Chapter 11

POTENTIAL RESETTLEMENT AREAS

11. POTENTIAL RESETTLEMENT AREAS

11.1 INTRODUCTION

The population affected by the inundation in the reservoir area will need to be relocated. A resettlement plan must take into account a number of factors, including cost for resettlement, mitigation measures required to provide similar or improved living conditions for the resettled population and minimizing any adverse impacts on the host population. Additionally, the duration and human resources required for planning and implementing an effective relocation program need to be considered.

11.2 METHODS

The development of a resettlement plan proposed in this section considers the number of households and total number of people to be relocated, potential areas for resettlement selected based on people's preference and the carrying capacities of these areas and the host population. Some of these factors were dealt with in detail in previous Chapters, especially Chapters 6 and 8. Key information has been extracted and forms a foundation upon which the resettlement plan is based.

11.3 REQUIREMENTS FOR RESETTLEMENT

The act of involuntary resettlement can result in very serious hardship to the population being resettled , as well as the hosting population. A successful resettlement effort requires that , as much as possible, the following are true:

- Families being resettled are assisted to regain their former livelihoods, or the equivalent, in a reasonable period of time
- Host populations are given the support they need to absorb the incoming populations without subjecting themselves to undue hardships. The infrastructure of the hosting community must be able to continue to provide the same level of services, or better, as those that were available before the resettlement effort.
- Both resettlers and hosts are involved in planning, negotiation and execution of the resettlement plan
- To the extent possible the preferences expressed by the local population should be honoured.

11.4 LOCAL PREFERENCES FOR RESETTLEMENT

A number of informal and formal public meetings were held in all districts directly affected by the planned reservoir. These meetings served the dual functions of informing the public about these critical plans in their area and to elicit responses from the local community regarding their attitudes and preferences.

Some of the issues that were raised include:

1) Desire by local community to be involved in the process, as early as possible, to ensure their needs are addressed.

2) Stated willingness to be displaced and a stated preference for resettling nearby with relatives and friends

3) A certain amount of scepticism that locals will be compensated adequately for their loss of land or that the dam will be of any real benefit to them. This scepticism appears to be based upon observations of other plans on similar projects.

The household survey questionnaire also asked respondents about their resettlement preferences. These responses are summarised below.

11.4.1 Resettlement Preferences

Most respondents expressed a desire to resettle close to their existing location. Of the total sample group, 88% stated a preference for settling nearby (near the reservoir or in a nearby village). Table 8.11 details these responses.

Most respondents expressed an interest in relocating with village and family members or with village people (75% and 22%, respectively). The responses to question H7 are detailed in Table 8.10.

Eighty-six percent (86 %) of respondents stated a preference for employment in mixed farming and animal husbandry. Most of the remainder prefer farming only.

Table 11-1 Employment Preferences

Item H10 - What would be your most preferred employment opportunity in the resettlement area?

District	Response (%)									
	1	2	3	4	5	6	7	8	9	10
Mwingi	18	68	5	3	-	5	-	-	-	3
Embu	3	91	-	-	1	2	-	-	1	-
Tharaka Nithi	11	87	-	1	-	-	-	-	-	1
All	9	86	1	1		2	-	-		1

Key:

1. Farming only
2. Farming with animal husbandry
3. Animal husbandry alone
4. Hired labor
5. Operating a store
6. Manufacturing
7. Fishing
8. Farming with fishing
9. Bee keeping
10. Fishing and part time work

11.5 LOCAL PREFERENCES FOR COMPENSATION

Input was received from formal questionnaires as well as informal field surveys and interviews. In most of the informal discussions, a preference was stated for some type of settlement which would guarantee resettlers getting sufficient land, while also getting cash to help through the transition period. Concerns were raised about cash-only settlements since it was observed that frequently the cash is not sufficient to buy appropriate land or is not applied to the purchase of land by the heads of household controlling the cash.

The questionnaire gives a more mixed view with the largest grouping preferring cash alone (39%) or cash and land compensation (23%) (see Table 8.12).

11.6 PREVIOUS EXPERIENCE ON RESETTLEMENT

11.6.1 Experience of Resettlement in Africa

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

Several scientific studies have been carried out on problems related to resettlement and have shown that physiological, psychological and socio-cultural difficulties often arise among persons who had been relocated against their will.

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.

Resettlement operations in the past have suffered from deficiencies of policy, organisation, implementation and resources. Some of the key issues were:

- 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.
- Government agencies tend to prepare resettlement components hurriedly and superficially.
- Assistance to resettlers is typically confined to short-term relief.
- Resettlement components are underfinanced.

- The productive capacities and incomes of those displaced are not restored within a reasonable transition period. The result is lasting impoverishment.

- Resettlers and hosts are not invited to join in planning, negotiation and execution.

A review of past several case studies 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 else, 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 cooperating 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.

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.

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.

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.

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.

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.

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.

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.

The Kainji Lake experience in Nigeria is an example of a successful resettlement. 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.

11.6.2 Experience of Resettlement In Kenya

Kenya's experience of involuntary resettlement are not different from those of Africa in general. Some of the relevant findings are summarised below:

Kamburu/Gitaru

The residents of the Kamburu and Gitaru dam areas faced many social and health problems. 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.

For the Kamburu and Gitaru dam areas, 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.

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.

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.

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.

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 resettlers fared rather badly on all counts. The money the resettlers 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 resettlers.

The Kiambere experience showed 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 resettlers in making decisions on resettlement issues; and (iv) devising ways of handling the host population.

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 resettlers may have been partly due to the fact that they were not further assisted in deciding where to resettle..

One major problem with 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. It was 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 refuge 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.

11.7 RESETTLEMENT OPTIONS

Field surveys indicate that most areas immediately surrounding the affected villages are sparsely populated and could likely accommodate some degree of resettlement. Field survey results have been analyzed in combination with chosen preferences, agro-ecological zones and carrying capacity and the results of the land evaluation study to prepare a final recommendation.

There are two possible resettlement options: a) a person to be resettled in his/her district and if possible division or location; or b) person to resettled outside his/her own district.

From field interviews, most of the respondents would prefer to be resettled within the same district and if possible with their kin who are not within the dam area.

Given this preference, it is relevant to note the land availability and potential for resettlement in the special management area and other areas neighbouring villages.

There are three possible combinations of compensation package:

a) land for land;

b) money for land; and

c) combination of the two.

Experiences from other resettlement programmes indicate that a) land for land , or b) a combination of cash payments and land have been the most successful. This implies the need to look for land for resettlement.

Further experiences indicate that to ensure minimum cultural disturbance, it is best to resettle the people affected as close as possible to their existing sites, i.e. within the sub-location or location.

11.8 MITIGATION MEASURES

Below is a summary of the types of potential impacts and recommended mitigation measures associated with a resettlement program. More specific discussion is presented in Section 11.10.

Table 11-2 Mitigation Measures

Impacts	Mitigation Measure
Displacement of population	Early development of an action plan for settlement of affected families in suitable environment.
Loss of immobile household assets	Ensure that compensation is adequate for continuance or improvement of current life-styles. Compensation for buildings on the basis of size and construction materials. Land compensation based on size and quality of land.
Land tenure conflicts	Land adjudication and registration should be carried out in all areas in order to facilitate the management of peripheries of the reservoir area. This can be done before implementation of the project.
Weakening social cohesion	Maintenance of social cohesion through fostering community organisation and minimising dispersal of kinship groups.
Physiological, psychological and socio-cultural stress	Resettlement in a familiar and predictable environment within the vicinity of the reservoir.
Ethnic conflicts	Resettle the affected population in areas with the same clans or ethnic groups.
Increasing tension and conflict may worsen security	Provision for increased security in resettlement areas. This will greatly enhance the success of resettlement activities.
Effect on host population	Reduction of competition by strengthening receiving community infrastructure and resources, particularly water supplies, dips; marketing, educational and health facilities, pasture and arable land, close monitoring and evaluation of changes in the resettlement environment.
Increased population density in all areas adjacent to reservoir as a result of resettlement	Provision of agricultural and livestock extension services to enable households to cope with the reduction in land available per households to cope with the reduction in land available per household without reduction in living standards.
Reduced food production and food security	Establish a management system for the implementation of resettlement issues.
	Include in its mandate provision for food relief and increased food security, including the provision /

Impacts	Mitigation Measure
	organization of extension services as required.
Displacement of people to less productive areas	Ensure that the productive capacity of the land resettled is equivalent to or an increase on that in the original household area.
A feeling of being isolated from benefits accruing from the reservoir area	Provide services within the reservoir area, and especially to resettled households. This should include: treated water supplies, sustainable fuelwood sources, alternative power sources (electricity), dispensaries, schools and improvements to transport and marketing systems.
Tendency for people to return to unmanaged buffer zones.	Rename the buffer zone as "Special Management Area". Actively manage this area with the twin aims of preventing dam salutation through local soil erosion, and providing benefits to the local people.
Damage to bee-keeping through removal of riverine vegetation	Provision of a well managed reservoir Special Management Area with indigenous trees suitable for bee-keeping.
	Provide extension services for bee-keeping. Provide and encourage the use of improved hives less damaging to the environment.
	Instigate a co-operative for marketing of honey and beeswax.
Depletion of firewood	Afforestation of the buffer zone with culturally preferred indigenous trees for fuelwood. Provision of alternative energy sources.
	Encourage development on-farm fuelwood supplies.
	In areas outside the Special management Area classify land by erosion risk. Provide extension services and assistance to combat soil erosion. On areas with steep slopes unsuitable for terraced cultivation, encourage the development of fuelwood plantations.
	Need for ex-situ conservation and gene banks.
Water-borne diseases infection	Reduce contact between humans and their livestock and the waters of the reservoir to minimize transmission of schistosomiasis, malaria and other water-related diseases. Provision of sanitation facilities, protected an treated water supplies at households and/or standpipes. Provision of

Impacts	Mitigation Measure
	health education.
Sudden and dramatic increase in demand for building poles and other natural resource derived materials	Ensure provision of building materials from sources that don not deplete the locally occurring natural resources.
Loss of riverine vegetation in the reservoir areas	Species with both economic, household, conservation and aesthetic value should be maintained by in-situ conservation measures. During construction and impoundment construct plant nursery adjacent to final water levels. Collect seeds and live plants from area to be impounded for growth and preservation in nursery. Following impoundment use nursery to re-stock the buffer zone.
Loss of socially and economically useful vegetation components and loss of biodiversity	Afforestation program based on indigenous trees within the buffer zone would facilitate community dependence on trees of economic and cultural value.
Damage to sites of value	Preservation of the archaeological, historical and cultural sites of value to the communities and potential for tourism, especially in the buffer zone.
Environmental Degradation	Integration of physical and biological conservation measures within improved systems of land use policies, maintaining the carrying capacity of the grazing and arable land.

11.9 COMPENSATION REQUIREMENTS

11.9.1 Introduction

The purpose of this section is to assess what compensation should be payable to the residents who may be displaced through the implementation of the proposed Hydropower Project.

11.9.2 Methodology

In order to determine what compensation would be payable it was necessary to undertake a physical survey of the assets owned by residents in the project area. A qualitative sampling of some 110 homesteads was carried out in 30 villages in the

three Districts. These were the same villages from which the household surveys were conducted by the team from Central Bureau of Statistics of the Kenya Government, as detailed in Chapter 8. However, the homesteads for compensation surveyed were not necessarily those from which the household surveys were conducted because both the sample sizes and the dates of the surveys were different. The survey for this section was about 30% of the sample by Central Bureau of Statistics.

The sampling of individual homesteads was randomly based on every 20th homestead. The survey team was accompanied by one official from the Provincial Statistical Office in Embu and the Assistant Chief in whose area the particular village was located.

In each homestead the survey team used a checklist to collect information on the following:

(i) Property rights

(ii) Land Use

(iii) Physical developments on the land

(iv) Land values and development costs.

Information on property rights included the land tenure, ownership and land size. Land use information included type of farming and farm products. The information on physical developments included the type of buildings, size, mode of construction, type of fencing, gate, etc.

Land value information and development costs were obtained through interviews with property owners, District Land Officers, District Agricultural Officers and District Quantity Surveyors. After data analysis, compensation requirements were based on the Government policy on compensation under the Constitution (Section 75) and the Land Acquisition Act, Chapter 295 of the Laws of Kenya.

11.9.3 Legal Basis for Land Acquisition

Section 75(1) of the Kenyan Constitution states that no property of any description shall be compulsorily taken possession of, and no interest or right over property of any description shall be compulsorily acquired, except as provided for in the law, and for prompt payment of compensation. The person whose right or interest is acquired has a right to appeal in a court of law for both the determination of his/her right and for obtaining prompt payment of the compensation.

The limitation placed by the constitution on compulsory acquisition is exercised through the Land Acquisition Act, Chapter 295 of the Laws of Kenya. The Act lays down the procedure to be followed in acquiring property rights, including publication of notice of intention to acquire the land, the receiving of claims for compensation from persons interested in the land, determination of the compensation payable, payments of compensation, and taking possession of the land. The whole procedure is

normally undertaken on behalf of any acquiring authority by the Commissioner of Lands. The above procedure is normally followed in circumstances where property has appropriate registration documents.

11.9.4 Acquisition of Trust Land

Land which has not been adjudicated and surveyed in Kenya is held under Trust Land Act, Chapter 288 of the Laws of Kenya. Section 115 of the Kenyan Constitution vests into County Councils all land in their areas of jurisdiction that has not been adjudicated and registered "in trust and for the benefit of the persons ordinarily resident on that land". This is the manner in which communal customary land rights in Kenya are managed. It is, however, intended that in the long run all land in the whole country should be adjudicated and registered in the family or individual names. The process which started in the 1950s is, however, far from complete.

Compulsory acquisition of Trust Land is called "Setting Apart" and basically amounts to terminating the customary rights and interests subsisting over a specified portion of the land on payment of compensation to individuals or groups, who under customary law were entitled to the rights and interests, and vesting of the land in the authority which requests the setting apart. Section 117 of the Constitution spells out the purposes for which County Councils may set apart the land. Further, under Section 118 (2) of the Constitution, land can be set apart at the instance of the Government for specific purposes. The nature of the undertaking and, to an extent, who is undertaking the project determines whether the land is to be set apart at the instance of the County Council or the Government. Generally, however, projects with national impacts almost invariably can be handled by the Government whereas those with a more local connotation can be handled by the Country Councils.

The Mutonga/Grand Falls Hydropower Project which will be located in three Districts is certainly a national project. Thus where customary land will be involved as in Mwingi or Tharaka-Nithi District , the setting apart should be at the instance of the Government. The setting apart extinguishes all previous customary law interests in the land. The notice of setting apart is normally published on behalf of the County Council and the Government by the Commissioner of Lands in a similar procedure to the requirements of Land Acquisition Act.

11.9.5 Basis for Compensation

Compensation claims in Kenya are statutory and depend upon the provisions of the Land Acquisition Act. The principle of equivalence is that statutory compensation cannot and must not exceed the owners' total loss. It is unfair to the owner to pay him/her less, and it is equally unfair to the public for the acquiring authority to pay more. Thus in determining compensation under the Land Acquisition Act, the following matters,and no others shall be taken into consideration, namely;

(i) The market value of the land taken, including improvements thereon,

(ii) Any damage sustained or likely to be sustained by owners at the time of taking possession of land by reason of severing such land from other land in same possession, i.e. in such cases where only part of the land is taken;

(iii) Any damage sustained by the owners at the time of taking possession of the land by reason of the acquisition injuriously affecting other property in the same possession, whether movable or immovable, in any other manner including actual earnings;

(iv) Any reasonable expenses incidental to change of residence or business where owners are compelled to move out;

(v) Any damage genuinely resulting from the diminution of the profits of the land between the date of publication of the notice of intention to acquire the land and the date of taking possession of the land. This may include loss of earnings from the date of notice of intention to acquire the land until the date when compensation is paid;

(vi) A sum equal to fifteen percent of the market value of land and improvements as determination, by way of compensation for disturbance.

Accordingly in the case of Mutonga/Grand Falls Project, the basis of compensation will be the value of land and improvements thereon owned by a household, any diminution in value of remaining land arising from severance or injurious affection, loss of earnings from farm produce during resettlement period, relocation costs as appropriate and the fifteen percent statuary addition for disturbance.

11.9.6 Compensation Requirements

11.9.6.1 Land

From a survey of 110 homesteads it was evident that in both Mwingi and Tharaka-Nithi land adjudication and registration has not taken place. All land is therefore owned under customary rights and will therefore need setting apart. The land is largely semi-arid, and most of the households practice subsistence farming by growing food crops and keeping animals, mainly goats. Since the land is not registered there are no sales records as evidence of price in the respective District Land Offices. Since the land is not registered, the owners do not know the acreage of land they use. How much land is communally in possession of a household is largely a vague estimate. The report proposes to use the total area of land intended to be acquired in both districts to arrive at the estimate of land to be compensated. The rough value estimate gives the price of land in Tharaka - Nithi as Kshs.5,000-10,000 per acre and Kshs. 5,000 - 15,000 per acre in Mwingi.

In Embu, parts of the District have land registration completed. The land is used for mixed farming and mixed cropping. The crops grown include maize and other food crops. Animals kept include indigenous cattle, sheep and goats. Evidence exists that land is selling between Kshs. 10,000 and Kshs. 20,000 per acre i.e. Kshs. 25,000 - 50,000 per hectare, depending on the relationship between the buyer and seller. The prices are much higher for aliens than for neighbours.

