JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF ENERGY
THE REPUBLIC OF KENYA

FEASIBILITY STUDY
ON
MUTONGA/GRAND FALLS HYDROPOWER PROJECT

FINAL REPORT

EXECUTIVE SUMMARY
FOR
ENVIRONMENTAL ASSESSMENT

MARCH 1998

NIPPON KOEI CO., LTD.
PASCO INTERNATIONAL INC.
TOKYO, JAPAN

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This Report consists of

Executive Summary

Executive Summary for Environmental Assessment

Volume I *Main Report*

Volume II *Supporting Report (1)*
(Engineering Study)

Volume III *Supporting Report (2)*
(Environmental Assessment)

Volume IV *Supporting Report (3)*
(Workshop Proceedings)

The cost estimate is based on the price level of June 1997 and the monthly mean exchange rates in June 1997. The monthly mean exchange rates in June 1997 are:

US$ 1.00 = KShs. 54.0 = J. Yen 120

Executive Summary for Environmental Assessment

1. INTRODUCTION

This report provides a summary of the environmental assessment studies which are described in greater detail in the Supporting Report (2) (Environmental Assessment Report).

(1) The Tana River

The Tana river is the largest and most important river in Kenya. Its catchment covers some 95,950 km^2 (approximately 17% of the land area of Kenya) and stretches between the Kenya Highlands and the Indian Ocean). The total river length from source to the Indian Ocean is over 1,000 km. The river is fairly confined within its banks up to Kora Rapids. Downstream of Kora Rapids the river spreads out onto the floodplain during periods of high flow. The catchment area includes a wide range of climatic conditions and vegetation, including: alpine glaciers, afro-alpine moorland and high-altitude forest through to semi-arid and arid plains, and a humid coastal delta. The following physiographic regions can be defined in the river basin:

- An upper catchment (9,420 km^2) upstream of Kamburu with altitudes above 1,000 metres above sea level (masl);
- A middle catchment (21,370 km^2) between Kamburu and Kora Rapids, with altitudes between 1,000 and 200 masl;
- A lower catchment (65,160 km^2) downstream of Kora Rapids, with altitudes below 200 masl. The floodplain is included in this section.

Figure SE.1 shows a general feature of the Tana river.

(2) Background to the Environmental Assessment

The Japan International Cooperation Agency (JICA) and the Tana and Athi rivers Development Authority (TARDA) agreed in August 1993 to carry out a feasibility study of the next proposed phase of hydropower development in the Tana river basin. The study was managed by the Study team responsible for presenting the overall conclusions and recommendations of the study.

The study examined the feasibility of development of hydropower options based on three possible dam sites within the middle catchment of the Tana river. Proposed dam sites are: Mutonga Dam two kilometres downstream of the confluence of the Mutonga river; and at two Grand Falls Dam sites, respectively five and seven kilometres downstream from the confluence of the Tana and Kathita rivers.

An initial Environmental Assessment was presented at a workshop held in Embu (13-16 Sept. 1994). Workshop conclusions were summarised in a report distributed to participants by the Study Team and TARDA. A number of issues were identified for further study before an informed decision could be made on preferred options, or indeed,

whether a hydropower scheme should be constructed at the proposed sites. Following the workshop, a second phase EA study ran from September 1994 to March 1995, when a second open workshop presented the study conclusions.

The Stage 2 study (September 1994 to March 1995) indicated optimal options for dam configuration, linking both engineering and environmental aspects. The main concern expressed in the environmental study was that there would need to be the capacity to manage the release of regular artificial floods of a size that would replicate the "normal" flooding pattern in the downstream reaches of the Tana.

From the environmental point of view, the key aspect of the engineering study was that the selected option required a capacity to release these floods while minimising adverse impacts during the construction, particularly the impounding period. These reservoirs would also regulate the last significant natural river flows into the Tana river system. The conclusion was that the dam would need to provide a storage capacity adequate to manage flood releases, but not so large that the downstream system would suffer severe or irreversible damage during the impounding period as well as during subsequent operation.

As part of the study process, a video was produced at Stage 2. This was based on a series of interviews with farmers in and around the proposed reservoir site who would be directly affected by dam construction. People in upstream areas who had been affected by the previous construction of reservoirs on the Tana river were also interviewed. Pastoralists, flood recession farmers and both large and small-scale irrigation farmers in the downstream areas were also interviewed.

