.2 Population affected by the proposed Grand Falls Reservoir (LGF)

The flooded area impounded by the proposed dam at Grand Falls (Low Grand Falls), together with an adjacent 100 metre buffer zone and land set aside for use by management and dam operations, will occupy an area of 84.8 km^2. This land forms part of 22 villages (see Figure 6-6). On an area proportional basis, the impounded and buffer zone land was utilised by an estimated 2961 people in 490 households at the time of the 1989 census. For 1996 population levels the total was estimated at 3770 people in 630 households (Table 6-2).

Figure 6-6 Villages impacted by the proposed Grand Falls (LGF) reservoir, including 100 metre buffer zone and the operations zone

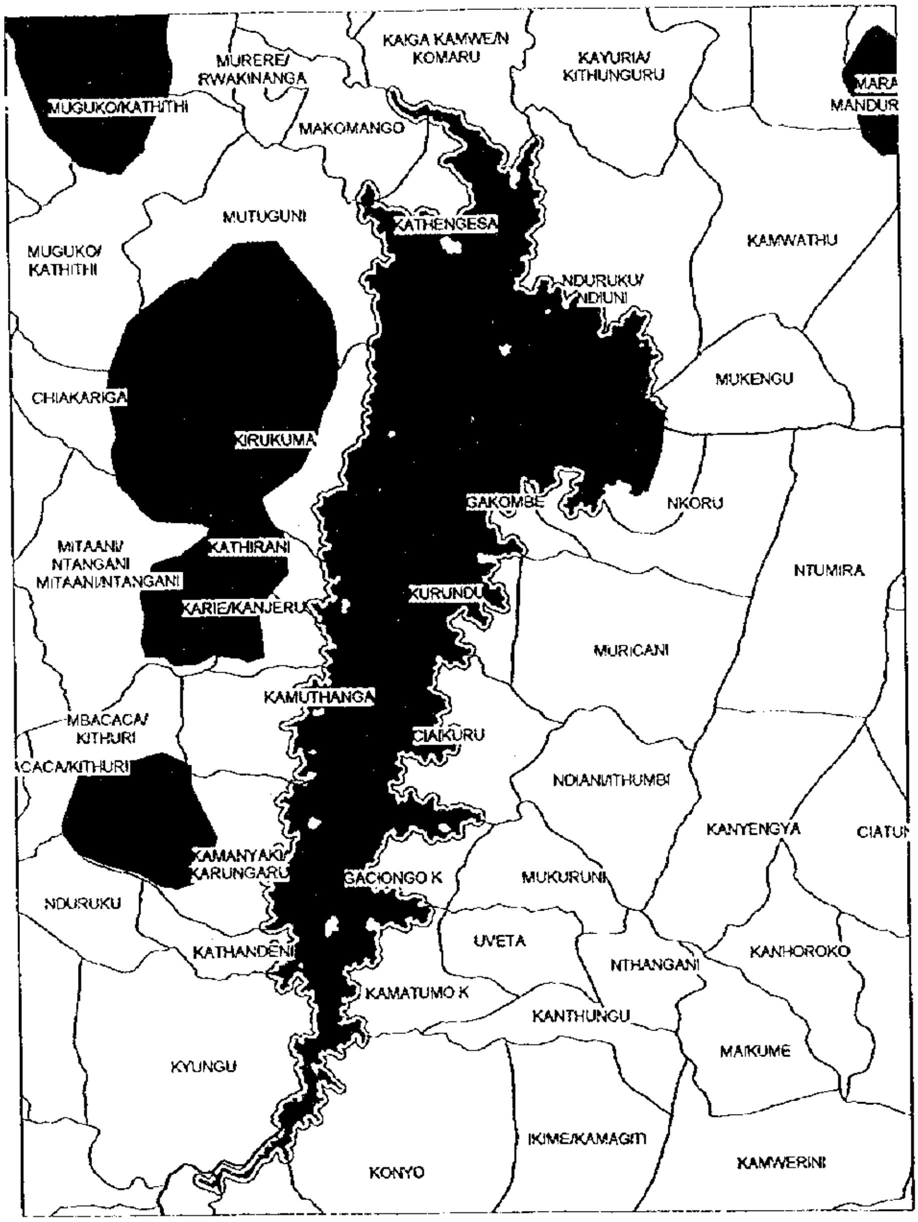


Table 6-2 Estimated Population impacted by the proposed Grand Falls (LGF) reservoir, including 100 metre buffer zone and the operations zone