Both Tharaka Nithi and Mwingi have sparse population densities, with homesteads 3-4 kilometres apart, as compared to Embu where homesteads are about 1-2 kilometres apart. The average land holding in Embu is 5 acres i.e. 2 hectares, while land in the other two districts is communally owned in much larger portions of 10 acres (4 hectares).

11.9.6.2 Buildings

Each of the homesteads in the three districts has a main house and one or more outbuildings. The type of houses and outbuildings were classified into permanent, semi-permanent and temporary according to the materials used in construction of the elements. A building constructed of permanent materials for floor, walls and roof was described as permanent, while a building with any of the two elements in permanent materials was described as semi-permanent. A building constructed of mud/wattle walls,earth floor and thatch roof was described as temporary.

Based on the above classification a total of 75.9% of the main house in all the homesteads were temporary, 16.8% semi-permanent and only 7.3% were permanent.

Most of the permanent buildings were relatively small with a plinth area of 50 square metres. The construction was mainly stone/concrete blocks/ burnt clay bricks for walls, corrugated iron sheets for roof and cement screed for floors. There was only one such building in the homesteads where they occurred. The semi permanent buildings had similar roofs, cement screened floors, and mud/wattle walls plastered both sides or unburnt clay bricks. The incidence was about two units in each homestead where they occurred, and each unit measured 20m2. The temporary buildings consisted of thatched roofs, rammed earth floors and mud/wattle walling. There was an incidence of about 3 buildings in each homestead including those with permanent and semi-permanent buildings. The average plinth area per unit was 15 square metres.

Within each homestead there were one or more outbuildings including external kitchen, pit latrine/shower room and granaries. Large households had more outbuildings than smaller households. Most of the outbuildings (72%) were made of temporary materials and the remaining 28% were made of semi-permanent materials. The average plinth area for the kitchens way 10 square metres, while both toilets and granaries measured approximately 1 square metre.

The fencing was mostly of hedges. Only 5% of the homesteads had constructed gates, usually made of timber, while 95% of the homesteads had no gates. Thus improvements in the form of fencing was minimal.

11.9.6.3 Trees

On average a homestead had 6 mature trees planted either for timber or ornamental value. The trees include Mutororo, Mikao and Mwarange (local names). On average these command a value of Kshs. 2,000 for each homestead based on annual sales of the products

11.9.6.4 Beehives

The keeping of bees is a prevalent economic undertaking by the people of this area region some homestead have an many as of 100 beehives. Each beehive was established to cost about Kshs. 200.

11.9.7 Compensation for Loss of Production

The following are annual average household crop production for the area based on the sample.

Maize	-	10 bags
Millet	-	20 bags
Sorghum	-	10 bags
Green peas	-	10 bags
Pigeon Peas	-	3 bags
Cow Peas	-	4 bags
Castor	-	1 bags

The people may need to be compensated for 1 year's loss of production during which they can not continue with agricultural production due to the demands of resettlement.

A part from crops, the people also engage a great deal in honey production. Each beehive produces about 10 kg of honey annually. It is therefore possible for a household with 100 be-hives to harvest 1000 kg of honey annually, which may be disrupted during resettlement.

11.9.8 Compensation for Transmission Line Leeway

This will not present much problem because the transmission line passes through buffer zone which will be acquired compulsorily for purposes of the project. However within Mukonga/Ikonga sub location, transmission line slightly goes outside the boundary of the buffer zone. It is our suggestion that the tiny pieces of land be included as part of the buffer zone so as to do away with leeway for the transmission line. The land can then be compensated for together with buffer zone.

11.9.9 Local Preferences for Compensation

The general feeling among the residents was that should their land be taken, they should be given an alternative land for resettlement in exchange of their own. In practice with past land acquisition cases in Kenya, the Commissioner of Lands would

be unwilling to enter into a land for land negotiation because it would create a dangerous precedence in matters of compulsory acquisition of land. Furthermore if this were to be done, people would expect to be compensated with land of similar characteristics to the one that they would be surrendering for public purpose. It would be difficult to avail such land to every displaced community. This would give rise to controversies over compensation. These controversies would take too long to settle and unduly delay the project. The most expeditious way of settling compensation dues therefore is by cash payment. In the present project, however, a proposal has been made to create special zone for resettlement. Care should be taken to discourage the community that they would get land equivalent to what they previously owned.

11.9.10 Recommendations

It is recommended that the legal system be reviewed to determine whether land-for-land or land-and-cash solutions could be used instead of the customary cash compensation to displaced households.

While any non-cash solution is more difficult in the short-term, experiences on other projects indicate that a pure cash compensation often leaves the community with long term handicaps which they find difficult to overcome.

Where land is available in the Special Management Zone it should be sold out to those who will be interested rather than compel those not interested.

In terms of compensation, the following analysis is indicative of the amount required, regardless of the mix of the specific solution. Even if resettled households are assisted in the purchase of land, that land has a cost which much enter into the calculation. The following analysis indicates the average amount each household should receive in terms of cash compensation, or a mix of cash and land equivalent.

Table 11-3 Estimated Compensation Required per Household

Item	Average amount (in Kshs)
Land (2.0 Hectares)	40,000.00
Buildings	52,000.00
Other Improvements	12,000.00
Disturbance @ 15%	16,000.00
Sub-total	120,000.00
Add Loss of Production	24,000.00
Sub-total	144,000.00
Add Contingencies @ 10%	14,000.00
Total	**158,000.00**

Assuming that there are about 600 households in the area to be resettled, the estimated amount of compensation would be approximately Kshs. 95,000,000. This figure is judged to be a good estimate given that a recent acquisition for Third Nairobi Water Supply Project in 1989 cost Nairobi City Council Kshs. 150,000,000 by way of compensation. The land covered was only 400 hectares, involving 400 households in a high potential area in Muranga District therefore on how many households are will actually be involved and the total acreage of land being acquired the compensation figure will be adjusted appropriately at the time of acquisition.

11.10 PROPOSED RESETTLEMENT PLAN

11.10.1 Background Information

In order to formulate a resettlement plan the following factors must be incorporated into the plan:

Population of the Area to be Resettled

Analysis of the population in the area indicates that with the combined development of both Mutonga and Grand Falls an estimated 1017 households will require resettlement, with a projected popualtionof 6,125 people.

Table 11-4 Population to be Resettled, projected to year 2005 (see Table 6-3)

	Grand Falls (LGF)	Mutonga	Combined Development
Population	5143	1015	6125
Households	870	159	1017

Population in the Areas to Host Resettlers

Table 11-5 Population in Host Areas (SMZ) projected to Year 2005

	Grand Falls (LGF)	Mutonga	Combined Development
Population	28171	6811	32750
Households	5010	1122	5769

Land Hectarage included in Reservoir Area

Based upon land valuation in the field, replacement through purchase of the land that will be inundated in the 3 districts would cost between 141,613,000 ksh and 338,420,000 ksh for the combined development of both reservoirs.

Table 11-6 Estimated Cost of Land Compensation (Reservoir area, 100 metre buffer zone and operations zone)

District	Hectares	Cost	Total Cost (ksh)	
Mutonga Reservoir				
Embu	1,093	25-50,000	27,325,000	54,650,000
Mwingi	890	12-35,000	10,680,000	31,150,000
Tharaka-Nithi	199	12-25,000	2,388,000	4,975,000
Total	2,182		40,393,000	90,775,000
Grand Falls (LGF)				
Mwingi	3,719	12-35,000	44,628,000	130,165,000
Tharaka-Nithi	4,759	12-25,000	57,108,000	118,975,000
Total	8,478		101,736,000	249,140,000
Both Reservoirs				
Embu	1,093	25-50,000	27,325,000	54,650,000
Mwingi	4,567	12-35,000	54,804,000	159,845,000
Tharaka-Nithi	4,957	12-25,000	59,484,000	123,925,000
Total	10,617		141,613,000	338,420,000

11.10.2 Amount of Compensation Required

Total compensation would take into the value of land, household improvements, transition and translocation costs and loss of productivity. These are summarized in section 11.9, Table 11.3, and an average compensation per household of 158,000 ksh is estimated.

For the combined development of both reservoirs, the number of households to be relocated is about 1,017, which indicates a total of 160,686,000 ksh. However, this

calculation assumes an average of 2 Hectare per household, or a total of 2,034 hectares.

As indicated above the total area to be inundated, including the 100 metre buffer zone and operations zone, is estimated at 10,617 hectares. Assuming an approximate value of 20,000 per Hectare, the remaining 8,583 hectares would require a compensation of an additional 171,660,000 ksh, bringing the total estimated compensation required for the combined development to 332,346,000 ksh.

Table 11-7 Total Estimated Compensation required for Relocation of Displaced (Ksh) populations

	Mutonga	Grand Falls	Combined
Household	25,122,000	137,460,000	160,686,000
Other non-household land	37,280,000	134,760,000	171,660,000
Total	**62,402,000**	**272,220,000**	**332,346,000**

11.10.3 Land Use Potential and Resettlement

Given the land potential based upon the carrying capacities of the various Agro-ecological Zones, the following conclusions can be made on possible resettlement areas:

- In Embu and parts of Tharaka-Nithi (Tharaka South and parts of Tharaka Central divisions), the carrying capacity for both livestock and crop production increases westwards with the altitude (toward the Mount Kenya slopes) and away from river or dam area. Therefore land for land resettlement will mean less land is required given the higher carrying capacity and productivity of the land. The ratio will depend on specific resettlement areas.
- Because most of the land outside the reservoir area is of higher potential area, it is mainly better suited or better used for crop production than pastoral production. This implies that there will be a slight shift in production process in favour of crop production. The acceptance of this by the people to be resettled and the impact of greater demands on these lands are not clear. It is critical that any resettlement plan does not result in land degradation from overuse or overgrazing.
- In Mwingi and Tharaka North, land potential is more or less the same in the proposed dam areas and areas outward from the dam area. This implies that land for land resettlement would be on an equal ration.
- The production pattern will be more or less the same. However, there might be additional opportunities with the creation of the dam, i.e., fishing , possibilities of irrigation, etc.

11.10.4 Possible Sites for Relocation

Relocation of displaced households within the same village area is considered as the optimum solution. Where the resulting population density would be too great, the option of relocation within neighbouring areas, with a preferance for the same location, needs to be considered. Table 11.8 summarises the changes in population density within the proposed SMZs for Mutonga and Grand Falls following relocation of the population displaced by inundation of the reservoirs.

Table 11-8 Summary of population density within SMZs following relocation

	Grand Falls	Mutonga	Combined
Population displaced (year 2005)	5143	1015	6125
Households displaced (year 2005)	870	159	1017
Area of proposed SMZ (km^2)	344.0	227.6	511.0
Projected 2005 SMZ population	28,171	6,811	32,750
Projected 2005 SMZ households	5,010	1,112	5,769
Population density	81.89	29.93	64.09
Combined population including relocated households	33,314	7,826	38,875
Combined households including relocated households	5,880	1,271	6,786
Resulting population density	96.84	34.38	76.08
Required household land @ 2 ha/household (km^2)	117.6	25.42	135.72

Calculations indicate that given the estimated population within the area, projected to the year 2005, villages adjacent to the proposed Mutonga reservoir should be able to absorb the displaced households with population density increasing from an estimated 29.9/km^2 to 34.4/km^2. The greater land area appropriated for the proposed Grand Falls reservoir results in a larger increase in population density within the proposed Grand Falls SMZ. In addition, the projected population density within this SMZ was estimated to be greater – resulting in an increase from an average of 81.9 to 117.6 persons per km^2. There may therefore be a requirement to extend the Grand Falls SMZ further to the East to include additional land area currently under relatively low population density. The alternative is to increase the carrying capacity of the land through the introduction of small scale irrigation in suitable locations.

11.10.5 Mitigating Factors

The relocation of households will result in a more densely populated host population and will place stresses upon that population. Also, the process of relocating presents difficulties for the displaced households.

The following mitigation measures are indicative of those that could be applied to lessen the burden on the host population as well as accelerate the integration of the displaced populations.

1. Assist local leaders in development of a long-term plan to improve infrastructure and services to better handle both the existing and the new population. More roads or improvement in present road system should be provided to allow an easy access to markets, schools, clinics, recreational centres, etc.

2. Research and plan for the provision of access to small-scale irrigation schemes in recognition of the need for increasing land productivity where population density has increased.

3. Increase the availability of electricity to public facilities such as schools, hospitals, clinics and possibly permanent dwellings in order to provide a measurable benefit to the local populations.

4. Make provision for supply of piped water to the resettled communities (drawn from the reservoirs and from the Mutonga/Kathita rivers as appropriate).

5. Transport links across the Tana at Katama Bridge will be inundated by the reservoir. The serviceability of the bridge should be replaced by providing an alternative service for people, vehicles and livestock to cross the reservoir.

6. Sexually transmitted and water-related diseases, especially malaria and bilharzia, are predicted to increase. Medical facilities, including mobile clinics and health education programs should be provided for both construction workers and local residents. Piped water should be provided near the reservoir and the value of introducing an mosquito control program should be considered.

11.10.6 Resettlement Recommendations

11.10.6.1 Recommended Approach to Resettlement Plan Implementation

The failure of many resettlement schemes has been due to a lack of planning and serious oversight to ensure that the plan is realistic and is given the priority it deserves. With those shortcomings in mind, we recommend the following approach:

- Establishment of a separate project to deal with the design and implementation of a resettlement plan. One of the common complaints from past projects in Kenya and elsewhere is that insufficient attention is paid to the resettlement process. Instead, other tasks take priority and there is no long-term attention to the of resettlement issues.

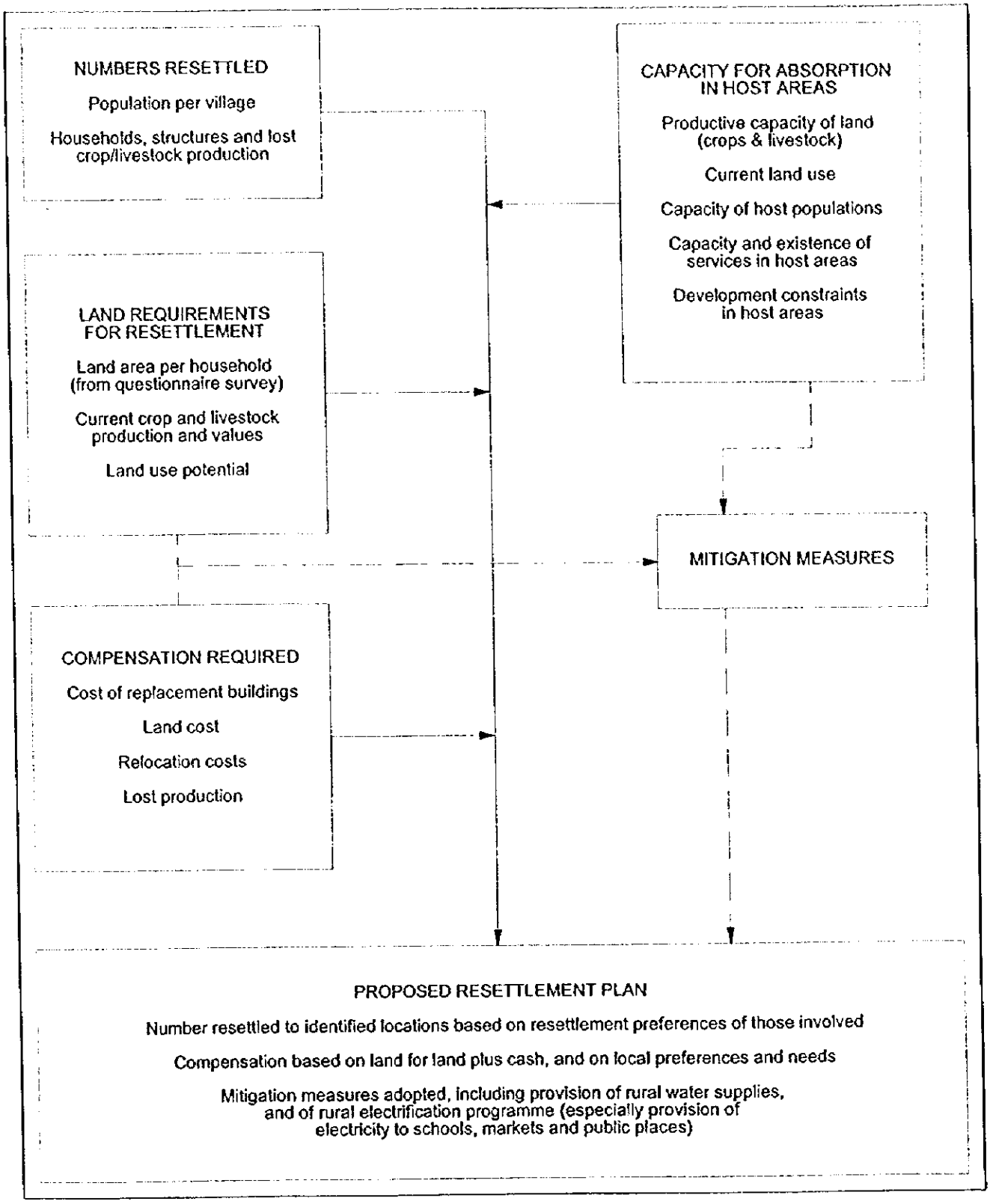
- Ensure that the resettlement effort has its own budget which cannot be used on other tasks.
- Establish a steering committee made up of local leaders and appropriate government officers in addition to development experts to participate in the development of a resettlement plan and to oversee its execution. In the case that a separate project is established, this committee will provide oversight and co-ordination for the project.