The results of the study and the video were presented at a workshop held in Nairobi during March 1995. The workshop was attended by representatives from organisations and institutions present at the previous workshop, with additional representatives from the East African Wildlife Society, the Green Belt Movement, the NGO council, CARE and other environmental and social based NGOs. The conclusions of the study team were that the best option would be the combined development of a reservoir at Mutonga and the Low Grand Falls option (LGF). This option was considered as being the least environmentally damaging while still providing the capacity to release floods, and at the same time producing the highest power output.

The Stage 2 Study recognised that there were a number of aspects of the Tana river environmental systems that were not clearly understood and would require further investigation before a final decision could be made as to the optimum design and management strategy for the dam. Aspects singled out for further study during phase 3 included:

- Resettlement - preparing an outline plan of resettlement and buffer zone management; indicating mitigation measures and costs of compensation.
- Hydrology - additional work to define "normal" floods; and further work on the effects of sediment trapping on downstream channel erosion and the potential for sediment release.

- Downstream Riverine Corridor - proposing a plan of reservoir operation to release downstream floods while minimising the loss of generation capacity; and further study on sediment transport and the implications for downstream nutrient supply.
- Consultation - emphasis was placed on ensuring that the process included adequate consultation with communities and institutions affected by the proposed development, both in the reservoir area and in the downstream corridor.

(3) Conclusions from Studies of Existing Reservoirs

A literature review was carried out to learn from previous experience of environmental and socio-economic impacts at the existing five dams projects on the Tana river. The review focused on impact assessments conducted, mitigation measures adopted and monitoring activities implemented following construction of the dams. Important implications for the current project, derived from shortcomings in previous environmental assessments, were also highlighted as follows:

<u>**Impact on Displaced Populations**</u>

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

2) Although the number of persons affected by the establishment of these reservoirs is small compared to the number of displaced people for some other large African dams, greater emphasis should have been placed during the preliminary studies on necessary relocation programmes.

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

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

5) Squatters who had been compensated have returned to some areas. Experience from these lessons indicates that compensation for the displaced population should be based on land for land plus infrastructures and facilities.

6) Cash compensation in agriculturally oriented communities ultimately results in an impoverishment of many families.

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

Impact on Agriculture & Local Food Supply

1) In case of the Tana river reservoirs, development appeared to have insignificant impact on increased availability of water for irrigation and hence food supply.

2) No control and no serious management of fish stocks was considered when the lakes were established, so the local fishermen had free reign. Later on, the authorities had the difficult problem of restocking Masinga and were obliged to take unpopular measures such as prohibiting fishing activities altogether.

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

Impact on Water Supply & Sanitation

1) The establishment of the lakes did not appear to have helped to improve the water supply to the local communities.

2) Due to lack of analysis of water quality before the dams were built, it was not possible to determine whether this had deteriorated. A chemical analysis indicated that chemical content in the Masinga reservoir had increased but remained acceptable. Overall, the waters in Masinga, Kamburu, Kindaruma were found to be unfit for human consumption (unless treated) due to highly developed *E. coli* populations indicating faecal polution.

3) The use of the water for domestic purposes was judged to be risky. This risk was being increased by a lack of adequate sanitary installation.

Impact on Water Related Diseases

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

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

Impact on Plant Cover & Sedimentation

1) Sedimentation of the Tana river reservoirs has threatened the capacity and lifetime of the dams.

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

3) There were no afforestation programs or efforts to limit agricultural activities in the vicinity of rivers in order to prevent erosion.

2. RESERVOIR POPULATION AND RESETTLEMENT AREA

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

(1) Households & Population affected by the Reservoir

Areas that will be directly impacted by the proposed reservoirs include the area of inundation of each reservoir and the surrounding buffer zone. Areas of inundation were calculated on the basis of the reservoir full supply levels (FSL). Buffer zones were set at 100 metres from the FSL. People would be excluded from both of these areas. The buffer zone can be described as an "Intensive Management Zone". In addition, an area adjacent to and surrounding the proposed dam structures was added to enable the development of housing, offices and other structures required for the operation and management of the reservoirs. These areas, termed the "Operations Zone" were defined to include all land area on the right hand bank of the Tana up to a distance of 1 km from the proposed dams. Although people would be living and operating within these areas, they represent a special case since existing residents/farmers would be required to move.