Sublocation	Census ID	Village	Pop 1989	House 1989	Area (km²)	Pop 1996	House 1996
Mukonga/Ikonga	43464011	Mugwuni	29	5	0.6600	36	6
Mukonga/Ikonga	43464021	Mukindu	6	1	0.1719	6	1
Gakombe	43472011	Gakombe	228	36	4.8516	281	45
Gakombe	43472021	Nkoru	109	17	11.0268	135	21
Gakombe	43472051	Ciaikuru	165	29	6.3817	204	36
Gakombe	43472061	Kurundu	210	34	6.6532	260	41
Kanthungu/Kamaindi	43473011	Gaciongo K	139	23	3.1285	172	28
Kanthungu/Kamaindi	43473071	Konyo	45	7	1.7394	56	9
Kanthungu/Kamaindi	43473081	Kamatumo K	66	12	2.5734	35	5
Gatue	46312131	Mukengu	14	3	0.4137	17	3
Gatue	46312141	Nduruku/Ndiuni	246	40	10.1510	216	36
Kamanyaki	46332011	Kirukuma	519	75	9.0794	713	119
Kamanyaki	46332021	Kathirani	177	29	1.6316	366	61
Kamanyaki	46332031	Karie/Kanjeru	107	21	1.9399	133	26
Kamanyaki	46332041	Kamuthanga	108	18	1.9265	134	22
Kamanyaki	46332051	Kamanyaki/Karungaru	165	31	4.4133	278	46
Kamanyaki	46332061	Kathandeni	174	31	1.9114	153	26
Kamanyaki	46332071	Kyungu	20	4	1.9079	40	7
Marimanti	46342071	Kaiga Kamwe/Nkomaru	49	9	1.9141	60	11
Marimanti	46342081	Kathengesa	234	39	7.5465	289	49
Marimanti	46342091	Makomango	13	2	0.3476	16	3
Kanyuru	46343061	Mutuguni	138	24	4.4062	170	29
		TOTAL	2961	490	84.7763	3770	630

Source: CBS, 1989 Census; Field Survey 95/96 data

6.2.3 Population Projections within the Affected Areas

From the above tables, total population within each of the proposed reservoir areas was estimated as:

Proposed Reservoir	Population 1989	Households 1989	Population 1996	Households 1996
Grand Falls	2961	490	3770	630
Mutonga	722	127	838	140

Average annual % rate of increase in each area was therefore calculated as:

	Population	Households
Grand Falls	3.5109	3.6554
Mutonga	2.1513	1.4020

Table 6-3 indicates population projections to year 2010. For the purposes of this study, the year 2005 is taken as the latest date by which the population would be required to move.

Table 6-3 Population projections to year 2010, within reservoir areas and 100 metre buffer zones and the operations zones.

	Population			Households		
Year	Grand Falls	Mutonga	Combined dams	Grand Falls	Mutonga	Combined dams
1989	**2961**	**722**	**3666**	**490**	**127**	**613**
1990	3065	738	3786	508	129	633
1991	3173	753	3909	526	131	653
1992	3284	770	4036	546	132	674
1993	3399	786	4168	566	134	696
1994	3519	803	4304	586	136	718
1995	3642	820	4444	608	138	741
1996	**3770**	**838**	**4589**	**630**	**140**	**765**
1997	3902	856	4739	653	142	790
1998	4039	874	4893	677	144	815
1999	4181	893	5053	702	146	841
2000	4328	912	5217	727	148	868
2001	4480	932	5387	754	150	896
2002	4637	952	5563	781	152	925
2003	4800	973	5744	810	154	955
2004	4969	994	5932	840	156	985
2005	**5143**	**1015**	**6125**	**870**	**159**	**1017**
2006	5324	1037	6325	902	161	1050
2007	5510	1059	6531	935	163	1084
2008	5704	1082	6744	969	165	1118
2009	5904	1105	6964	1005	168	1154
2010	6111	1129	7191	1041	170	1191

6.2.4 Indirectly Affected Populations

Populations within an area adjacent to the reservoir area will be indirectly affected through the resettlement of people forced to move from the reservoir areas. As described above, the concept of a 3 km zone surrounding the 100 metre buffer zone has been proposed as the basis for creating a Special Management Zone (SMZ). Within the SMZ it is proposed that land will be managed so as not to have a negative impact on the reservoirs. In addition, it is proposed that the majority of the required resettlement would occur within the SMZ. These SMZs are described below - one surrounding the proposed Grand Falls reservoir (LGF), with a second SMZ for Mutonga reservoir. The option with the combined Mutoga and Grand Falls (LGF) reservoirs would combine both of these SMZs.

Proposed Grand Falls (LGF) Special Management Zone

Villages affected by this SMZ are indicated by Figure 6-7. The complete area of each village either completely or partly enclosed by the 3 km line is included within the SMZ. Villages adjacent to Kijege forest reserve are also included in order to facilitate resettlement from village areas between Kijege and the proposed reservoir (especially Kirukuma, Kathirani and Karie/Kanjeru).