11.10.6.2 Recommendations

Based upon the preceding analyses, the following recommendations are presented:

1. Establishment of an institution to oversee the entire resettlement process, provide assistance to both displaced families and host populations and to liase with the government where necessary on their behalf. This group should where possible include local leaders, but not be limited to them.
2. Ensure involvement of the local inhabitants in development of the detailed plan. To the extent possible, allow individuals to negotiate their own plan, recognising the wide variety of needs of different groups of people.
3. Develop a plan consistent with local preferences.
4. Recognise that even though formal land adjudication has not taken place in all areas, the land is nevertheless considered to be owned by the people/households currently working or living on that land. Failure to consider this fact could lead to unsuccessful implementation of the resettlement plans and resulting social unrest and economic problems,
5. Provide a combination of land and cash compensation, and choices within the general framework to allow for personal or community realities. Where land is to be acquired, provide assistance through the local communities for identifying suitable land.
6. Relocation should be primarily to villages in the immediate vicinity. However, due to increased density it should be recognised that grazing activities would likely need to be moved outside of these areas in order to avoid undue hardship on the host population.
7. The Government should begin planning and negotiations with the affected people at least 3 to 4 years prior to the relocation activity.
8. An analysis of retraining needs should be conducted and a retraining program implemented, if justified by the analysis, for some of the displaced population who might wish to pursue new lines of employment.
9. Review of the legal and policy framework on issues related to resettlement and compensation, with recommendations for modification should such be necessary.

Schematic Outline of Proposed Resettlement Plan



Section 3

RESERVOIR ENVIRONMENT

Chapter 12

NATURAL RESOURCES

12. NATURAL RESOURCES

12.1 INTRODUCTION

The Mutonga/Grand Falls Hydropower Project comprises the development of two dam sites on the Tana River downstream of Kiambere as follows:

- approximately 4.5 km downstream of Grand Falls (Grand Falls Dam)
- approximately 2 km downstream of confluence of the Tana and Mutonga Rivers (Mutonga Dam).

Specific aims of this section of the feasibility study were to conduct botanical and fish surveys of the study area and list potential mitigation measurers against likely impacts of the project on the natural vegetation and fish populations of the study area. The study area covered the proposed reservoir areas and surrounding land, a portion of which is proposed as buffer or management zones.

Baseline data were assembled on the natural resources of the study area, describing salient features in terms of flora and fauna and their utilisation. Documentation of riverine habitats was considered especially important since significant areas of former riverine habitat have already been submerged by the five existing reservoirs upstream.

Fish and fisheries form an important resource of the Tana basin, as well as the basis for potential economic benefit resulting from construction of the dams. Some documentation existed describing the fish fauna of the lower Tana and of the existing dams. However, no documentation existed on the fish fauna of the Mutonga and the Kathita tributaries originating from the Mt. Kenya and Nyambene highlands.

A likely major impact of the development of these proposed reservoirs is that it may alter the whole fishery of the Tana River Basin. All along the entire Tana River system fishing of some sort takes place and it is a major economic activity in the lower Tana and its delta region. Impounding the Tana at the proposed sites could result in an adverse ecological impacts as a result of (1) reduction in flooding on the flood plain, and (2) the creation of a barrier to fish migration, and (3) loss of river habitat through transformation to lacustrine conditions. Any remaining links between the lower Tana and the upper reaches of the Tana and its tributaries will be cut off. A number of fish species currently depend migration for feeding and reproductive purposes either as adults or juveniles and interference with migratory routes up the Mutonga and Kathita tributaries may lead to disappearance or extinction of some fish species.

12.2 METHODS

12.2.1 Botanical Survey

Several vegetation attributes were assessed during this study. These included floristic composition, distribution, vegetation structure, conservation status and economic value.

A list of plant species of the study area was compiled from collections and sight records made by the consultant in the field. Species of plants that were not identified in the field were collected, pressed and carried to Nairobi for identification. The collected specimens were later confirmed against herbarium specimen at the East African Herbarium, Nairobi.

Sample plots were used to determine the vegetation structure of the Study Area. Measurements of tree parameters including position along the transect, height, depth and spread of crown were used to draw vegetation profiles of the study area.

A recent Landstat sub-scene was used to compile a vegetation map of the Study Area. Tonal differences, colour intensity, texture and pattern were used to identify and delineate the various vegetation zones of the Study Area. This was enhanced by the analysis of aerial photography. The delineated vegetation units were field-checked through ground truthing.

The list of the recorded plant species of the Study Area were screened for their conservation status according to the IUCN Plant Red Data Book classification. (Lucas & Synge, 1978). The degree of threat was indicated as follows:

Rare:	Species confined to a restricted geographical area or habitat, or thinly scattered over a more extensive range.
Vulnerable:	Species of which most or all populations are decreasing because of over - exploitation, extensive destruction of habitat, or other environmental disturbances, and species that are still widespread but are under threat from serious adverse factors throughout their range.
Endangered:	Species in danger of extinction, whose survival is unlikely if the factors causing their decline continue to operate. Included are species whose numbers have been reduced to a critical level or whose habitats are so reduced that they are in immediate danger of extinction.
Extinct:	Species which are no longer known to exist after repeated searches of the known localities or other likely places.

During the field investigations, interviews were conducted among the Tharaka local experts with a good knowledge of the local plants. The importance of the plant resources to the local community as sources of food, fodder, medicine, fibre, building material and other forms of material culture was discussed and recorded.

12.2.2 Faunal Survey

The consultant made reconnaissance surveys by criss-crossing the riverine habitat, bushland and the forests of the Study Area. All animals observed during the survey

were recorded and photographs taken where possible. The consultant also recorded evidence of animal presence including the occurrence of pellets, droppings, spoors, tracks and feeding activities. In addition, the local people were interviewed for information in regard to the presence of wildlife of the area including the nocturnal species that were unlikely to be sighted during the day.

12.2.3 Fish Survey

Samples of fish were collected from sites shown on Figure 12-1 between August and November, 1995. Sampling was carried out using a combination of gear and fishing methods including:

- a fleet of gill nets (1", 2", 2.5", 3", 3.5" and 4" mesh size).
- 2 seine nets of 0.5 cm and 1.0 cm mesh sizes, respectively.
- 4 set of fyke nets set against the water flow
- 4 sets of traditionally made basket traps (Migono)
- A assortment of baited hooks on line. Bait was usually frogs, intestines of fish, cockroaches, or earth worms.

The fish caught were sorted by species. Where time permitted, individual fish of each species were measured for total length (TL) and fork length (FL) using a fish measuring board and weighed to the nearest gram on portable electronic or mechanical balances. Each specimen was then dissected, sex and stage of gonad development determined, ovaries weighed and stored in 70% alcohol for future counting of eggs; stomachs were examined and the types of food eaten determined. Where time was limiting, fish samples were stored in 4% formalin, returned to the laboratory in Nairobi where they were transferred to 70% alcohol and measurements and other data were taken.

12.3 THE RIVERINE ENVIRONMENT

The study area as shown by Figure 12-2 is dissected by the Tana River and a number of large perennial tributaries including the Mutonga and Kathita rivers which have their confluence with Tana within the area of the proposed reservoirs. The other notable rivers in the study area include the Thingithu and Thanantu which are major tributaries of the Kathita River. Apart from these permanent rivers, there are several seasonal streams which have running water during the rainy season, but dry up partially or completely during the dry season.

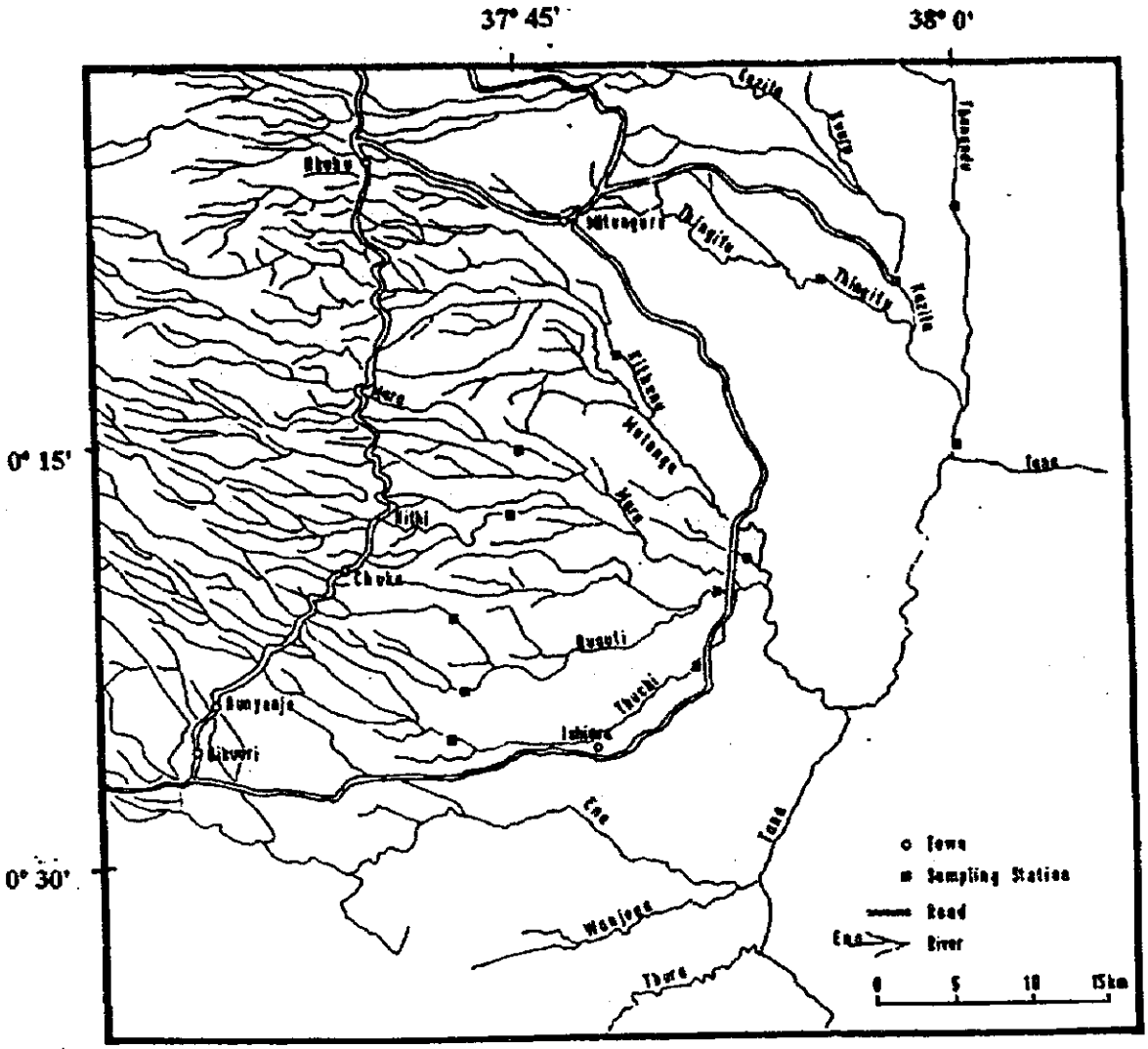
In several places the Tana and its tributaries flow in steep valleys at 50-100 m below the adjacent ridges which have side slopes in excess of 30%. In such cases the influence of the river water is not felt far from the immediate banks due to differences in elevation of river course in relation to the adjacent land.

The Tana and its tributaries are associated with a narrow band of riverine vegetation which is limited in extent, being normally less than 100 m on either bank.. The riparian vegetation of the study area is basically a woodland. This is an open stand of trees over 10m in height and with a canopy cover of 40% or more. The riverine

vegetation is mainly evergreen in sharp contrast with the surrounding vegetation especially in the dry seasons when trees in the bushland have shed their leaves.

The Tana River, its tributaries and the associated riverine habitat support a wide range of plant species and aquatic fauna.

Figure 12-1 Fish sampling stations on the Mutonga and Kathita tributaries of the Tana River.

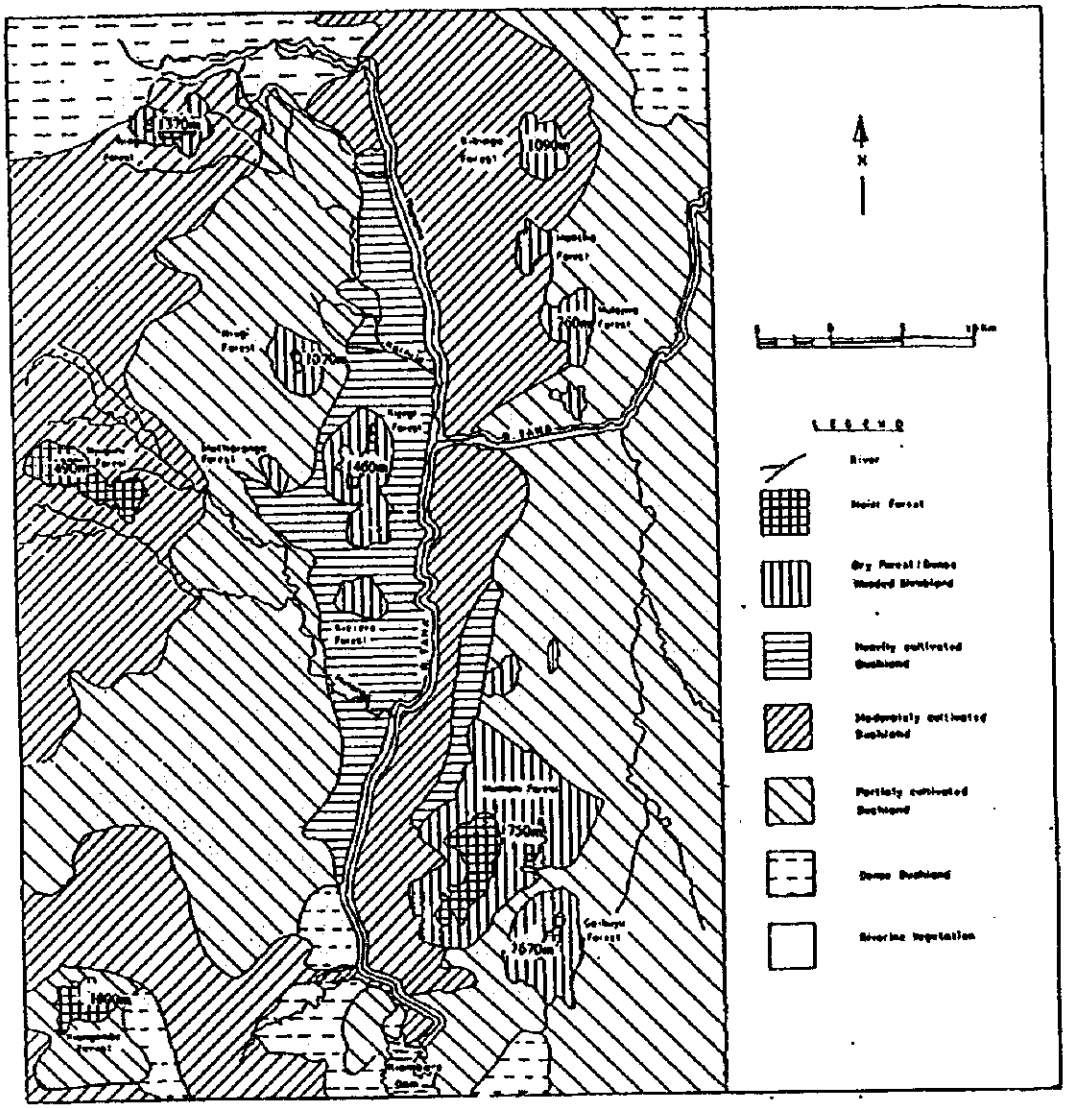


12.3.1 The Riverine Flora

Recorded plant species are listed in Annex 12-1. The list was compiled from collections and sight records made during field investigations in October, 1995. A

total of 431 plant species were recorded during the survey. The recorded plants belong to 90 families of both flowering and non flowering plants as shown in Annex 12-2. The most abundant families of plants are the Graminae (7.7%), Paplionaceae (6.0%), Euphorbiaceae (4.9%) and Acanthaceae (4.2%). Other common families include Mimosaceae (3.9%), Rubiaceae (3.9%) and Compositae (3.7%).

Figure 12-2 Map of the study area showing major land use categories.



The distribution of species in the three major habitats (riverine, forests and bushland) of the study area is showed in Annex 12-3. and summarised by Table 12-1. Out of the total number of species recorded in the study area, 21% are found along the riverine habitat. The plants fall into five growthform categories including the trees, shrubs, herbs, lianas and climbers as shown inTable 12-1. Based on the information presented in Annex 12-3, large plants including trees and shrubs constitute 60% of the riverine flora while the herbs, lianas and climbers form the remaining 40%.