The study area as a whole, defined by the affected sublocations, included an area of 1,656 km^2 with a population of 59,799 at the time of the 1989 national census. Within the areas that would be directly affected by the combined reservoirs, an area of 106 km^2 supported a population density of 34.5 at the time of the 1989 census and a population estimated at 43.2 per km^2 at 1996 levels. It is estimated that, by the year 2005, this directly affected population will have increased to 57.7 persons per km^2, or a total of 6,125 people in both of the proposed reservoir areas, Mutonga and Grand Falls (LGF). indicates population projections to year 2010. For the purposes of this study, the year 2005 is taken as the latest date by which the population would be required to move. Population projections to year 2010 within reservoir areas, 100 metre buffer zones and the operations zones were calculated as follows

Population:

Year	Grand Falls	Mutonga	Combined dams
1989	2,961	722	3,666
1997	3,902	856	4,739
2005	5,143	1,015	6,125
2010	6,111	1,129	7,191

Households:

Year	Grand Falls	Mutonga	Combined dams
1989	490	127	613
1997	653	142	790
2005	870	159	1,017
2010	1,041	170	1,191

By contrast, the estimated population displaced by the significantly greater area of the larger High Grand Falls reservoir was calculated as 7,226 from 1,220 households in 1989. The year 2005 projection of these population figures was estimated to be 12,073 from 2,024 households.

(2) Special Management Zones

Surrounding the proposed reservoirs and the 100 metre buffer zone, it is proposed to develop a "Special Management Zone" (SMZ). Within the SMZ it is proposed that land will be managed so as not to have a negative impact on the reservoirs. In addition, it is proposed that the majority of the required resettlement would occur within the SMZ. Three SMZs are described in the Chapter 6 of Supporting Report (2) - one surrounding the proposed Grand Falls reservoir (LGF), with a second SMZ for Mutonga reservoir. The option with the combined Mutoga and Grand Falls (LGF) reservoirs would combine both SMZs (see Figure SE.2). Population projections within the Special Management Zones were calculated as follows:

SMZ Population:

	Grand Falls (LGF)	Mutonga	Combined
1989	16,219	4,845	19,602
1997	21,375	5,744	25,337
2000	23,707	6,123	27,897
2005	28,171	6,811	32,750
2010	33,476	7,576	38,448

SMZ Households:

	Grand Falls (LGF)	Mutonga	Combined
1989	2,821	898	3,477
1997	3,760	1,004	4,479
2000	4,187	1,047	4,925
2005	5,010	1,122	5,769
2010	5,996	1,203	6,758

By contrast, the population within an SMZ sufficeint to cater for the needs of the larger High Grand Falls was estimated to be 29,714 in 5264 households in 1989. The projected year 2005 estimates were calculated as 49,645 people in 8,734 households.

(3) Potential Resettlement Areas

The population affected by the inundation in the reservoir area, inclusive of 100 metre buffer zone, 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. These points are considered in more detail by Chapter 11 of the Supporting Report(2), which also details the experience of resettlement from existing Tana river reservoirs and from examples elsewhere in Africa.

Requirements for Resettlement

Involuntary resettlement results in serious hardship for the population being moved, as well as the host population. A successful resettlement effort requires the following:

- 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 available before resettlement.
- Both displaced and host populations are involved in planning, negotiation and execution of the resettlement plan
- Preferences expressed by the local population should be honoured.

Local Preferences for Resettlement

Most respondents expressed a desire to resettle close to their existing location. Of the total sample group, 88% stated a preference for settling near the reservoir or in a nearby village. Most respondents expressed an interest in relocating with village and family members or with village people (75% and 22%, respectively). Eighty-six percent (86 %) of respondents stated a preference for employment in mixed farming and animal husbandry. Most of the remainder prefer farming only.

There was a general willingness to be displaced but, at the same time, a certain amount of scepticism that people will be adequately compensated for their loss of land or that the dam will be of any real benefit to them. This scepticism was based upon observations of other plans on similar projects, specifically Masinga and Kiambere from where about 15% of people living in the study area had already been displaced.

Local Preferences for Compensation

Input was received from formal questionnaires as well as informal field surveys and interviews. A preference was stated for a resettlement package that would guarantee sufficient land, while also providing 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.

Compensation Requirements

The Supporting Report (2) considers, in Chapter11, the current legal basis for land acquisition and summarises the results of a sample survey designed to provide a basis for estimating the requirements for compensation. This includes details of land, buildings and amenities, crops, trees, beehives, and the compensation required for loss of production. Compensation requirements per household were estimated as follows:

	Average amount (Kshs)	Amount in US$, (As of June97)
Land (2.0 hectares)	40,000.00	740.74
Buildings	52,000.00	962.96
Other Improvements	12,000.00	222.22
Disturbance @ 15%	16,000.00	296.30
Sub-total	120,000.00	2222.22
Loss of Production	24,000.00	444.44
Sub-total	144,000.00	2666.66
Contingencies @ 10%	14,000.00	259.26
Total	**158,000.00**	**2925.92**

Total compensation would take into the value of land, household improvements, transition and relocation costs, and loss of productivity. 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 only 2 Hectare per household, or a total of 2,034 hectares.