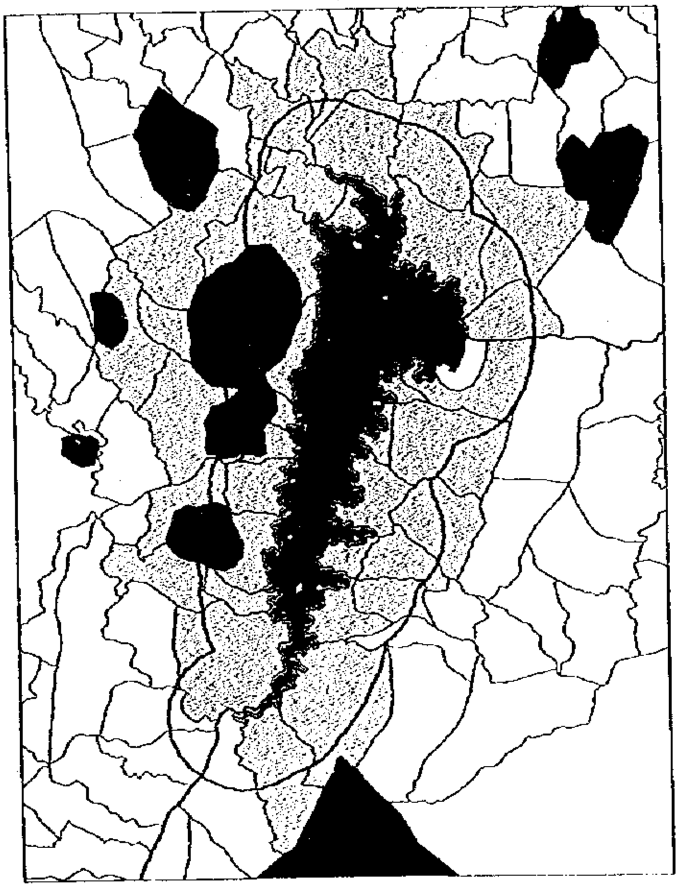


Figure 6-7

Grand Falls Reservoir (LGF) showing village areas included within the proposed Special Management Zone surrounding the reservoir and buffer zone.

Proposed Mutonga Special Management Zone

Villages affected by this SMZ are indicated by Figure 6-8. The complete area of the majority villages either completely or partly enclosed by the 3 km line is included within the SMZ.