Table 12-1 Distribution of Plant Species by Major Habitats and by Growth Form

Habitat	Percentage (%)Plant Species	Growthforms	Percentage (%) Plant Species
Bushland	51	Shrubs	37
Forest	28	Herbs	35
Riverine	21	Trees	23
		Climbers	3
		Lianas	2

The structure and composition of the riverine vegetation of the study area is represented in terms of vegetation profiles (Figures A12-1 to A12-4 in Annex 12) on four sites along the Tana between Katama and the Grand Falls dam site. In addition, transects were laid to cover the riverine vegetation at Katama, Mutonga dam site, Tana at the Kamanyaki Primary School and the Grand Falls dam site where vegetation parameters of relative density and relative frequency were estimated. The results of vegetation analysis are summarised in Table 12-2.

Most of the larger trees of the study area occur in the riverine habitat. The trees that are strictly confined to the riverine environment are *Ficus Sycomorus*, *Spirostachys venenifera*, *Lawsonia inermis*, *Acacia robusta*, *Phoenix reclinata*, *Newtonia hildebrandtii*, *Diospyros abyssinica*, *Albizia harveyi* and *Garcinia livingstonii*. Other common trees which constitute the riverine vegetation are *Sepium ellipticum*, *Ficus sur* and *Acacia elatior*. Trees found in the riverine habitat but are also common in the adjacent bushland community are *Acacia tortilis*, *Acacia senegal*, *Tamarindus indica*, *Balanites pedicillaris*, *Delonix elata*, *Terminalia brownii*, *Sterculia stenocarpa* and *Adansonia digitata*.

The understorey of the riverine vegetation is dominated by the shrubs, lianas and climbers including *Hippocratea africana*, *Thespesia danis*, *Acalypha fruticosa*, *Lawsonia inermis*, *Harrisonia abyssinica*, *Acacia ataxacantha*, *Entada leptostachya* and *Calotropis procera*.

The herbs found in the riverine environment are mainly aquatic macophytes that are found in water, growing on mud substrate or along the moist river banks. The common aquatic macrophytes were *Polygonum senegalense*, *Polygonum salicifolium*, *Kanaha laniflora* and *Sphaeranthus ukambensis*. *Phragmites karka*, *Phragmites mauritianus*, *Echinochloa haplada*, *Panicum maximum* and *Pennisetum sphacelatum*

are common riparian grasses. The common sedges of the riverine vegetation were *Cyperus immensus*, *Cyperus alternifolius*, *Cyperus articulatus* and *Fimbristylis hispidula*.

Table 12-2 Relative Frequency of Tree Species in the Reservoir Area and Riverine Area

Tree Species	Relative Frequency (%)	
	Reservoir Area	Riverine Area
Ficus sycomorus	24	20
Spirostachys venenifera	13	15
Lawsonia inermis	11	8
Acacia robusta	10	11
Acacia tortilis	9	11
Tamarindus indica	8	15
Phoenix reclinata	6	3
Newtonia hildebrandtii	4	9
Diospyros abyssinica	3	4
Acacia senegal	3	2
Balanites pedicillaris	2	2
Delonix elata	2	
Albizia harveyi	1	
Terminalia brownii	1	
Sterculia stenocarpa	1	
Adansonia digitata	1	
Garcinia livingstonei	1	

12.3.2 The Riverine Fauna

Reports from the local community indicate that the study area formerly supported high densities of wildlife including elephant (*Loxodonta africana*), buffalo (*Syncerus caffer*), rhino (*Diceros bicornis*) and impala (*Aepyceros melampus*). All these large mammals have now disappeared from the study area due to poaching, loss of habitat and other forms of human encroachment.

Wildlife remaining in the study area are presented in Table 12-3 and Table 12-4. The sykes monkey (*Cercopithecus mitis*) and vervet monkey (*Cercopithecus aethiops*) are found amongst the tree canopies of the riverine zone. Several bird species are closely associated with the riverine aquatic habitats. These includes the grey heron (*Ardea cinerea*), pied kingfisher (*Ceryle rudis*), the African fish eagle (*Haliaeetus vocifer*) and Egyptian goose (*Alopochen aegyptiacus*). The Tana River and its tributaries support populations of hippopotamus (*Hippopotamus amphibious*). The African crocodile (*Crocodylus niloticus*) was also recorded. These crocodiles are often found on sandy banks along the rivers where the water is slow moving. Two other reptiles found along the rivers are the African turtle (*Trionyx triungis*) and the monitor lizard (*Veranus nilotica*).

Details of the fish fauna are presented by Section 12.5 below.

Results of a survey carried out on the aquatic fauna of Tana River at Kiambere Dam (ADEC 1983) show that the invertebrate fauna is dominated by adults and larval stages of aquatic insects particularly Hemiptera, Diptera and Odonata. Mayfly nymphs (Ephemeroptera) are also abundant on river sections with rocky substrate. The larvae of the midge *Chironomus* are present in the bottom soft mud of the back water pools. Similar invertebrates fauna are expected to occur in the river system of the study area.

Table 12-3 Animal species recorded during fieldwork in the study area.

Mammals		Reptiles	
Common Name	Scientific Name	Common Name	Scientific Name
Hippopotamus	*Hippopotamus amphibious*	African Crocodile	*Crocodylus niloticus*
Baboon	*Papio anubis*	Monitor Lizard	*Veranus niloticus*
Vervet monkey	*Cercopithecus aethiops*	Agama Lizard	*Agama agama*
Sykes monkey	*Cercopithecus mitis*	African Python	*Python sebae*
Bush Pig	*Potomochoerus porcus*	Black Mamba	*Dendroaspis polylepis*
Warthog	*Phacochoerus aethiops*	Black-necked spitting Cobra	*Naja nigricollis*
Aardvark	*Orycteropus afer*	Leopard Tortoise	*Geochelone pardalis*
Spotted hyaena	*Crucuta crocuta*	African Turtle	*Trionyx triungis*
Dikdik	*Rynchotragus kirkii*		
Ground squirrel	*Euxerus erythropus*		
Porcupine	*Hystrix cristata*		

Note: This list should also be seen within the context of mammal and reptile species recorded in the Kora National Reserve, downstream of Grand Falls, during 1982. In Kora, 57 species of mammal, including 11 small rodent species, and 38 species of reptile were recorded. (Cheptumo et. al. 1986, Cunningham van Someren 1986, Alibhai & Key 1986). A large number of these species are also likely to be present in or near the reservoir area.

12.4 FOREST RESERVES AND BUSHLAND COMMUNITY

12.4.1 Forest Reserves

A forest is a continuous stand of trees at least 10 metres tall with interlocking crowns. The study area generally falls under the Eco-Climatic zone IV which is semi-arid Acacia-Commiphora bushland with low rainfall of 500-700 mm per annum. Such climatic conditions are not suitable for the development of the forest vegetation. However there are several hilly inselbergs in the study area which rise above 1,200m asl and provide wetter conditions for forest development.

The distribution of forests in the study area and environs is shown in Figure 12-2 and Table 12-5. It should be noted that forests are not found within the area of the proposed reservoirs but occur close to, or partly within the proposed management zone bordering the reservoirs on the steep hills of Kijege, Ntugi, Mutaranga and

Kierera on the western side of the proposed reservoirs and Mumoni, Gaikuyu and Mutejwa to the east of the proposed reservoirs.

The most common plant species of the study area including the forests are listed in Annex 12-1 while their distribution in the three major habitats is showed in Annex 12-3 and summarised by Table 12-1. Out of the total number of species recorded in the study area, 28% are found in the forests. Prominent forest trees include *Bridelia taitensis*, *Warburgia ugandensis*, *Pappea capensis*, *Acokanthera schimperi*, *Olea europea*, *Ochna inermis* and *Teclea simplicifolia*. Common shrubs are *Scutia myrtina*, *Tephrosia villosa*, *Acacia ataxacantha*, *Bauhinia taitensis*, *Acalypha fruticosa*, *Pavonia patens*, *Triumfetta tomentosa* and *Abutilon mauritianum*.

Table 12-4 List of bird species recorded in the study area.

Common Name	Scientific Name	Family
African fish eagle	*Haliaeetus vocifer*	Accipitridae
Northern white-tailed lark	*Mirafra albicauda*	Alaudidae
Pied kingfisher	*Ceryle rudis*	Alcedinidae
Egyptian goose	*Alopochen aegyptiacus*	Anatidae
Cattle egret	*Bubulcus ibis*	Ardeidae
Grey heron	*Ardea cinerea*	Ardeidae
Yellow-billed hornbill	*Tockus falavivopstris*	Bucerotidae
Speckled mousebird	*Colius striatus*	Coliidae
Laughing dove	*Streplopelia senegalensis*	Columbidae
Senegal coucal	*Centropus senegalensis*	Cuculidae
Streaky seed eater	*Serinus striolatus*	Fringillidae
Chin-spott flycatcher	*Batis molitor*	Muscicapidae
Southern black Flycatcher	*Melaenornis pammelaina*	Muscicapidae
Variable sunbird	*Nectarinia venusta*	Nectariniidae
Crested guineafowl	*Guttera pucherani*	Phasianiidae
Crested francolin	*Francolinus sephaena*	Phasianiidae
Bearded woodpecker	*Thripias namaquus*	Picidae
Golden backed weaver	*Ploceus jacksoni*	Ploceidae
Black headed weaver	*Ploceus cucullatus*	Ploceidae
Yellow bishop	*Euplectes capensis*	Ploiceidae
White-crowned shrike	*Eurocephalus ruppelli*	Prionopidae
Common bulbul	*Pyconotus barabatus*	Pycnonotidae
Zanzibar sombre grenbul	*Andropadus importunis*	Pycnonotidae
Superb starling	*Spreo superbus*	Sturnidae
Ruppell's robin chat	*Cossypha semirufa*	Turdidae
Brown-chested alethe	*Alethe poliocephala*	Turdidae

Note: This list must be seen within the context of other bird lists made in adjacent areas. In particular, 281 species were recorded in Kora National reserve (Coe & Collins 1986). It is expected that longer periods of study by experienced ornithologists would almost certainly result in a bird list for the area in excess of 200 species.

Virtually all the climbers and lianas of the study area are found in the forest habitats. The common climbers are *Cissampelos pareira*, *Kedrostis foetidissima*, *Dragea abyssinica*, *Keinia kleiniodes* and *Jasminum fluminense* among other climbers. Forest lianas include *Chasmanthera dependens*, *Tiliocora funifera*, *Adenia gummifera*,

Zehneria scabra and *Meyna tetraphylla*. The rest of the forest plants are mainly shade tolerant herbs of which common species are *Gloriosa simplex*, *Commelina bengalensis*, *Panicum denstrum*, *Justicia* flora and *Dichoriste thunbergiiflora*.

The general structure of forest vegetation of the study area is shown in Figure A12-8 in Annex 12. Two basic types of forest are associated with the prominent hills of the study area. These are the dry forest on the lower slopes and the moist evergreen forests on the higher altitudes of Kijege, Mumoni, Gaikuyu and to a small extent on Ntugi hill. The dry forests are mainly dominated by deciduous trees that shed their leaves in the dry season. Towards the lower zones the dry forest grades into a wooded bushland with scattered trees. The moist evergreen forests are mainly dominated by evergreen broad-leaved trees. These forests develop at altitudes above 1,000 m a.s.l. where conditions are wetter and the temperatures cooler.

Table 12-5 Distribution of Forests in the Study Area

Forest	Ownership	Area (ha)	Conservation Status
Mumoni Hill (Mwingi)	Govt. land	2	Gazetted (1938)
Mumoni (Mwingi)	Govt. land	10,441	Gazetted (1993)
Gaikuyu (Mwingi)	Trustland	3,075	Gazetted (1993
Kierera (Tharaka- Nithi)	Trustland	793	Gazetted (1959)
Kijege (Tharaka-Nithi)	Trustland	3,296	Gazetted (1959)
Mutejwa (Tharaka-Nithi)	Trustland	1,376	Gazetted (1959)
Mutaranga (Tharaka-Nithi)	Trustland	300	Gazetted (1959)
Ntugi (Tharaka-Nithi)	Trustland	1,379	Gazetted (1959)
Njuguni (Tharaka-Nithi)	Trustland	2,003	Gazetted (1959)
Maatha (Tharaka-Nithi)	Trustland	2,003	Gazetted (1959)
Kikingo (Tharaka-Nithi)	Trustland	1,234	Gazetted (1959)

Sources: UNEP Country Biodiversity Studies (Kenya) in Situ conservation Report, 1991. Ministry of Environment and Natural Resources, Forest Department, Karura

12.4.2 Forest Fauna

The more commonly encountered wildlife of study area are listed in Table 12-3. The animals that are mainly found in the forests are the Sykes monkey the Vervet monkey and the baboon. The bushpig (*Potomochoerus porcus*) and the Warthog (*Phacochoerus aethiops*) are also common residents of the forest habitat. Most of the birds listed in Table 12-4 except the fish eagle (*Haliaeetus vocifer*) cattle egret (*Bubulcus ibis*) grey heron (*Ardea cinerea*) pied kingfisher (*Ceryle rudis*) and the Egyptian goose (*Alopochen aegyptiacus*) will be associated with the forest habitat especially the dry forests of the lower hill slopes of the Mountains.

12.4.3 Bushland Community

A bushland is a vegetation type dominated by an assemblage of woody plants of 3-7 m high with a canopy cover of 40% or more. Emergent trees are dotted in the bushland community while the ground layer is covered by grasses and other herbs. The dominant vegetation of the study area is the Acacia/Commiphora bushland. Part of the bushland community together with the strip of riverine vegetation will be submerged upon the commissioning of the two reservoirs.

The bushland community includes a large number of plant species listed in Annex 12-1. Out of the total number of plant species recorded in the study area 51% are found in the bushland (see Annex 12-3 and Table 12-1). Based on these data, the trees and shrubs constitute 55% of the bushland flora while the herbs (mainly grasses) constitute most (43%) of the remainder. The climbers and lianas are very few in the bushland vegetation and each group contributes 1% or less.

The structure of the bushland vegetation is shown in the vegetation profiles of Figures A12-5 to A12-8 in Annex 12. The most abundant trees of the bushland community are listed in Table 12-6. These trees form a community of emergents dominated by *Acacia tortilis*. Other common trees scattered in the bushland community are *Balanites pedicillaris, Hyphaene compressa, Sterculia stenocarpa, Adansonia digitata* and *Terminalia brownii.*

The middle layer of the bushland canopy is dominated by shrubs of *Commiphora africana*. Shrubs of *Lannea alata* are also extensive in the bushland community. Other common shrubs include *Boscia coriacea, Combretum aculeatum, Acacia* senegal, Acacia *brevispica, Grewia villosa, Carissa edulis* and *Capparis tomentosa.*

The floor of the bushland community is covered by herbs of which the most common are grasses. The major grasses of the bushland are *Aristida kenyensis, Brachiria deflexa,* Cenchrus *ciliaris, Chloris roxburghiana, Dichanthim insculptum, Digitaria milanjiana Diheteropogon amplectus, Eragrostis superba* and *Heteropogon contortus.*

Table 12-6 Density of Common Tree Species in Bushland Community of the Reservoir Area.

Tree Species	Density (trees/10 ha)	Relative density (%)
Acacia tortilis	18	26
Balanites pendicillaris	13	19
Hyphaene compressa	11	16
Sterculia stenocorpa	5	7
Adansonia digitata	4	6
Delonex elata	4	6
Terminalia brownii	4	6
Acacia senegal	3	4
Tamarindus indica	2	3
Dalbergia melanoxylon	2	3
Acacia robusta	2	3
Total	68	100

12.4.4 Bushland Fauna

Most of the mammals and reptiles and many of the birds listed are residents of the bushland habitat. Exceptions are hippo, crocodiles, turtles, monitor lizards and aquatic birds that are associated with riverine environment. Others are the primates (baboons, Sykes and Vervet monkeys) that are more normally associated with forests and the riverine tree canopies.

The common mammals of the bushland community are the dikdik (*Rynchotragus kirkii*), the ground squirrel (*Euxerus erythropus*) and the porcupine (*Hystrix cristata*). Some of the reptiles found in the bushland community are African python (*Python sebae*), leopard tortoise (*Geochelone pardalis*), agama lizard (*Agama agama*) and several snakes.

12.5 FISH FAUNA

Mutonga dam will capture water flows from the Tana outflow from Kiambere dam and from the Mutonga River whilst the Grand Falls dam will capture outflow from Mutonga dam and from the Kathita tributary system. One of the objectives of the present Environmental Impact Assessment was to gather data on current fish resources in the Tana and its tributaries in the vicinity of the proposed reservoirs, to assess the nature and scale of potential environmental impacts and to propose appropriate mitigation measures.

12.5.1 The Fish Fauna: Survey Results

12.5.1.1 Diversity of Fish Species

Ten different fish species were caught and identified in the Mutonga and Kathita tributaries of the Tana river in August, September and November 1995. These species are shown in Table 12-7.

Table 12-7 The fish species occurring in the Mutonga/Kathita tributaries of the Tana River, Kenya, 1995.