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 KShs.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. These figures are based on current land valuation and will increase accordingly if land prices rise. The total estimated compensation required for relocation of displaced populations was estimated as follows:

	Mutonga	Grand Falls	Combined
Household (Ksh)	25,122,000	137,460,000	160,686,000
Non-household land (Ksh)	37,280,000	134,760,000	171,660,000
Total (Ksh)	**62,402,000**	**272,220,000**	**332,346,000**
Total in US$ (June 1997)	1,156,000	5,041,000	6,155,000

By contrast the greater area required for the High Grand Falls option would require an estimated compensation of Ksh 422,432,000 or US$ 7,823,000 using the same criteria as described above for Mutonga and Low Grand Falls.

(4) Relocation

Estimated changes in population density within the proposed SMZs for Mutonga and Grand Falls following relocation of the population displaced by inundation of the reservoirs are given below. 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 to 34.4 persons per 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 (by year 2005) resulting in an increase from an average 81.9 to 96.8 persons per km^2. There may therefore be a requirement to extend the Grand Falls SMZ further East to include additional land currently under relatively low population density, and/or to increase productive capacity of the land through introduction of small scale irrigation in suitable locations (in addition to the proposed rural water supply programme). Population density within SMZs following relocation (including a comparison with the situation for High Grand Falls) can be summaried as follows:

	LGF	MUT	Combined	HGF
Population displaced (year 2005)	5,143	1,015	6125	12,073
Households displaced (year 2005)	870	159	1017	2,024
Area of proposed SMZ (km^2)	344.0	227.6	511.0	759.8
Projected 2005 SMZ population	28,171	6,811	32,750	49,645
Projected 2005 SMZ households	5,010	1,112	5,769	8,734
Population density	81.89	29.93	64.09	65.34
Combined population (year 2005)	33,314	7,826	38,875	61,718
Combined households (year 2005)	5,880	1,271	6,786	10,758
Resulting population density	96.84	34.38	76.08	81.23
Required household land @2 ha/hh (km^2)	117.6	25.4	135.7	215.2

(5) Resettlement Recommendations

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 are recommended:

- 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.

Recommendations

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

- Establishment of an institution to oversee the entire resettlement process, to 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.

- 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.

- Develop a plan consistent with local preferences.

- Recognise that even though formal land adjudication has not taken place in all areas, the land is considered as 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,

- 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.

- 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.

- The Government should begin planning and negotiations with the affected people at least 3 to 4 years prior to the relocation activity.

- 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.

- Review of the legal and policy framework on issues related to resettlement and compensation, with recommendations for modification should such be necessary.

(6) Mitigation Measures

The following mitigation measures are indicative of those that should 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.

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) Make provision for electricity supplies to public facilities such as schools, hospitals, clinics in order to provide a measurable benefit to the local populations.

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

5) The bridge across the Tana at Katama will need to be replaced by an alternative service for people, vehicles and livestock to cross the reservoir.

6) Water-borne and sexually transmitted 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 a mosquito and schistosomiasis control programmes must be considered.

3. RESERVOIR ENVIRONMENT

(1) Natural Resources

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 and preliminary surveys of these areas were conducted.

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 adverse ecological impacts as a result of (i) reduction in flooding on the flood plain, (ii) the creation of a barrier to fish migration, and (iii) 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. Interference with migratory routes up the Mutonga and Kathita tributaries is likely to lead to disappearance or extinction of some fish species.

A recent satellite image was used to compile a vegetation map of the study area. This was enhanced by the analysis of aerial photography and the delineated vegetation units were field-checked.

A list of plant species of the study area was compiled from collections and sight records. Species not identified in the field were collected, pressed and carried to Nairobi for identification. These were later confirmed at the East African Herbarium, Nairobi. Sample plots were used to determine vegetation structure. 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. The list of the recorded plant species was screened for conservation status according to the IUCN Plant Red Data Book classification.

During field investigations, interviews were conducted among Tharaka experts with knowledge of the local plants. The importance of 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.

Chapter 12 of the Supporting Report (2) provides further details of these and other surveys carried out to describe the natural resources available within the study area.

Economic, Social And Cultural Utilisation of Natural Resources

The plant species of the study area present a unique plant diversity that is utilised extensively by the local community. Close to 20% of total number of plant species in the study area, including trees, shrubs, herbs, grasses, climbers and lianas are commonly utilised 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 in greater detail by section 12.6 of the Supporting Report (2) .