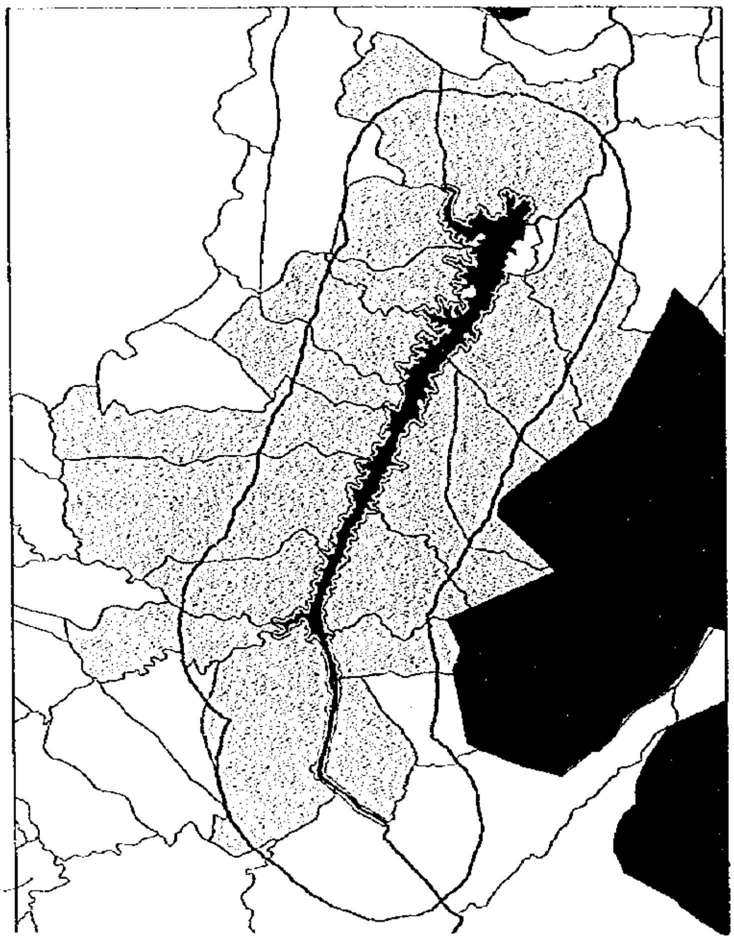


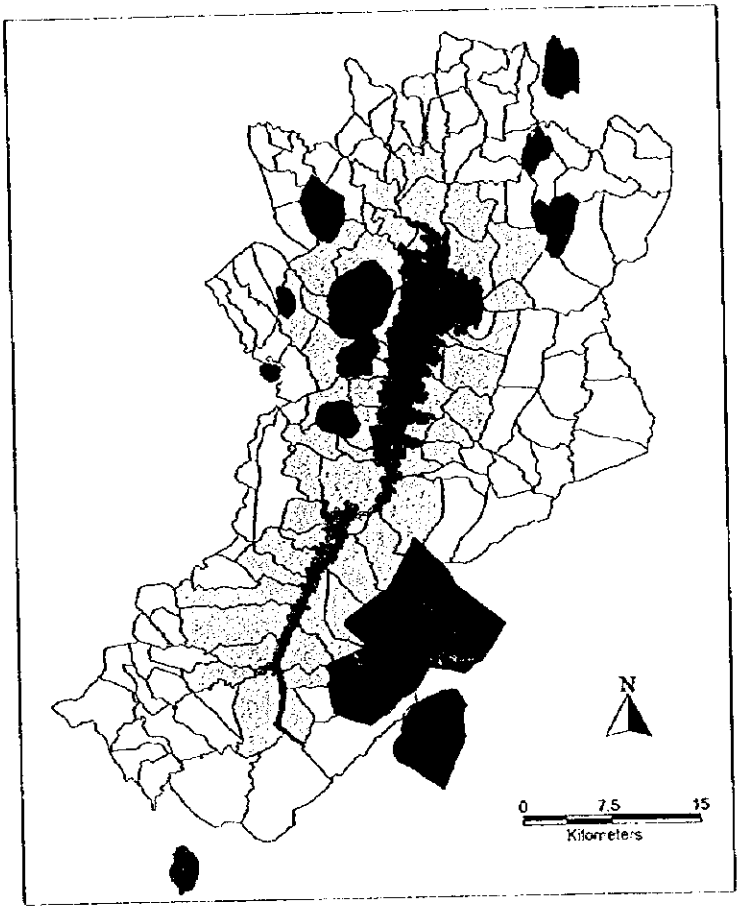
Figure 6-8

Mutonga Reservoir showing village areas included within the proposed SMZ surrounding the reservoir and buffer zone.

Proposed Special Management Zone combined Grand Falls (LGF) and Mutonga

The area occupied by the proposed Special management Zone for the combined development of both Grand Falls (LGF) and Mutonga reservoirs is indicated by Figure 6-9. There is a small area of overlap between the individual SMZs for Mutonga and Grand Falls resulting in a total SMZ area slightly less than the combined individual SMZ areas. As with the individual SMZs, the proposed SMZ for the combined development includes the entire areas of the affected villages.

Figure 6-9 Proposed Special management Zone for Mutonga and Grand Falls Reservoirs combined



Population within the Special Management Zones

The population densities within the area at the time of the 1989 national census are indicated in the Annex to Chapter 6. Total population with the two SMZs is indicated by Table 6-4, along with population projections (Table 6-5) based on the 1996 field survey data from the reservoir areas.

Table 6-4 Population densities within the Special Management Zones: 1989 national census, (excluding populations within the reservoir areas, 100 metre buffer zones and operations zones).

Zone	1989 Population	1989 Households	SMZ Area (km^2)	Population density ($/km^2$)
Mutonga	4845	898	227.6	21.29
Grand Falls (LGF)	16219	2821	344.0	47.14
Combined	19602	3477	511.0	38.36

(Calculated areas exclude those forest reserves included within the SMZ)

Table 6-5 Population projections within the Special Management Zones

Year	SMZ Population			SMZ Households		
	Grand Falls	Mutonga	Combined	Grand Falls	Mutonga	Combined
1989	**16219**	**4845**	**19602**	**2821**	**898**	**3477**
1990	16788	4949	20241	2924	911	3589
1991	17378	5056	20901	3031	923	3704
1992	17988	5164	21582	3142	936	3823
1993	18620	5276	22286	3257	949	3946
1994	19273	5389	23012	3376	963	4073
1995	19950	5505	23763	3499	976	4204
1996	20650	5623	24537	3627	990	4339
1997	21375	5744	25337	3760	1004	4479
1998	22126	5868	26163	3897	1018	4623
1999	22903	5994	27016	4039	1032	4771
2000	23707	6123	27897	4187	1047	4925
2001	24539	6255	28806	4340	1061	5083
2002	25401	6389	29745	4499	1076	5246
2003	26292	6527	30715	4663	1091	5415
2004	27215	6667	31716	4834	1107	5589
2005	**28171**	**6811**	**32750**	**5010**	**1122**	**5769**
2006	29160	6957	33818	5194	1138	5954
2007	30184	7107	34921	5383	1154	6146
2008	31244	7260	36059	5580	1170	6343
2009	32341	7416	37234	5784	1186	6547
2010	33476	7576	38448	5996	1203	6758