Species Name	English Name	Vernacular Name
Anguilla bengalensis/nebulosa	African mottled eel	Mukunga
Mormyrus Kannume	Elephant snout fish	Surufina
Barbus gregorii	Barbus	Mbamba
Barbus oxyrhynchus	Barbus	Mbamba
Barbus mathioae	Barbus	Mbamba
Labeo cylindricus	African carp	Ntira
Alestes affinis	Alestes	none
Amphilius grandis	Mountain catfish	Kiambara
Clarotes laticeps	Broadhead catfish	Ndomo
Oreochromis sp.	Tilapia	Tilapia

12.5.1.2 Abundance

With no previous records of fish catches from Mutonga and Kathita tributary systems of the Tana in the Kenya Fisheries Department landing statistics, it is difficult to provide reliable abundance data on the fish species occurring in this region. However from the experimental fishing done during the survey period (14 days) *B. oxyrhynchus* and *L. cylidricus* were the most abundant species of a commercial size range. The mountain catfish, *A. grandis*, is also abundant in the upper reaches of the streams especially beyond the Thuci-Meru tarmac road into the Mount Kenya forest. The other species occurred in numbers less than one hundred caught during the survey period using a combination of gear. Numbers of fish caught are summarised in Table 12-8.

Table 12-8 Numbers of fish caught during the survey period in the Mutonga and Kathita tributaries of the Tana River, Kenya 1995.

	Tributaries / River								Total
Species	Thuci	Ruguti	Mutonga	Kathita	Tana at Grand Falls	Naka	Tungu	Thamia	
A. bengalensis	8	2	-	3	-	-	-	-	13
M. kannume	52	-	-	27	-	-	-	-	79
B. gregorii	-	-	21	-	-	-	-	-	21
B. oxyrhynchus	684	1395	148	503	45	-	-		2,775
B. mathioae	-	-	47	-	-	-	-	-	47
L. cylindricus	155	-	162	942	4	-	-	2*	1,265
A. affinis	-	-	-	47	-	-	-	-	47
A. grandis	93	-	-	-		947	693	1,035	2,768
C. laticeps	-	-	-	-	84	-	-	-	84
Oreochromis sp.	-	-	-	-	8	-	-	-	8

* Juveniles measuring 9.4 and 8.2 cm, respectively.

12.5.1.3 Distribution

The distribution of the fish species caught during the survey period indicates that *B. oxyrhynchus* and *L. cylindricus* occur in all the Mutonga/Kathita tributaries. Similarly, the catfish *A. grandis* occurs in the upper reaches of all the streams towards the edge of the Mt. Kenya forest from about the altitude beyond 4,500 ft above sea level. The 93 individuals of the species caught in Thuci River was at the bridge near Ishiara market during the rains. The fact that they did not occur here during the dry weather confirms a belief that during the rains, the strong currents associated with the increased volume of water carry down the mountain catfishes to the lower reaches of these rivers. Whether this forms part of a necessary migration is at present unclear.

B. mathioae and *B. gregorii* were only caught in the Mutonga river. The elephant-snout fish, *M. kannume* was only caught in Thuci and Kathita rivers while *A. bengalensis* were caught in Thuci, Ruguti and in the Tana at Grand Falls. However, there is no apparent reason why these species were not caught in all the streams especially around the confluence of Thuci, Ruguti, Mara and Mutonga. It is thought that their absence from these sites may be due to insufficient sampling over a relatively short period.

However, fish species may have very specific niches. For example *C. laticeps, A. affinis* and *S. mossambicus* were caught only in Tana at Grand Falls. These species have been reported below Grand Falls in Kora National Park, and there is no reason why the majority of those recorded at Kora should not also occur at Grand Falls. Table 12-9 shows the recorded species composition of fish communities throughout the Tana River system excluding marine species. Nine species were caught in the Tana Delta, eleven species occurred in the exisitng Tana River dams, twenty one species were caught in a 90 km stretch of the Tana River spanning the Kora Rapids above Garissa in 1982 (Campbell *et al.*, 1986) and ten species were caught in the Mutonga and Kathita tributaries during the present survey.

It is interesting that young boys fishing in the smaller streams such as Naka, Thamia and Tungu for the mountain catfish have, since 1994, started catching juvenile *L. cylindricus*. One fishermen, Mr. Munene Bore, informed the fish survey team that when these juveniles were first caught near Chuka Town on Thamia stream all the young boys fishing for mountain catfish stopped fishing and eating fish all together suspecting that these alien fish could be poisonous since nobody had seen them before. This may be the result of downstream environmental changes, or a change to migratory habits - perhaps in response to the building of Kiambere dam. A monitoring program for this migratory phenomenon and possible environmental change needs to be initiated.

12.5.1.4 Size-Frequency Distribution

A standard means of determining the structure of fish populations is by analyzing their size frequency distribution. Length is related to age and to overall nutrient levels in the rivers, and is also an important parameter of fishery management models.

Figure A12-9 in Annex 12 shows the length frequency distribution of B. oxyrhynchus from Thuci, Ruguti, Mutonga and Kathita rivers. Individuals of this species reach small sizes in Ruguti and Kathita while some large specimens reaching 30 cm total length and above were caught in Thuci and Mutonga.

As shown by Figure A12-10 in Annex 12, L. cylindricus caught in Kathita tributary had size frequency distribution characterized by three, or possibly four, clearly discernible peaks. The small sizes in Kathita and Thuci indicate breeding populations in these rivers. That the population from Mutonga is also a breeding population was indicated by an abundance of large individuals caught with ripe ovaries. The absence of small individuals in samples from this river may be the result of inadequate sampling, or alternatively may indicate irregular breeding cycles.

The other species with an appreciable size range is A. grandis (Figure A12-11 in Annex 12). Tungu stream had a more normally spread population. Specimen of samples from Thamia and Naka streams had similar distribution although Thamia feeds into Tungu while Naka feeds into Ruguti. Therefore whether these are two district population is another matter for future investigation.

Lower than 3,500 ft a.s.l. the occurrence of mountain catfish, *A. grandis*, is rare and occurs only during the rain seasons. This probably explains the occurrence of 93 specimens of the species in Thuci in the height of the rains in mid-November 1995.

The eels (*A. bengalensis*) occur in two distinct size classes. The larger class comprised adults of a size range 102 - 120 cm, all of which were caught during the dry period in August/September, and the juvenile small eels caught during the height of the rains in mid-November 1995. These juveniles were in the length range 54-60 cm. The remaining species sampled were recorded in small numbers and had relatively narrow size distributions as shown by Table 12-10.

Table 12-9 Inventory of the freshwater fish fauna of the Tana River, Kenya.

	Upper Dams	Mutonga/Kathita	Kora[1]	Delta
Alestes affinis	-	+	+	-
Amphilius grandis	-	+	-	-
Anguilla bicolor	+	-	-	+
Anguilla bengalensis/nebulosa	-	+	+	-
Barbus gregorii	-	+	-	-
Barbus mathioae	-	+	-	-
Barbus oxyrhynchus	-	+	+	-
Barbus tanensis	+	-	-	-
Barbus zanzibaricus	-	-	+	-
Barbus sp. (unidentified)	+	+	+	+
Chiloglanis brevibaris	-	-	+	-
Clarias mossambicus	+	-	+	+
Clarotes laticeps	-	+	+	-
Cyprinus carpio[2]	+	-	-	-
Discognathus sp.	-	-	+	-
Engraulicipris fluviatilis	-	-	+	-
Eutropius depressirostris	-	-	+	-
Glossogobius giuris	-	-	+	-
Gnathonemus macrolepidotus	-	-	+	-
Labeo cylindricus[3]	+	+	-	+
Labeo gregorii	-	-	+	-
Labeo mesops	-	-	+	-
Labeo victorianus[4]	+	-	-	+
Labeo sp. (unidentified)			+	
Lebistes reticulatus	-	-	+	-
Momyrus Kannume	+	+	+	+
Oreochromis esculentus[2]	+	-	-	-
Oreochromis niloticus[2]	+	-	-	-
Oreochromis spilurus[5]	+	+	+	-
Petrocephalus catastoma	-	-	+	-
Protopterus amphibius	-	-	-	+
Schilbe moebiusii	-	-	-	+
Synodontis multipuntatus	+	-	-	-
Synodontis sp.	-	-	+	-

[1] Campbell *et al.*, 1986.

[2] Introduced species.

[3] *Labeo cylindricus* may be synonymous with *L. gregorii* (Copley 1958).

[4] This species may be misidentified since it is thought to occur in rivers flowing into L. Victoria.

[5] Sarotherodon mossambicus was also recorded but this is thought to be a misidentification of *Oreochromis spilurus*.

Table 12-10 The range of sizes for less frequently caught fish species in the Mutonga and Kathita tributaries, 1995.

Species	Size range (total length)
Alestes affinis	11-15 cm
Barbus mathioae	20-21 cm
Barbus gregorii	24-25 cm
Clarotes laticeps	26-32 cm
Momyrus Kannume	29-34 cm
Oreochromis sp.	19-20 cm

12.5.1.5 Breeding Ecology

For the survival of these fish species in these rivers, there must be breeding success. Physiological factors as well as factors such us food availability, water temperature, and location of the spawning ground interact in complex ways to ensure reproductive success. These factors control egg growth and development and also determine the timing of spawning. Although the short duration of the present survey did not enable definition of breeding seasons or spawning times, it can be said with certainty that a majority of species recorded in this area also breed in these streams as shown by Table 12-11.

The spawning location for most of these species, except the eel, must be somewhere in the Tana River system. At least it is known with certainty that both *Labeo cylindricus* and *Amphilius grandis* breed almost within the localities they were caught. Long term studies, covering periods of at least one year, are needed to fully address the breeding pattern/times of the fishes of Mutonga/Kathita tributary system. Such studies must also encompass the study of the trophic relationships especially amongst the fishes and with the benthic invertebrate fauna.

12.5.2 Migratory Fish Species

12.5.2.1 Nature of migrations in fish.

Migration is a category of large-scale movement by which fish to return to specific areas or habitats, usually in order to breed. Studies of migration are fundamental in fisheries ecology because the migration circuit delimits the area in which the stock or population of fish lives. At this point it is important to note that "migrations" contrast with "emigrations" which are movements of fish which entail changes of environments, but which do not involve return to the region from which the emigrants came from originally.

In some species mature fish have spectacular migrations for "spawning" and / or "feeding". This means that they breed in one area and grow up and feed in another. In addition to spawning and feeding migration another category, "osmoregulatory migration" is recognized. This later category includes "anadromous" fish such the

salmon, which return to freshwater to spawn, and the "catadromous" fish such as the eel which leaves the fresh waters to spawn in the sea. These eels feed in freshwater until sexual maturation occurs when they stop feeding and undertake extensive downstream migration across the estuaries into the deep sea where they spawn and usually die. Eggs then hatch into young eel larvae called "leptocephali" which drift with ocean currents to the coastal margins. Here the leptocephali grow and metamorphose into "elvers" which ascend the rivers and streams where they grow and mature.

Table 12-11 Reproductive status of some fish species in Mutonga and Kathita tributaries of the Tana, 1995.

Species	Breeding status
Labeo cylindricus	Mature males and females, in samples. Larval stage were caught. Juveniles caught in streams at edge of Mt. Kenya forest.
Amphilius grandis	Mature males and females caught. Some fish had released their eggs by September
Barbus gregorii	Mature fish with eggs
Barbus oxyrhyncus	Mature fish with eggs
Barbus mathioae	Mature fish with eggs
Clarotes laticeps	Mature fish with eggs
Mormyrus Kannume	Mature fish with eggs
Allestes affinis	All immature
Anguilla bengalensis	No evidence of gonad development, but young eels caught in mid-November
Sarotherodon mossambicus	All immature

12.5.2.2 Migratory fish of the Tana

Amongst Tana River fishes the only fishes known to undertake large-scale migrations are the freshwater eels. Three species of eels are thought to inhabit the Tana River. In this study all the specimens caught were *Angiulla bengalensis (nebulosa).* Large specimens of *A. bicolor bicolor* are reported from the existing dams and a specimen measuring 80 cm total length and weighing 1.1 kg was caught in mangrove creeks in Gazi during the Kenya-Dutch Expedition in July, 1992. Very little is known about the biology of the eels in the Tana River and the adjacent marine waters at the coast. However, based on the specimens of *A. bengalensis* that were caught during the survey period, the specimens in the length class 102 -120 cm total length were most certainly resident population growing to attain sexual maturation. The other class in the size range 54-60 cm total length comprised young eels which had migrated upstream from the sea recently.

Several other fish species undertake short-term up or downstream movements in response to changes in the hydrological regime. *Clarias mossambicus* are known to breed in flooded areas, and many species of *Barbus* and *Labeo* are known to move upstream during periods of high flow in order to breed. *Amphilius grandis* are normally carried downstream following heavy rains. It is most likely that this is a normal part of their annual / seasonal cycle.

12.5.3 Lessons From The Existing Reservoirs

The fisheries of the existing Tana River dams and those at the Delta including marine fish landings were reviewed during the second phase of the Environmental Assessment of the Grand Falls Hydropower project. The data reviewed covered the period 1989 to 1993 and these have been updated by incorporating the 1994 fish landing from the existing dams.

The potential fisheries benefits of the proposed reservoirs are likely to have some similarities to the upstream dams. However, the situation of the proposed reservoirs at the lowest altitude of all the Tana River dams will result in differences in productivity and management requirements. The proposed dams will be the only ones to receive major inputs from urban and agricultural catchments. The reservoirs will be typically tropical, high nutrient load, warm water dams with the attendant management problems of eutrophication, deoxygenation and waterweed control.

The climatic and edaphic conditions of the cascades remain basically similar but a variety of unique morphometric conditions exist in every reservoir. The Masinga Reservoir has a strong thermal stratification relatively close to the surface showing classical clinograde curves with hypolimnetic anoxia in the deepest area below 30 m.

The composition of the plankton community and of the Crustacean zooplankton in the three existing reservoirs is similar (Table 12-12), although Kiambere is richer in diversity than Masinga. All reservoirs were dominated by the cyclopoid copepods *Thermocyclops decipiens* and *T. cosmilis*. The calanoid copepod *Tropodiaptomus asimi* and *Mesocyclops sp.* occurred intermittently.

The dominant phytoplankters in the Masinga and Kamburu Reservoirs are blue green algae particularly *Cyclotella spp.*, *Tetraedon sp. Microcystis* and *Cylindrospermopsis sp.* Chlorophyll a concentration ranged between 8.3 µg/l in Masinga to 19.2 µg/l in Kiambere. Cyanobacteria are dominant among the phytoplankton in Kamburu and in particular *Microcystis sp.* and *Anabaene sp.* This high abundance has been associated with nutrient enrichment from the inflows of the Thiba River which traverses the Mwea Irrigation Scheme.

Zooplankton biomass, which forms the primary food basis for the juveniles of these reservoir fisheries, is highest in Kiambere with values ranging from 320 to 360 mg/m^3. Other invertebrates found in the plankton samples are the dipteran larvae *Chaoborus* and flatworm *Mesostoma*. The littoral communities are rich in aquatic insects, both in their larval (nymphal) and adult stages. In particular *corixids odonates* and mayflys are abundant.

Table 12-12 Dominant Plankton Groups in the Upper Dams

Phytoplankton Species	Masinga	Kamburu	Kiambere
Peridinium sp.	2+	2+	+
Nitschia sp.	5+	2+	2+
Tetrahedron sp.	+	4+	2+
Microcystis sp.	+	8+	2+
Pediastrum sp.	+	+	2+
Melosira sp.	+	2+	3+
Ceratium sp.	+	2+	3+
Closterium sp.	-	+	2+
Synedra sp.	-	+	2+
Botryococcus sp.	-	+	3+
Cyclotella sp.	+	3+	+
Zooplankton species			
COPEPODA			
Thermocyclops	3+	2+	3+
Tropodiamptomus	3+	2+	+
CLADOCERA			
Diaphanosoma	+	+	5+
Moina	+	2+	4+
Ceriodaphnia	+	+	2+
ROTIFERA			
Brachionus	+	+	3+
Polyarthra	+	+	2+
OTHERS			
Chaoborus	+	+	2+
Mesostoma	+	+	+

Degree of abundance in scale 1-10.

The conclusion is that the existing reservoirs support a full array of food organisms and as a result support large fish communities with high or potentially high fisheries output. The following species have been recently recorded or found in the reservoirs during the surveys:

Indigenous Species

Cichlidae — *Oreochromis spilurus is* the most common fish species in all the three dams. However the communities in both Kamburu and Kiambere are breeding at a very small size < 10 cm, which indicates a stressed population. *Oreochromis* are phytoplankton and fine detritus feeders, and are maternal brooders.

Mormyridae — This family is represented by *Momyrus kanume*, *Petrocephalus catostoma* and *Marcusenius macrolepidotus*, which are endemic to the Tana River. They are bottom feeders. *Marcusenius* feeds mainly on insect larvae and *Petrocephalus* feeds on insect larvae and zooplankton.

Cyprinidae — This family is represented by *Barbus tanensis* which is endemic to Tana River. It is an opportunistic feeder. *Labeo cylindricus* is dominant in Kiambere dam, feeding on benthic micro-organisms such as Diatoms, microcrustaceans, rotifera and detritus. *L. victorianus* is also reported to

occur, but this may in reality be a misidentification of another species.

Clariidae — *Clarias mossambicus* is found intermittently in all the dams and forms a substantial component of the fisheries. It is an endemic bottom grubber. It digs the mud in search of insects and insects larvae, crustacean, mollusc, fish and plants detritus. Its feeding habits and its capacity to breath atmospheric oxygen enable them to live in near anoxic environment conditions.