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. These are discussed in greater detail by sections 12.7 and 12.8 of the Supporting Report (2) along with potential mitigation measures.

Mitigation Measures

- Rehabilitate all degraded land during and following completion of construction activities.
- Replant indigenous trees in order to restore lost biodiversity.
- Prior to construction and impoundment, important components of the currently existing natural vegetation should be carefully removed, relocated to nurseries and maintained during construction activities. Following impoundment, these plant nurseries will provide the means to replant and rehabilitate disturbed land and restore important components of the lost vegetation.
- Carry out soil erosion measures, including terracing and planting of sediment binding grasses on exposed slopes and other surfaces.
- Avoid introduction of aquatic weeds. In particular, boats and equipment previously used in Lakes Naivasha or Victoria should not be allowed.
- Initiate an aquatic plant monitoring programme.
- Carry out surveliance for waterborne and other diseases. Initiate control programmes, including the control of schistosomiasis and of malaria.
- Initiate a community oriented appraoch to the conservation of forests in the area. This should combine forest protection with access for activities such as bee-keeping and education.
- Clear shrubs and trees that will be flooded by the proposed reservoirs. Integrate this with community oriented programmes of utilization for buliding poles, tiimber, furniture, fuelwood and charcoal production to be carried out for the benefit of affected villages. Integrate this programme with subsequent agro-forestry programmes.
- Initiate agro-forestry programmes in the resettlement area in order to mitigate against the loss of fulewood resources.
- Create a buffer zone with minimal human activity round the proposed reservoirs. Arrange for necessary access to the reservoir at suitable locations.
- Initiate, and finance, a comprehensive community oriented land use management strategy within the resettlement area.
- Initiate an environmental, social and health monitoring programme.

(2) Sediment Load

There are two major concerns related to the sediment load of the Tana rivers. The primary engineering concern is that much of the sediment load will be trapped, reducing storage volume and defining the effective life of the reservoir.

In addition to the coarse and medium sediments carried by the Mutonga and Kathita tributaries, as a result of week flocculation some of the clay particles will form settle within the reservoir. Mud trapping efficiencies of 15% have been estimated at Kiambere. It can be expected that this will be significantly higher for the larger Low Grand Falls.

The downstream implications of sand and gravel trapping is increased stream erosivity immediately downstream of the reservoir and downstream of the Kora rapids and a change in sediment load and composition affecting river morphology and suspended mud and associated organic matter and nutrients carried out downstream by flood water – this is though to play an important rule in maintaining the fertility of the flood plains in the lower reaches of the Tana river.

As part of the study, samples have been taken during late dry season and during the peak flood period. A crude estimate of sediment transport shows a gross annual movement of 5.5 million tons for the sample year. However, this sampling procedure appears to have missed much of the fine clays and silts which form the major component of the parent material in the upper catchment. To some extent this will be a result of temporary seasonal deposition and erosion of sediments within the river system itself; coarse sediments will be deposited at the point where the fast tributaries of Kathita and Mutonga join the slower main stream, eroding during peak flood periods.

The conclusion is that the actual sediment transport and hence volume trapped by the reservoirs is therefore likely to be greater than initial figures indicate. Given these discrepancies, it is clear that further detailed studies will needed to establish actual daily sediment loads, inlcuding all fine material, over a complete anual cycle.

(3) Water Quality & Pollution

The water quality of the reservoirs and hence of the river downstream, is a result of the quality of the inflow and processes within the reservoir. The only real potential for managing water quality is to control discharge within the upper catchment, which is effectively determined by rural and urban land use. The water quality in the Lower Grand Falls reservoir is likely to be different than that of Kiambere, or the other up-stream reservoirs.

Water quality varies with the seasons, with generally higher quality discharge during the dry season when farming practices are limited, sediment load is low and there are no flash floods transporting non-point sources of contamination. However during the rains, there are high levels of contamination, including both physical and chemical, and most significantly biological and bacteriological from both the Mutonga and the Kathita rivers and the discharge from Kiambere.

The discharge contains both phosphates and nitrates. The implication is that there will be a slow build up of nutrients in the reservoirs, which would support high primary productivity and could encourage fish production. However, algal blooms are unlikely to be a major problem, as they will be limited by the availability of phosphate which is expected to be strongly locked onto clay particles and will be deposited in bed sediments.