Anguillidae — Eels have been reported occasionally by fishermen in all the dams. Three species of eel are recorded from the Tana. *Anguilla bengalensis* (or *nebulosa*), *A. bicolor* and *A. mossambica*. Of these only the first species is regularly recorded. Eel populations remaining in the dams are likely to be limited to older fish. Dam construction is thought to have prevented upstream movements of elvers and without recruitment eel populations of the reservoirs and upper catchment will disappear.

Introduced Species

Cichlidae — Tilapine fishes largely belong to the genus *Oreochromis*. *O. niloticus* is one of the most popular for culture and for stocking dams, and naturally the most introduced of all tilapine species. *O. leucostictus,* a relatively smaller species which also occurs in the three dams; is resistant to low dissolved oxygen concentrations. Other species found in the upper dams include *Tilapia zilli* and *T. rendalli* which are virtually indistinguishable in appearance and habit. The situation is further confused where both species are present, as in Masinga Dam, because they appear to hybridise freely. Both species eat higher plants. *Tilapia* are zooplankton feeders until they reach 50 mm length, then become omnivorous (weed, zooplankton, insect larvae and macrophytes) until 100 mm length. Beyond 100 mm *Tilapia* are mainly macrophyte feeders (if there are macrophytes) or they feed on detritus.

Cyprinidae — The other fish species found commonly in all samples is *Cyprinus carpio*, introduced to Kenya from Uganda in 1969. It has been criticised for its digging habits which cause turbidity and deoxygenated conditions in fish ponds and dams.

In addition to the above species a few specimens of guppies *Poecilia reticulata* and *Haplochromis sp.* were reported in seine net samples particularly in 1993 at Masinga dam.

12.5.3.1 Trends in fish landings

Statistics of fish landings from the Tana River dams during the last 6 years (Table 12-13) show that on average 993 mt. of fish were landed annually with Masinga Dam alone contributing 77% (863 mt./yr) with the rest coming from Kamburu (13%) and Kiambere (10%). For Masinga and Kamburu the trends in the annual fluctuations of the landings follow the same pattern where, after significant increases in the landing from 1989 to a peak in 1991 the landing dropped appreciably in subsequent years. For Kiambere, where

there are no records until 1990, fish landings rose sharply from only 13.5 mt. to 63 mt. in 1991, 138 mt. in 1992 to a peak of 247 mt. in 1993 and 1994, respectively. Kiambere dam is younger than Masinga and Kamburu dams and its fish community is clearly still evolving to reach a stable state.

Tilapia have dominated the fishery in the dams. Since 1989 they have accounted for 844 mt (74%) on an annual average bases followed by the common carp, *Cyprinus carpio*, which has annually contributed an average of 205 MT (18%) and the mud-fish, *Clarias mossambicus* (4%). The remainder, equivalent to only 1% of the overall fish landings, largely consists of *Labeo victorianus, L. cylindricus, Mormyrus kannume, Barbus* spp. and the eels principally *A. bengalensis*. In essence the fishery of the existing dams is highly dominated by introduced species.

The landings for Tilapia rose dramatically from 1989 to a peak of 1,218 mt. and 121 mt. in Masinga and Kamburu, respectively, in 1991 (Figure). This was followed by a significant drop after which the recorded catches have remained relatively stable at around 500 mt. per year. Similar decline in the landings of tilapia also occurred in Kamburu. While there does not seem to be a definitive trend in the landings of the common carp in Masinga, landings in Kamburu have steadily fallen from 26 mt. in 1989 to 13 mt. in 1994. Landings for all species in Kiambere Dam have been increasing since records started in 1990.

Fish and fisheries of the Tana River dams up to 1987 were reviewed by Dadzie and Odero (Unpublished). Although the data available at that time was sparse and fragmented they reported that catches of the Tilapia and the common carp were already declining due to over-fishing. They further postulated that sediment accumulation in the dams favors the expansion of the common carp (a benthic feeder) fishery to that of zooplankton and phytoplankton feeding Tilapia. Their data also showed that *Clarias* did not feature in the fishery. *Clarias mossambicus* was first reported in the fishery statistics of the Tana River dams in 1986.

Figure 12-3 Recorded fish landings for existing Tana River Dams: 1989 - 1994.

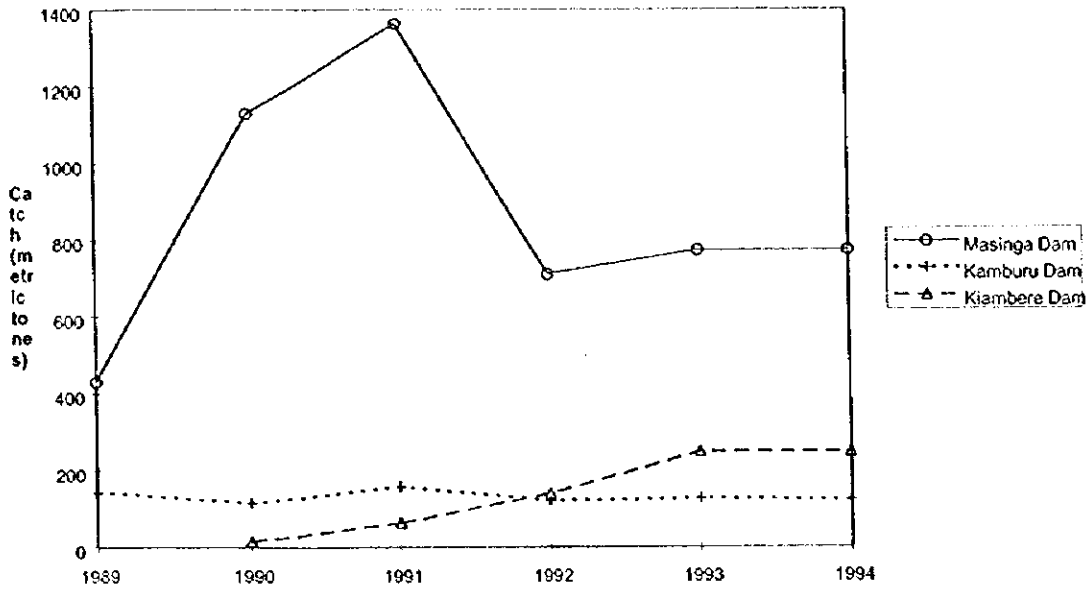


Table 12-13 Fish landings (metric tonnes) for existing Tana River Dams:1989 - 1994.

		1989	1990	1991	1992	1993	1994
Masinga Dam							
	Tilapia	275	913	1218	545	538	563
	C. Carp	129	192	108	133	212	186
	Clarias	26	22	34	29	19	21
	Others	1.5	2.5	2	2.5	2	2
	Total	**431.5**	**1129.5**	**1362**	**709.5**	**771**	**772**
Kamburu Dam							
	Tilapia	98	76	121	88	95	88
	C. Carp	26	26	19	16	18	13
	Clarias	17	1	15	12	7	15
	Others	2	11.5	2.5	4.5	5	6
	Total	**143**	**114.5**	**157.5**	**120.5**	**125**	**122**
Kiambere Dam							
	Tilapia		5	39	82	159	163
	C. Carp		6	4	40	56	48
	Clarias		1	13	8	17	23
	Others		1.5	7	7.5	15	13
	Total		**13.5**	**63**	**137.5**	**247**	**247**

Source: Statistics Section, Fisheries Department (Kenya), 1995

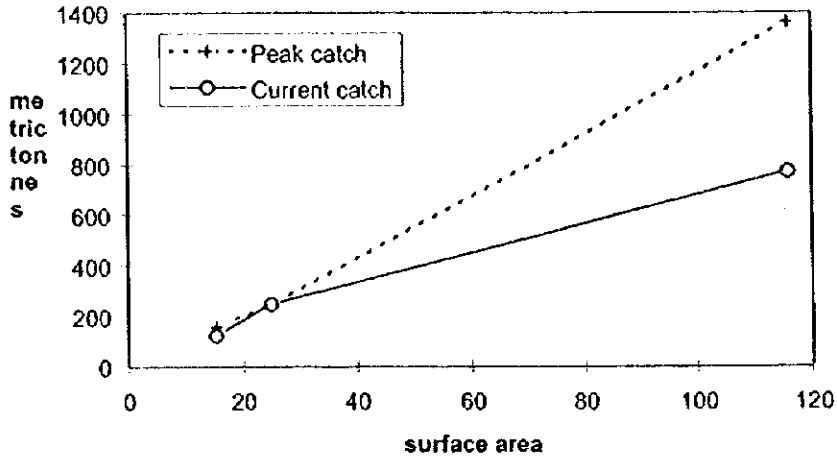
12.5.3.2 Fisheries Potential of the proposed Reservoirs

It is most likely that the three species currently dominating the fishery of the existing dams will also dominate the fishery of the proposed dams, and that the existing riverine species will play only a minor role in the overall fishery production. It is presently unclear what will happen to the fishery of these species in the Mutonga and Kathita tributaries, which the present survey discovered is significant but unrecorded. While the numbers of the majority of the riverine species are likely to decrease after the construction of the dams due to reduced opportunities for upstream and downstream movements, it is certain that eels will eventually disappear completely from the upper reaches of the Tana above Grand Falls once the dam is constructed.

During the filling phase, and during the initial years of operation large reservoirs are normally associated with a dramatic rise in the population of those fish species that are adapted to living in the newly created lacustrine conditions. Fish populations reach a peak but subsequently decline when the initial burst of nutrient release from dead vegetation is over. Current catches represent figures that are likely to most closely resemble the stable catches expected following early peaks, although fish catches in Kiambere may still reflect this early peak. The potential fishery output was based on current total recorded catch (1994 figures) from Masinga, Kamburu and Kiambere, and the relationship between these catches and the area of the three reservoirs (Figure 12-4). The combined catch that might be expected from Mutonga and Grand Falls (Low)

reservoirs, after a drop from the initial peaks, was calculated at about 530 metric tonnes per annum. The exact species composition may differ to some extent from exisitng reservoirs due to the lower altitude and generally higher temperatures that will be experienced in the proposed reservoirs. However, the dominance of Tilapia in the existing reservoirs is most likely to be reflected in catches from the proposed reservoirs.

Figure 12-4 Relationship between recorded fish catch (1994) and surface area of three existing reservoirs: Masinga, Kamburu and Kiambere.



12.6 ECONOMIC, SOCIAL AND CULTURAL UTILIZATION OF NATURAL RESOURCES

12.6.1 Plant and Animal Resources

The Tharaka people who are the inhabitants of the land to be covered by the proposed reservoirs utilize their natural resources as dictated by their culture and the prevailing environmental variables. Although the Tharaka people keep cattle and goats, they are primarily agriculturalists growing mainly bulrush millet, sorghum, maize, beans, cow peas and pigeon peas mainly using shifting cultivation. In addition to the above occupation, the Tharaka people possess tremendous wealth of knowledge on their natural biological resources which they use to good effect in their daily life.

In the past when wild game was plentiful in the study area the Tharaka people used to hunt the animals to supplement their protein requirements. Today the wild game has been decimated and hunting is no longer a significant activity of the Tharaka community.

The plant species of the study area however, present a unique plant diversity which is utilized extensively by the local community. A survey of the plant species in the

reservoir area used by the Tharaka people was made by the consultant during the present investigations. The results of this survey are presented below. Close to 20% of total number of plants in the study area, including trees, shrubs, herbs, grasses, climbers and lianas are commonly utilized by the local community to supply a wide range of needs.

The plants form an important part of the resources base of the local community and a large percentage of material culture is derived from them. This includes materials used as sources of food, fodder, fuelwood, building material, medicine, fibre, furniture, tools, weaving material, timber and many other supplies as discussed below.

12.6.2 Utilization of Plant Resources in the Reservoir Area

Many of the plant species found in the area have specific uses, some of which directly or indirectly support important economic activities, e.g. the leaves of *Hyphaene compressa* are used for weaving mats, baskets and hats, and is an important tree for generating cash - especially for women. A significant proportion (21%) of these useful species will be either removed entirely by the flooding of the reservoir, or their available habitat will be severely reduced. The list below documents the known uses of a number of the plant species recorded in the area, whilst their occurrence by major habitat is summarised in Table 12-14.

Table 12-14 Proportion of known useful plant species by major habitat

Habitat	Proportion of species (%)
Riverine	21
Bushland	62
Forest	17

However, this 21% of species that will be severely impacted by the impoundment of the reservoirs, does not indicate their relative economic importance, and it is recognised that the greater proportion of plant species with high economic importance occur in the riverine zone.

Plant Species	Tharaka name	Uses
Ximenia americana	Muroroma	Source of edible fruits (Ndoroma) and fodder for goats. The plant provides good hooks (Mpogoro) for hanging bee hives.
Lannea triphylla	Mutherema	The fibre from the bark of this plant is used for making ropes, baskets and mats. The leaves make good fodder for the goats. The fruits are edible.

Terminalia brownii	Mutithi	The leaves are used as fodder and in the making of traditional (Muratina) liquor by reducing the acidity of the drink. Source of fuelwood, charcoal and fodder. Good source of material for making of beehives. When the bark is chewed it is a remedy for coughs and sore throats.
Sterculia stenocarpa	Muyuria	The bark in extensively utilized for the production of fibre for rope making and building of houses.
Dalbergia melanoxylon	Mumanko	The bark is used as a deworming agent. Excellent hardwood which is used for building purposes. Becoming rare due to over - exploitation.
Psydrax schimperiana	Mutarankima	Fruit (ntarankima) eaten by monkeys.
Terminalia spinosa	Mutoro	Durable and termite resistant. Source for building poles and rafters.
Milletia tanaensis	Muangwa	This is a vulnerable species . It is endemic to central Kenya. In the study area it is only found in the forest reserves. It is an excellent hardwood, durable and termite resistant. It makes good building poles.
Erythrina abyssinica	Mukungugu	Used for making bee hives and traditional stools. The bark is boiled and the concoction is used for cure of fevers.
Boscia coriacea	Muthiuthiu	Source of very hard wood which is used for building and as fuelwood. The fruits are edible. Source of fodder especially during the dry season. When the leaves are blended in water, the leachate is used as an insecticide.
Bauhinia tomentosa	Muthakame	The stem is used to add aroma to milk or porridge. The stem is burnt and the smoking torch (Mutero) is inserted in a guard before the milk or porridge is added.
Entada leptostachya	Munyaritha	The bark fibre is used for rope making. The roots are used as a remedy for snake site. The roots are chewed and the juice is swallowed while some of it is applied on the part of the body bitten by the snake.
Clerodendrum myricoides	Murinyamaria	The branches are use in the making of arrows. The shrub is a source of fodder and fuelwood.

Grewia bicolor	Muragwa	The stem is used in house building and to make bows and arrows. The fruits are edible.
Capparis tomentosa	Mukumukumu	Provides shade in the boma. Source of fodder and fuelwood.
Ehretia cymosa	Muthiira	Wood used for fuel and beehive making.
Combretum acculeatum	Muthigora	Source of fodder and building material.
Commiphora africana	Muthugundu	Source of fodder for goats. The dry stem is split to make torches used when harvesting honey at night. Forms live fencing along the boma through vegetative propagation.
Acacia nilotica	Mwemba	The bark is boiled to make a refreshing beverage and a remedy for malaria. The plant is a source of fuelwood and the leaves and pods(wemba) make excellent fodder.
Euphorbia cuneata	Murembu	The latex of this plant is chewed to make gum. When the gum is applied around cut sticks it forms a substrate for trapping of birds.
Lantana trifolia	Gikenia	Used for festivities especially the ceremony preceeding planting season. Source of fodder.
Dichanthium insculptum	Nyaki	This grass is good for the grazing of cattle. It is also harvested for thatching.
Aristida kenyensis	Runywee	This grass is good for thatching but not palatable to livestock.
Phyllanthus avalifolium	Mukururu	The plant undergoes sporadic fruiting. The fruits are used by the whole household. Also a good source of fodder for goats.
Ficus exasperata	Mukuyu	The fruits (Nkuyu) are edible. Used for making beehives. The latex is used in making sticky substrate for trapping of birds.
Warburgia ugandensis	Muthiga	Source of good timber for building and furniture. Also used for fuelwood and charcoal.
Carissa edulis	Muragwa	Fruits are edible, very tasty.
Diospyros abyssinica	Mukoro	Fruits (makora) are eaten. Sources of excellent timber, furniture and buiding material.

Garcinia livingstonei	Muthuthuri	Fruits (nthuthuri) are edible. The tree is a good source of building material. The three-pronged twigs are used as stirring rods in cooking.
Panicum maxima	Nkamba	Source of fodder for cattle. Used for making brooms.
Grewia villosa	Mubuu	Fruits are edible . The wood is used for building and as a source of fuelwood. The bark provides fibre for making of baskets.
Calotropis procera	Muvuhu	The latex from the shrub is used in the removal of a thorn from flesh. Leaves are used in preparation of malt for brewing.
Acacia brevispica	Mutanda-mbogo	Source of fuelwood, building material and fodder for goats.
Albizia harveyi	Mwira-ndathe	Used as a fodder, timber, fuelwood and bulding material.
Zanthoxylum usambarense	Muguchwa	This is an important medicinal plant of this area. The bark is boiled to make a concoction for the cure of malaria and other ailments
Lanea schweinfurthii	Muura	The fruits are edible. However they often cause accidental deaths through choking when swallowed by human being and animals. The plant is a source of fodder and fuelwood.
Jatropha spicata	Mwatha	The latex from the plant is used for making glue for trapping of birds by boys.
Bridelia cathartica/ taitensis	Muthwana	Fruits (nthwana) are edible. Leaves are used as vegetable. The stem is termite resistant and a source of building material.
Ochna inermis	Mururuti	A source of building material and fuelwood.
Acalypha fruticosa	Munkuru	Used for building granaries.
Tamarindus indica	Muthithi	An important tree in this region. It is a source of fruits which are consumed locally or sold in the market as a source of cash. The branches are used for making walking staves. The tree is used for setting beehives and as a source of fuelwood and building material.

Acacia senegal	Mungora	A multipurpose tree for this area. The foliage and pods provide fodder for goats and sheep while the branches and stems provide suitable boma fence. The tree produces gum arabic which is eaten by children. The tree is a good source of building poles and the bark is chewed for cough remedy
Securinega virosa	Mukururu	Source of fruits and of fodder for goats. Also a good source of medicine; the roots are boiled and the concoction used as treatment of malaria.
Lannea alata	Mutherema	Source of fibre for thatching purposes
Euphorbia nyikae	Muthuuri	Source of building material especially roofing
Erythrina burtii	Mukunguu	Source of snake bite antidote
Hyphaene compressa	Kirara	An important tree for generating cash especially for women. The leaves are used for weaving mats, baskets and hats and the products are sold in the local markets and beyond.
Thunbergia guerkeana	Thunju	The underground swollen root is eaten by cattle during drought.
Melia volkensii	Mukau	The stem is suitable for making timber. The seeds are eaten by goats.
Solanum renschii	Muthugathugi	The roots of this plant are boiled in chicken soup and taken as a cure for malaria
Lawsonia inermis	Mugokora	The dye from boiled leaves is used to decorate mats. The stem and branches are used as building materials and for making furniture. The plant is a source of fodder for the goats.
Ficus sur	Mukuyu	Sources of edible fruits. The trunk is used for making beehives while the tree is used for the beehives setting
Cyperus alternifolius	Ithanje	Used for making of mats.
Indigofera schimperi	Gakina	The roots are chewed for cough remedy
Acacia alatior	Mugunga	Provides boma fence. The foliage is used as fodder for goats. An important source for fuelwood and charcoal. The tree is used for making beehives.

Ocimum basilicum	Makuri	Used for attracting bees to the beehive and as mosquito repellant
Amaranthus spinosa	Terere	Source of food as a vegetable
Acacia robusta	Mugunga	Same uses as Acacia elatior
Commelina bengalensis	Mukengeyia	Used as fodder. The leaves are used as vegetable especially during drought.
Acacia tortilis	Mugaa	An important sources of fuel wood and charcoal. The stem is used for beehives setting. The leaves and pods are used as fodder for goats while the thorny branches are used for fencing purposes.
Commiphora africana	Muura	Leaves used as fodder for cattle while the stem is used for making beehives. Stems and branches used are in live fencing
Heteropogon contortus	Kiutha	An important source of thatching material. The grass is also used for grazing
Adansonia digitata	Muramba	Fruits are eaten by children. The bark provides fibre for making baskets (Kitheti). It is a suitable tree for setting the beehives
Delonix elata	Mwarange	An important medicine plant. The concoction from the leaves is applied both on livestock and human wounds. A suitable tree for setting beehives
Grewia villosa	Mubuu	The fruits are eaten by children. Good source of building material (fito). The stems are used for making arrows
Combretum aculeatum	Muruwa	Used for making bows
Grewia tembensis	Muragwa	Extensively used for making bows
Balanites glabra	Mubobua	Source of edible fruits. The fruits also provide a remedy for coughs. Suitable tree for the setting of beehives. A good source of building poles and tooth brush for cleaning teeth

12.6.3 Utilisation of Fish Resources

On average, the existing reservoir fisheries earned approximately 24 million Kenya shillings during the period 1933 and 1994 i.e. an average of 12 million Kenya shillings per year. In the Delta region, taking fish landings at Garsen outpost alone, roughly 3 million Kenya shillings was earned by the local fishermen in 1992 and 1993 combined. These statistics clearly indicate that, along the Tana, fish are an important source of both protein and revenue to the local communities.

There are no Fisheries Department records from the Mutonga and Kathita tributaries. However, based on the number of nets, basket traps and hooks found is use during this survey, fishing is widespread, and a local markets for fish exists (one of the eels, of 120 cm TL, caught during the survey was sold at Ishiara market).

However based on the present market prices of fish in the dams of about 9 Kenya shillings per kilogram of fish, and that the fish production from Mutonga and lower Grand Falls dams combined is likely to stabilize at around 530 mt./year, the fishery in these two dams is likely to be worth in the region of 4.8 million Kenya shillings at current prices.

12.7 POTENTIAL IMPACTS

The principal source of impacts in the reservoir area will result from:

- construction of the dams
- impoundment and flooding of the newly created reservoirs
- and from the operation of the reservoir.

While direct physical impacts stem from the construction activities, the greatest impacts will result from the impoundment of the water, flooding of the land to create a reservoir, manipulation of drawdown and from alteration of water flow downstream.

12.7.1 Riverine Vegetation

12.7.1.1 Impacts of Construction Activities

Project activities involving the construction of the proposed Mutonga and Grand Falls dams, the proposed network of roads, transmission lines and the work camps will drastically change the present features of the riverine environment, the proposed reservoir area and the surrounding landscape. Construction activities likely to cause significant impacts include excavation of soils and other geological formations and levelling of landscape. Other significant activities include the cutting, clearing and trampling of vegetation. The above activities, will have tremendous impacts on soils, flora and fauna of the riverine environment as outlined below:

Soils

The combined effect of the above construction activities at the dam sites and in borrow pits and quarries that will be required for the project will lead to acute and chronic soil erosion problems. Some of the excavated soils will be washed away as runoff to the aquatic habitats during the rainy season. This will contribute significantly to siltation. The fine silt particles will increase the water turbidity and reduce water transparency. In addition, the fine silt will smoother bottom-dwelling aquatic organisms. This may result in mortality of the affected fauna and benthic algae. There will also be an increased water

pollution emanating from domestic sewage and storm water from labour camps and wash from mechanical plants and machinery.

Flora and Fauna

The construction activities will change the salient features of riverine vegetation mainly through cutting, clearing and trampling of plants and excavations of soils and other geological formations. This will result in the destruction of community complexity, plant biomass and a loss of habitat for flora and fauna. In addition, there will be a loss of biodiversity. The most important riverine trees that will be affected are *Ficus sycomorus, Spirostachys venenifera, Hyphaene corriacea, Phoenix reclinata* and *Acacia robusta.*

The riverine corridor is poor in terrestrial fauna although the Sykes monkeys and vervet monkeys are common in the canopies of riverine trees. Construction activities themselves and resulting human disturbance are expected to have relatively minor impacts on the terrestrial fauna associated with the riverine vegetation. The aquatic fauna including the crocodile, hippo, turtles and monitor lizards will not be significantly affected by the construction activities. However, the bottom dwelling aquatic organisms including the benthic algae will be affected by the increased siltation of the Tana River.

12.7.1.2 Impacts of Commissioning and Operation Activities

The commissioning of the reservoir will create a totally new ecological system. There will be changes in the physical environment, species diversity, basic food chain links and productivity on the resultant reservoirs.

Following impoundment, a large amount of riverine and adjacent bushland vegetation will be submerged. This flooded vegetation will play an important role in the development of the initial stages of the reservoir ecosystem, providing food as well as a habitat in the form of drowned trees for benthic organisms.

During the early stages of reservoir formation there will be significant changes in water quality parameters including levels of nutrients, oxygen and hydrogen sulphide.

Nutrients

The flooding of natural vegetation will lead to decomposition of submerged biomass. Within a few months of inundation there will be rapid autochthonous release of nutrients from the drowned vegetation and other organic matter, soils and mineral elements. Consequently there will be a rapid increase in the level of nutrients including phosphates, nitrates, ammonia, potassium and other salts.

Changes in Oxygen Levels

As a result of decomposition of the submerged vegetation and detritus, dissolved oxygen concentrations will be significantly reduced. This is

attributed to utilization of oxygen by the micro-organisms in the process of aerobic decomposition.

Hydrogen Sulphide

Depletion of oxygen levels leads to anaerobic decomposition which results in the production of hydrogen sulphide. This is more likely to happen at the deep end of the reservoir especially when the reservoir becomes stratified. Hydrogen Sulphide gas is poisonous to aquatic fauna particularly zooplankton and fish.

When the river is dammed, it changes from a lotic to a lentic system characterised by reduced rates of water flow. The resultant still waters coupled with an increase in nutrients characteristic of the initial stages of man-made lakes, creates an ideal environment for the development of algae and aquatic macrophytes in the reservoirs, and may lead to eutrophication.

Algae

The dominant phytoplankton of the upstream reservoirs are the blue green algae particularly the species of *Microcystis, Anabaena, Cyclotella, Tetrahedron* and *Cylindronspermopsis.*

Algal development will correspond to the rapid production of nutrients from decomposition and mineralization. It is expected that there will be successive blooms of algae in the new reservoirs. Initially the blue-green algae, particularly *Microcystis aeruginosa* will predominate. These will be followed by overlapping blooms of diatoms such as *Melosira* and green algae such as *Rhodomonas.*

The algae will form the basis of primary production in the new reservoir. However, one of the algal species likely to cause problems in the proposed reservoir is the bloom forming *Microcystis aeruginosa.* Blooms of *Microcystis aeruginosa* have been reported to produce sufficient toxins to cause problems to human health and also to cause cattle deaths (Noble and Hemens, 1978). *Aphanizomenon* and *Anabaena* blooms are also reported to cause fish kills, cattle deaths and human health problems (Barica, 1975). In addition the blue-green algae imparts noxious tastes and odours to the water.

The initial flooding of the reservoir is expected to increase the extent of the area covered by periphyton or attached algae which will develop on the bottom of the newly formed shallows, submerged vegetation and the newly formed macrophytes.

Aquatic Macrophytes

The new reservoir will provide new habitats for aquatic plants. Some of this plant growth will be beneficial to the new reservoir. These plants will provide food for fish and other aquatic fauna, assist in stabilisation of shorelines and provide a more aesthetically attractive appearance to the new reservoir.

However, some plants may grow in profusion and interfere with man's utilization of the reservoir.

Gaudet (1979) described a characteristic pattern of succession of aquatic macrophytes in a new man-made lake. The floating macrophytes develop first, followed by emergent macrophytes and later by an increase in submerged macrophytes and finally by development of drawdown flora. Such a succession has, for example, been pronounced in Lake Kariba.

Development of Floating Macrophytes

The resultant reservoirs will experience still water conditions although marked fluctuations in. water levels will occur. This situation will mostly favour the development of aquatic floating macrophytes. Of great significance to the new reservoir will be the development of exotic aquatic macrophytes such as *Salvinia molesta, Pistia stratiotes* and *Eichhornia crassipes*. These aquatic weeds have caused tremendous problems in Africa, Asia and elsewhere. In Kenya *Salvinia molesta* has caused serious problems in Lake Naivasha, while *Eichhoria crassipes* is now a serious problem in Lake Victoria.

It should, however, be noted that the survey of the reservoir area during the field investigations, did not reveal presence of these species. Also no serious aquatic weed problems have been reported in the Tana river system upstream of the proposed Mutonga reservoir. Hence, the new reservoir, like the others upstream is not expected to be invaded by excessive growth of aquatic weeds. However, there is always the danger of introduction of noxious weeds from outside the Tana river system. Consequently measures should be taken to curb any future introduction of aquatic weeds in both Mutonga and Grand Falls reservoirs or on the other water bodies upstream including Kiambere, Kindaruma, Gitaru, Kamburu and Masinga reservoirs.

Emergent Macrophytes

The proposed reservoirs are not expected to be a favourable environment for the establishment of significant emergent communities. Due to the seasonal nature of the river flow, the new reservoirs are projected to have prominent fluctuations in water level. Similar fluctuations occur in the upstream reservoirs where most of the shoreline is barren or with minimal development of aquatic plants. However, there exists a possibility of establishing some macrophyte communities where the reservoirs margins do not experience dry conditions. Where there is silt deposition from incoming waters, the silt may stay moist and the formation of swamps can occur. These swamps will be dominated by the species: *Typha domingensis, Phragmites karka* or even *Cyperus papyrus*. Other swamp species may include *Ludwigia leptocarpa, Cyperus immensus* and *Echinochloa haploclada*. None of the above swamp communities are likely to constitute a serious danger to the new reservoirs.

Submerged Macrophytes

High turbidity levels and water level fluctuations will combine to curtail any significant development of submerged macrophytes in the new reservoirs. Due to these factors no submerged macrophytes (*Ceratophyllum demersum* and *Potamogeton pectinatus)* have so far colonised the upstream reservoirs. A similar situation is expected to prevail in the Mutonga and Low Grand Falls reservoirs.

Development of Faunal Community

The proposed reservoirs will create lentic conditions in what was originally a lotic environment. This will bring about changes in faunal community.

Zooplankton

The zooplankton community of the upstream reservoirs is dominated mainly by the copepods including *Thermocyclops decipiens, Thermocyclops cosmilis, Tropodiaptomus asimi* and *Mesocyclops sp.* (JICA, 1995). Other common members of zooplankton community include the cladoceras (*Disphanosoma, Moina, Ceriodaphnia*) and rotifers (*Brachionus; Polyarthra*) among other zooplankters. It is expected that a similar zooplankton community will develop in the new reservoirs of Mutonga and Grand Falls.

Benthos and Aufwuchs

The proposed reservoirs will present suitable conditions for the development of a rich benthic and periphyton invertebrate fauna both in their larva and adult stages. Aquatic insects expected to flourish in the reservoirs will be represented by the *Odonata* (damselfly and dragonfly nymphs), *Plecoptera* (stonefly nymphs), *Ephemeroptera* (mayfly nymphs) and *Diptera* (chironomid larvae). Other groups of benthic and periphyton organisms found in the upstream reservoirs are the snails of *Biomphalaria* sp. and *Lymnaea natalensis*. The above snails are expected to establish in the proposed reservoirs.

The presence of snails in the new reservoirs has far-reaching health implications in the study area. The *Biomphalaria* snail is the vector of parasite flukes of *Schistosoma mansoni* which causes intestinal bilharzia (Schistosomiasis) in human beings. This disease has now become a serious health concern in Mwea/Tebere Irrigation Scheme upstream of the proposed reservoirs. Schistosomiasis is highly likely to become a serious problem amongst settlements close to the proposed reservoirs.

Waterfowl and other Fauna

The two reservoirs will present new, more extensive and diversified aquatic habitats. This will attract more aquatic life into the area. The population of waterfowl including fish eagles, various species of ducks and goose, pelicans, and cormorants are expected to increase in the area.

The new reservoirs may form a suitable habitat for hippo and crocodile, although they may be killed by local people and as a result these species may disappear from the area. Hence their population is also expected increase in the area. Some of the organisms discussed above including phytoplankton, zooplankton, benthos and aufwuchs will form important food chain links that will support significant fish biomass. Consequently the new reservoirs are expected to have sustainable fisheries potential.

12.7.2 Forest Reserves and Bushland

12.7.2.1 Forest Reserves

Around the study area there are patches of densely vegetated hills of which the more important are gazetted as forest reserves. These are areas of particular importance for watershed protection. The gazetted forests are closed to human settlement and farming although minor human activities like beehive setting and collection of firewood is tolerated.

It should be emphasised that the forest reserves are not situated within the proposed reservoir area. Hence there will be no direct impacts in terms of submersion of vegetation and loss of habitat as will occur in the area to be covered by the proposed reservoir.

However, the forest reserves of Kijege, Ntugi, Kierera and Mumoni lie close to the proposed management zone. Consequently, any increase in land pressure emanating from the resettlement scheme is likely to result in human encroachment on the forest reserves. The encroachment into the forest reserves will mainly comprise the demand for fuelwood, building material, medicinal sources, honey harvesting and land for grazing.

12.7.2.2 Bushland Community

The Acacia-Commiphora bushland community constitutes the largest percentage of the area to be flooded by the proposed reservoirs. The construction activities and the subsequent commissioning of the dams will drastically change the salient features of the bushland community. Ultimately the terrestrial bushland ecosystem will be replaced by an aquatic system.

It should be emphasised that the area to be flooded is mainly under some form of cultivation and the bushland community in this area has already been extensively modified by man and domestic livestock. Nevertheless the project activities are expected to have significant impacts in this area.

The soil and rock excavations, the levelling of landscapes, clearing, cutting and trampling of vegetation, and flooding will culminate in a loss of habitat for the flora and fauna. In addition, there will be a loss of biomass from the trees and shrubs that will be destroyed in the area of the proposed reservoirs. Although the reservoir area contains no unique species, there will be to some extent, a loss of biodiversity including plants of economic and medicinal value.

The most important plants of economic value that will be destroyed by the project activities are *Acacia tortilis*, *Hyphaene compressa* and *Tamarindus indica*. Among the plants of medicinal value that will be affected by the project are *Erythrina burtii*, *Solanum renschii* and *Entada leptostachya*. The above plants form a significant component of the material culture of the Tharaka people.