Despite this, water quality remains of some concern, particularly where human water supplies are extracted from the river, or from the future the reservoir. Improved treatment and waste management should be considered for the upper catchment. Similar improved treatment may be needed for communities relying on water discharged from the reservoirs.

(4) Nutrient and Particulate Matter Flushing

Fieldwork was carried out during the dry season in September 1995 and during the November rains, to establish water quality parameters in Kiambere reservoir, in the Mutonga and Kathita rivers and the main Tana channel. A deterministic three-dimensional segmented and layered model was used to predict the water quality and flushing of nutrients and particulate matter through the proposed Mutonga and Low Grand Falls Reservoirs. The 3D models of the Mutonga and Grand Falls reservoirs were run in series-one flowing into the other-and were used to simulate typical wet and dry season conditions with steady 20 and 80 percentile fluvial flows, respectively.

The analysis of the Kiambere reservoir data indicated that it trapped about 15 to 20% of the wash load of clay particles, which are weakly flocculated by the presence of natural salts in solution (75 ppm) and settle at an estimated rate of 5×10^{-6}m/sec.

The models predicted that about 60% of the suspended load of clay particles and 85% of associated phosphate and organic matter would be trapped, mainly in the Low Grand Falls reservoir during typical wet and dry season conditions. The models predicted that the two reservoirs operating in series would trap about 40% and 55% of the daily influx of dissolved nitrate, mainly in the Low Grand Falls reservoir, during typical wet and dry season conditions with recycling of organic nitrogen from settling detritus, but not from the bed. If conditions in the bed allowed optimum rates of recycling of organic nitrogen from settled algal detritus, trapping rates would be expected to fall to about 25% and 40% during typical wet and dry seasons, respectively.

During floods from the Mutonga and Kathita rivers much higher, but as yet unquantified masses of suspended silts and clay will pass rapidly through the Grand Falls reservoir, as a cold density current, scouring the soft bed. This might either settle in the dead zone below the out-take or pass downstream through the turbines.

The model predicted that algal growth in the surface layers would not be significantly affected by recycling of dissolved available inorganic nitrogen into the lower layers of the reservoir, unless strong winds caused upwelling.

The particulate phosphorous trapped in the settled mud and detritus will not be recycled easily and will not be available to phytoplankton in the photic zone. The model predicted that the reservoirs would trap about 50% and 80% of the relatively small incoming loads of dissolved available phosphate in the wet and dry seasons and that the algal blooms in the surface layers are likely to be limited by lack of phosphorous.

The model predicted a 2-4 m deep photic zone with variable and an acceptable range of chlorophyll-a concentrations (i.e. 5-15 mg/m^3) depending on light penetration, and the horizontal flux of nutrients. The model also predicted a moderate DO sag in the deeper layers of both reservoirs. However, the DO sag could deepen further with time as a result of an accumulation of settled decaying organic matter raising the benthal oxygen demand in the dead zones of the reservoirs.

The model predictions are sensitive to factors affecting the growth of the specific algae species in the Tana river reservoirs - which were not available. This information would have to be obtained from further research. The coefficients should be tested by simulating conditions in the existing Kiambere reservoir.

There is a need to construct rating curves for the flux of suspended mud, organic matter and particulate and dissolved nutrients for the Mutonga and Kathita rivers. There is also a need for a daily record of meteorological conditions and synthesised sediment and pollution loads so that the models can be run for a number of years, including solar heating and wind effects. There is a need to study the detailed behaviour of the passage of sediment laden floods from the Mutonga and Kathita rivers through the reservoirs, using a fine-gridded 3D model.

(5) Reservoir Infilling Periods

The time taken to fill the newly created reservoirs will depend on the rainfall at the time. The probable range of time periods taken to fill the reservoirs were estimated using the daily river flow series at Grand Falls and at the confluence of the Mutonga and Tana, together with the follwoing sets of of operating rules.

1	Minimum downstream environmental flow	30 cumecs
	Additional flow released downstream	none
2	Minimum downstream environmental flow	50 cumecs
	Additional flow released downstream	none
3	Minimum downstream environmental flow	30 cumecs
	Additional flow released downstream	25% of inflow
4	Minimum downstream environmental flow	50 cumecs
	Additional flow released downstream	25% of inflow

Starting at a randomly chosen point the reservoirs were filled, allowing for the above operating rules and accounting for evaporative loss. Each simulation was run 1000 times and the resulting infilling periods in days are summarised below.