There are virtually no wildlife in terms of large mammals remaining in the bushland community. However, the project will destroy the habitat for small mammals such dikdik, the many rodent species thought to occur in the area, and reptiles. The area likely to be flooded does not contain any animal species known to be either rare or endangered in Kenya except the pancake tortoise (*Malacochersus tornieri*).

12.7.3 Potential Impacts on Fish Fauna

Although the construction of the proposed reservoirs will create new fishery, the migratory eel species will eventually be lost due to the physical barrier created by the dam. As a result, population numbers are likely to decline and if the lower Tana on its own does not constitute sufficient habitat for these species survival, ells in the Tana may in the long term become extinct.

Whereas the evolution of the fishery in the dams will be characterized by initially high outputs, the levels of production will decline in time to stabilize at lower levels once the new environments have stabilized. Formation of algal blooms, eutrophication, sediment deposition in the dams as well as over-fishing are some of the factors whose combined effect may add to this effect and result in further reduced levels of fish production. Because of the new macro-environment created by the dams the numbers of the indigenous species are expected to decline, with some species probably disappearing completely from the Mutonga and Kathita tributaries above the dams. Since both local and the commercial fishing activities will expand there will be more consumption of the fish locally especially in market centers along the Meru-Embu road where the people are relatively affluent. Experience from upstream reservoirs and fisheries elsewhere in Kenya suggest that the people who are most likely to profit from the expanded fisheries in the new reservoirs will not be local people but experienced fishermen from elsewhere in Kenya, especially from the Lake Victoria region.

Lastly, the dams have some potential to provide a tourist attraction facility some of whom will be interested in sport-fishing and angling. However, in this respect, it must be noted that there are few, if any, signs of overseas tourist interest in the existing dams on the Tana River, and it is therefore likely that little or no interest will be shown by tourists towards the proposed reservoirs[1]. However, what is more likely is that local tourists from the major urban centres could become interested in recreational opportunities offered by the new reservoirs.

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[1] The creation of the proposed reservoirs will flood the rapids and white water on the Tana River below Kiambere, and in so doing will destroy any possibility of using these resources for certain, potentially lucrative, forms of adventure tourism such as white water rafting and canoeing.

12.8 PROPOSED MITIGATION MEASURES

12.8.1 Potential Mitigation Measures against impacts on the Riverine Vegetation

Construction of the proposed reservoirs will have significant impacts on the area of operation. There will be loss of habitat for both flora and fauna and a reduction in biodiversity. The site preparation activities and removal of natural vegetation will stimulate soil erosion and to some extent siltation of the Tana River system.

The impoundment of the Tana River will create an lacustrine aquatic ecosystem in place of the current riverine and terrestrial systems. This transformation will have significant environmental implications. The new reservoirs will attract new organisms to the area and there will be development of complex aquatic food chains, as well as potential health hazards. In order to mitigate against negative impacts of project development, the following measures are proposed.

Soil Erosion and Loss of Biodiversity

Both before, during and following the completion of dam construction and other site preparation activities there needs to be a programme to rehabilitate the degraded environment.

Before the start of construction activities, important parts of the currently existing natural vegetation should be carefully removed, relocated to nurseries and maintained during construction activities. Following dam completion, these plant nurseries will provide the means to replant and rehabilitate disturbed land.

In order to curb soil erosion and siltation processes it will be essential to create adequate terracing and to carry out landscaping. Consequently there should be planting of sediment binding grasses on the exposed slopes and other surfaces. In addition, indigenous trees and other plants should also be planted to restore some of the lost biodiversity and increase the aesthetic value of the disturbed sites. Following land preparation activities at the dam site, natural vegetation has virtually no chances of survival. The reservoir management authorities should therefore undertake to restore some biodiveristy in the disturbed area and the vicinity of the reservoir.

Trees need to be planted around the reservoir, on road reserves, reserved spaces and office administration blocks. Wherever possible roads should be built along the contours. Suitable tree species naturally occurring in the area should also be planted in the stretch below the dam and other areas where construction borrow pit activities, excavations and mound piling have taken place.

Other measures to rehabilitate the disturbed area include the preservation of a buffer zone separating the reservoir and adjacent settled areas. The buffer zone should be free of any form of interference. This reserve will provide a habitat for some of flora and fauna that survive the site preparation process and subsequent impounding.

Development of Aquatic Weeds

Introduction of aquatic weeds into the proposed reservoirs must be carefully avoided. Small populations of aquatic weeds can explode very rapidly in the new reservoirs created by the dams. It is therefore necessary to educate the people especially the lake-side dwellers, visitors, aquarium hobbyists and fishermen of the dangers of transporting aquatic weeds such as *Salvinia molesta, Eichhornia crassipes* and *Pistia stratiotes*. In particular fishing and sporting boats and nets that have been used in Lake Naivasha or Lake Victoria should never be allowed to be used in the new reservoir or the other upstream Tana reservoirs.

A systematic aquatic plant monitoring programme should be initiated from the time of closure of the dam. Any infestation of the new reservoir with aquatic weeds should be dealt with objectively. A prompt assessment should be carried out and best control method devised.

Control of Waterborne Diseases

Conditions in the newly created reservoirs will favour the establishment of populations of the snail vectors of Bilharzia. Surveillance of both *S. haematabium* and *S. mansoni* amongst the adjacent settlements will need to be carried out on a regular basis and control measures should be maintained around the shores of the reservoir.

General control of schistosomiasis includes:

- parasite survey of urine and stools,
- treatment of people infected,
- snail surveys,
- avoidance of water pollution by use of hygienic sanitary facilities,
- and health education of the people on hygiene and sanitation.

The increased water surface and expanded shore line of the reservoir, together with the lacustrine rather than riverine conditions, will increase breeding opportunities for mosquitoes. As a result, populations of *Anopheles* mosquitoes, vectors of *Plasmodium falciparum* and other malaria causing parasites will increase. It is therefore certain that there will be a significant increase in cases of malaria following the construction of the dams and infilling of the reservoirs.

Control of malaria needs to be effected immediately construction work begins. Methods include prophylasis, chemotherapy, chemical control, environmental management and personal protection.

12.8.2 Potential Mitigation Measures against impacts on Forest Reserves

Although the forest reserves are not situated within the area of the proposed reservoir, they are close to the proposed management zone. Therefore any increase in land

pressure especially from the surrounding resettlement area is likely to have negative impacts on the forest reserves.

Any human encroachment on the forest patches will be of great environmental concern since the forest reserves constitute important catchment areas in this semi-arid zone. In addition, the forests are a refuge to some endemic plant species that are on the list of threatened plants in Kenya. Two of the endemic and threatened plant species were recorded during the field investigations of October, 1995. The were a Cycad (*Encephalartos powysorium*) and a tree/shrub (*Milletia tanaensis*).

Encephalartos powysorium is an Cycad endemic to Kijege forest of the study area. This is one of the only five Cycad species found in Kenya. According to IUCN classification, the Cycad is listed as vulnerable. Although the local people have no use for the Cycad, horticulturists and Cycad collectors have been known to plunder the sites.

Milletia tanaensis is a tree or shrub about 2-4m tall. The plant is endemic to central Kenya and is listed as vulnerable. The plant was also found in the Kijege forest of the study area. *Milletia tanaensis* has a hard wood which is termite resistant. The plant is in high demand for the supply of poles for building purposes by the local people. It should be noted that all forest reserves in the study area are gazetted and therefore protected by the Forest Act. The Forest Act specifically forbids certain activities within gazetted areas. These include cutting and burning, access at certain times, building of certain types of structures and roads, cultivation, grazing and collection of honey without appropriate authority. The act also prohibits activities such as cutting and burning on alienated public lands not specified as forest areas or central forests.

Although the forest patches in the study area are protected, the enforcement of the Forest Act is lax. During the field investigations several human activities including cutting of trees, bee keeping and cattle grazing were observed in the forest reserves. There will be a need for enforcement of the Forest Act in order to protect the threatened species and other forest resources and attributes in the remaining forest patches. In common with many other areas, pure enforcement is unlikely to result in significant improvements, and it is suggested that a more community oriented approach be adopted. This should combine forest protection with access for important activities such as bee-keeping, and environmental education.

In addition to enforcement of the Forest Act, the area around the forest reserves will require to be managed on a sustainable basis. This will be part of the resettlement area that will absorb the displaced population from the proposed reservoir following infilling. Hence there will be an increase in land pressure and an increased demand for resources. Suitable land management strategies including the incorporation of sylvopastoralism will provide basic resources like food, fodder, fuelwood and building material on the resettlement area. This will subsequently reduce the need to encroach on the forest reserves.

12.8.3 Potential Mitigation Measures against impacts on the Bushland Community

Except for the relatively narrow band of riverine vegetation along the Tana and its tributaries, the bushland community constitutes most of the area to be flooded by the proposed reservoirs. The project activities and the subsequent transformation of the bushland community to an aquatic ecosystem will lead to loss of habitat and a reduction in biodiversity of flora and fauna and increased soil erosion in the surrounding areas as discussed in above. Mitigation measures for the control of soil erosion, loss of biodiversity development of aquatic weeds and spread of waterborne diseases have been discussed in above and also apply in respect of the impacts arising from project development in the bushland community. However, the following discussion is relevant to the bushland community.

Terrestrial Wildlife

Generally the wildlife in the bushland of the proposed reservoir is so depleted that the creation of the reservoir is not of significant concern. The present terrestrial avifauna will move to the surrounding bushland habitats. However, water birds will be expected to settle in and colonise the new reservoir as they have done in the upstream reservoirs.

The area covered by the proposed reservoir does not contain significant populations of any animal species known to be rare or endangered in Kenya with the exception of the pancake tortoise (*Malacochersus tornieri*) The tortoise is listed as threatened, by the World Conservation Union (IUCN). The pancake tortoise is restricted to certain rocky regions of Kenya including the study area. The population is presently threatened by over-collection for pet trade. Consequently, the pancake tortoise has been placed on Appendix II of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The Leopard tortoise (*Geochelone pardalis*) is not among the list of endangered species in Kenya but the numbers of this species are declining. It is recommended that a survey be conducted to ascertain the status of the pancake tortoise in the proposed reservoir areas, and that following this survey suitable mitigation measures are identified and implemented.

Although the vegetation of the proposed area has generally been referred to as bushland, it is actually a mosaic of cultivated land, fallow and shrubland in various stages of succession. This vegetation is currently sustained in a relatively stable state by the traditional bush/fallow system of cultivation, burning, grazing and browsing by livestock. The area to be flooded by the proposed reservoirs does not contain any known populations of endangered plant species.

Charcoal Production

An important commercial proposition for the exploitation of trees found in the reservoir area is the production of charcoal. In this connection, the charcoal producing trees of *Acacia tortilis*, *Acacia robusta*, *Delonix elata*, *Terminalia brownii* and *Tamarindus indica* should be harvested and converted to charcoal

rather than being left to decompose during the inundation. The estimated number of charcoal producing trees that would otherwise be inundated by the proposed reservoirs is shown in Table 12-15.

Estimates of charcoal production are based on information supplied by local people. Medium sized mature trees of *Acacia tortilis* and *Terminalia brownii* would produce 10 bags of charcoal per tree. The mature large sized trees of *Delonix elata*, *Tamarindus indica* and *Acacia robusta* would produce 20 bags of charcoal per tree. Using the traditional pit methods of charcoal production, the above trees would produce a total of 41,420 and 249,660 bags of charcoal in the proposed Mutonga and Grand Falls reservoirs respectively. Based on the local price of KSh.100 per bag, a combined total value for charcoal in the proposed Mutonga and Grand Falls would amount to approximately KSh.29 million.

Whilst the production of charcoal from these trees is economically sound, and may provide some benefit to those loosing their homes and land to the reservoirs, there is the difficulty of limiting such an operation to the reservoir areas only. Accordingly, there is a danger that charcoal production will expand to include a larger area, and that other tree resources in the bushland and in particular the forest habitats outside of the proposed reservoir areas will also be used for charcoal production.

It is therefore proposed that the operation to utilise trees in the proposed reservoirs must be combined with and closely integrated with other proposals to create alternative woodfuel supplies in the area adjacent to the proposed reservoirs.

Table 12-15 Estimates of Trees with Potential for Charcoal Production in the Proposed Reservoirs

Tree Species	Estimated Number of Trees in the Proposed Mutonga Reservoir	Estimated Number of Trees in the Proposed Grand Falls Reservoir	Total
Acacia tortilis	1,962	11,826	13,788
Delonix elata	436	2,628	3,064
Terminalia brownii	436	2,628	3,064
Tamarindus indica	218	1,314	1,532
Acacia robusta	218	1,314	1,532
Total	3,270	19,710	22,980

Development of Lentic Environment

Within a few months of impoundment and subsequent inundation of the bushland area, there will be rapid autochthonous release of nutrients from drowned vegetation and other organic matter and soils. As a result of the decomposition of the submerged vegetation and detritus, oxygen levels in the new reservoirs will be significantly reduced. Anaerobic decomposition and

subsequent production of hydrogen sulphide will subsequently take place particularly in the deepest parts of the reservoirs.

Hydrogen sulphide is poisonous to aquatic fauna particularly zooplankton and fish. It is also corrosive to the turbines and its foul smell is rather irritating. High levels of nutrients will lead to eutrophication and the resulting reduction in oxygen levels is likely to lead to fish kills.

To mitigate against high release of nutrients, production of hydrogen sulphide and reduction in oxygen concentration in the new reservoirs there will be a need to clear the trees and shrubs prior to inundation. Presence of trees and large shrubs in the new reservoirs will interfere with fishing, boating and dam operations activities. Hence a requirement to clear trees and shrubs at the base or to a height of 15 cm from the ground. Clearing should preferably be carried out at a late enough stage to minimise regeneration. The cut trees and shrubs in the proposed reservoir area should not be wasted or burnt. Instead, they should be preserved to provide material for building poles, timber, furniture, fuelwood and charcoal especially for the work force in the area of operations and the resettled community.

Buffer Zone

In order to protect the new reservoirs from the activities of the surrounding community there will be a need to set a buffer zone around the reservoir margins. Creation of a protected zone will act as a refuge for a small proportion of the wildlife displaced from the inundated area. The setting of a buffer zone must be coupled with an effective management and policing strategy to avoid environmental degradation in the protected zone. Human activities should be minimal.

Resettlement Area

The displacement of people presently living in the area that would be flooded will increase population pressure on the surrounding resettlement area. This will lead to rapid escalation in the exploitation of plant resources for building and for supply of fuelwood and charcoal. In addition there will be more intensive land use in the marginal areas. **This will lead to environmental degradation unless sustainable land management strategies are adopted in the resettlement area.**

The reservoir management authorities will be required to come up with, **and to finance,** a comprehensive land use management strategy for the resettlement area. Such a programme should be aimed at encouraging better land use and preventing erosion. There will be need to incorporate extension work and for education on suitable land use practices. A programme of re-afforestation, re-vegetation of degraded areas and introduction of agroforestry and silvopastoralism should be initiated.

Monitoring

Environmental monitoring is envisioned as an important process in the management of the reservoirs. The monitoring programme will reveal changes and trends brought about by presence and operations of the reservoirs. The basic activities for a sound monitoring programme should at least include the following:

- collection and analysis of environmental data
- preparation of periodical reports and liaison with other relevant agencies
- identification of unexpected environmental impacts
- formulation of counter-measures to mitigate the unexpected negative effects.

It is proposed that a team of environmental experts monitor the environment of the new Mutonga and Grand Falls reservoirs and the upstream reservoirs for an initial period of two years and thereafter prepare proposals for a long-term monitoring and management of all the man-made lakes along the Tana River. The environmental team of experts should also train a core of the reservoir management authority staff to establish and manage an environmental unit for long-term monitoring of the Tana reservoirs and the catchment areas.

12.8.4 Potential Mitigation Measures against impacts on the Fish Fauna

One of the conflicts the construction of the dams will cause will be economic gain from the new fisheries verses loss of an important biodiversity, the three eel species in the Tana, and probably the loss or severe deduction of other species of resident fishes in the Mutonga and Kathita tributaries of the Tana.

Following construction, the dams will be higher than the young eels (elvers) will be able to climb unaided. Fish ladders offer one traditional solution to such problems, but experience with fish ladders suggests that these would not provide an effective solution. The young eels would be subjected to heavy mortality by fish eating birds and other predators whilst moving through fish ladders. However, a long channel, or series of channels, running from the upper limits of the dam and rejoining the river further downstream would be more likely to facilitate movement of eels upstream past the obstacle of the dams. Such channels could be integrated within the requirements of local irrigation schemes.

Local people should be trained on simple fishery management practices such using the correct mesh size nets, releasing juvenile fish as well as the importance of closed area and closed season practices as management tools. Use of poisonous chemicals or plant material that paralyze and eventually kill fish of all ages, now a normal practice in the Mutonga and Kathita tributaries, must be discouraged by the Fisheries Department allowing the local fishermen in the area to fish using recommended fishing gear. There should also be fishery extension and support schemes to enable the local people to acquire skills and facilities which would allow them to participate/benefit from the new fishery. Soft loan schemes, for example, must be provided to the local fishermen. There

is need to reduce post-harvest loss from the new fishery and to improve the marketing strategy by providing better storage and transport facilities. Tourist facilities such as hotels, kiosks and fishing camps must be provided. Security too must be provided if local or overseas tourism is to expand in the area.