A: Grand Falls (LGF)

Rule	70% probability of infilling	average time	minimum	maximum
1	153 days (5.1 months)	121 days	22 days	300 days
2	205 days (6.8 months)	161 days	31 days	379 days
3	184 days(6.1 months)	143 days	22 days	443 days
4	248 days (8.2 months)	191 days	31 days	577 days

B: Mutonga

Rule	average time	minimum	maximum
1	15 days	1 days	46 days
2	18 days	1 days	97 days
3	20 days	1 days	61 days
4	25 days	2 days	126 days

C: High Grand Falls simulation

Rule	70% probability of infilling	average time	minimum	maximum
1	632 days (21 months)	516 days	221 days	996 days
2	743 days (24.8 months)	615 days	236 days	1,286 days
3	811 days (27 months)	698 days	332 days	1,240 days
4	895 days (32.8 months)	823 days	380 days	1,625 days

Clearly, the infilling times for Mutonga are relatively short with average times taken to fill ranging from 15 to 25 days for the different operating rules used by the simulations.

Impoundment periods for Grand Falls (LGF) are considerably longer with average estimates ranging from 121 days to 191 days (with an estimated maximum of up to 577 days). It must be realised however, that these average infilling periods will be exceeded 50% of the time, i.e. there is only a 50% probability of infilling during these periods, or a 50% chance of taking a longer periods to fill the reservoir. A greater certainly can be estimated by assuming higher probability levels. In this study 70% probability levels were assumed and these indicate infilling periods of between 153 days (5.1 months) and 248 days (8.2 months) for the four different operating rules used.

By contract, infilling periods for the larger volume of High Grand Falls reservoir were estimated by simulation to be an absolute minimum of 220 days, with 70% probability of infilling estimated at between 632 and 895 days (21 to 32.8 months) and a maximum estimated infilling period of 1,635 days (54 months or 4 and a half years). These estimated infilling periods would **guarantee a prolonged and very serious *de facto* downstream drought** of between 2 and 3 years – whatever the upstream conditions and rainfall elsewhere in the country.

Effect on Downstream Users

Infilling of Mutonga is expected to have no appreciable impact on downstream systems.

The effects of impoundment of Grand Falls reservoir on downstream flows are considered to be serious from the point of view of all downstream population. The minimum downstream flows released by the simulations (30 and 50 cumecs) are both significantly below the average monthly flows at Grand Falls. The most beneficial operating rule, releasing a minimum of 50 cumecs and releasing 25% of the remaining inflow (retaining 75%), results in a 70% probability of infilling within 8.2 months. The resulting downstream flows would be the equivalent of very low dry season flows throughout the year.

The effect of the impoundment of Grand Falls (LGF) would therefore be a *de facto* drought situation for all downstream users throughout the infilling period.

Mitigation Measures

No mitigation measures are possible, with the exception of drought relief and food aid programmes. It is considered that parts of the downstream area are only now beginning to recover from the effects of previous low-flow periods - caused by a combination of real drought events and *de facto* droughts resulting from the impoundment of the other reservoirs in the upper catchment.

This drought period is likely to have its greatest impact on the pastoralist communities since their livestock rely on the flooding of the floodplain for vital dry season grazing resources. In the absence of this grazing, the people and their livestock will be forced to move considerable distances in search of suitable grazing. The traditional refuge in such times is the Tana Delta and this are is therefore likely to bear the greatest impact in terms of increased grazing pressure and heightened social tensions, in an area where security is already an important issue.

4. DOWNSTREAM POPULATION AND ENVIRONMENT

(1) Population Numbers and Projections

Immediately below Grand Falls the Tana river runs through Tharaka-Nithi District, with Meru and Tharaka peoples practising small-scale agriculture together with livestock. To the south, the Tana river forms the boundary with Mwingi District. The river then borders Isiolo district with a mixed population of Boran and Somali pastoralists adjacent to the river, before entering the lower Tana basin proper. In Isiolo District the Tana flows adjacent to Garbatulla Division with an estimated 1996 population of about 15,000, of which a proportion will concentrate around Kinna, away from the Tana where amenities and security are improved. On an area proportional basis, the population of Isiolo District that falls within the Tana Basin is projected at 9,600 by 1996. However, people from a wider area are more or less completely dependent on the Tana river during dry seasons.

The major part of Tana river basin is covered by two districts, Tana river and Garissa, and although Garissa District extends beyond the actual river basin, virtually the entire district population depends to some extent on the river and on the riverine flood plain corridor, especially during the dry season. The rural population projection for 1996 for the two districts, plus those parts of Kilifi and Lamu falling within the Tana river basin, is estimated as 350,000. This is expected to have increased to 452,000 at the possible time of impounding and start of commissioning (year 2005). The majority of the population in Garissa is of Somali origin (referred to as Ogaden in the Census), the population of Tana river is recorded as being predominantly Orma and Pokomo. Population Projections from Tana river and Garissa Districts together with those parts of Kilifi & Lamu falling within the Tana river basin are given below togeterh with major tribal groupings in Tana river and Garissa Districts.

	1989	1996	2005
Garissa District	134,597	138,759	144,300
Tana river District	137,987	182,705	262,118
Lamu District	7,020	11,140	20,169
Kilifi District	13,608	17,931	25,565
Total	293,212	350,535	452,152

	Tana river	Garissa
Somali	1%	84%
Pokomo	37%	< 1%
Orma	33%	< 1%
Degodia	< 1%	3%

The above clearly represents a simplification of the actual situation as the tribal groupings used in the National Census do not, for example, distinguish between the Orma and Wardei and the populations are better described in conjunction with their specific economic activities. However, it is possible to give a rough breakdown of the total rural population groupings relying to a greater or lesser extent on the river downstream of the proposed reservoirs. Population projections for those areas adjacent to the Tana river downstream of the proposed reservoirs together with estimates of the proportion either partly or entirely dependant on the river are given below.

By the year 2005, close to the year of impounding and commissioning, the downstream population dependant on the Tana river will be in the region of 555,000. Chapter 15 of the Supporting Report (2) describes each of the major socio-economic groupings within the lower Tana basin in greater detail.

District / Division	Main Ethnic Group	Census 1989	Population projections 1996	2000	2005	Est. % dependence on Tana	Est. 2005 dependence on Tana river
Tharaka-Nithi / Tharaka	Meru / Tharaka	74,929	91,500	102,600	118,400	50%	59,200
Mwingi / Kyuso	Kamba	103,32,5	126,800	142,600	165,100	20%	33,000
Isiolo / Garbatulla	Boran	11,188	15,400	18,400	23,100	50%	11,600
Garissa	Somali	134,579	138,700	141,200	144,300	100%	144,300
Tana river	Pokomo / Orma	137,696	182,300	214,000	261,600	100%	261,600
Lamu	Orma	7,020	11,100	14,500	20,200	100%	20,200
Kilifi		13,608	17,900	21,000	25,600	100%	25,600
TOTAL		386,680	483,100	551,800	653,600		555,500

(2) Downstream Environment

Floodplain Grasslands

Floodplain grasslands occupy by far the largest area within the Tana river floodplain and delta, and by inference is the habitat most likely to suffer the effects of any negative impacts resulting from the Project. The floodplain grasslands form a vital function as dry-season grazing for a large number of livestock from a very much larger area of Tana river and Garissa Districts, and impacts on these grasslands may therefore be very widely felt. Although there is little detailed information on these grasslands, studies from elsewhere illustrate several important aspects.

Floodplain grasslands, throughout Africa, support large numbers of domestic and wild herbivores. A major contributing factor is the high quality of floodplain grasses. However, the most impressive aspect of floodplain grasslands is the close integration of the physical and biological components of the system. It is this close integration that results in the high carrying capacities generally associated with floodplain ecosystems. The traditional integration of human, physical and biological activities which make up the ecology of the floodplain can only work if there are communities of micro-organisms, plants and animals that are adapted to the particular frequency of environmental events. In the case of the Tana river floodplain the important driving variable is the twice-yearly flooding regime.

If flooding is reduced below a critical frequency, the particular assemblage of grass species that constitute the floodplain grass communities will inevitably change to more closely resemble the adjacent non-floodplain grasslands. Floodplain grass species are of generally high fodder quality, containing a relatively high content of crude protein. Moreover, they are also highly palatable, even when dry. In contrast, grass species from non-flooded areas lose their palatability on drying. Thus, even in areas of similar grass production, the floodplain species will always be more attractive to herbivores, and will have a greater productive capacity.

Reduction in flooding is therefore likely to result in a changed grassland species composition. This will in turn result in a decreased carrying capacity for domestic livestock (and wildlife). Since livestock constitute an important economic and cultural component of many of the Tana river's downstream systems, such impacts are likely to be significant and far-reaching.

Riverine Forests

Between Garissa and the delta, the Tana river supports patches of riverine forest which, for reasons of soil type, drainage, and ground water availability, are confined to raised riverside levees, or to levees alongside old courses of the Tana. Potential evapotranspiration by far exceeds precipitation. These forests owe their existence to the proximity of ground water resulting from the presence of the Tana in this otherwise arid region and to the periodic flooding of the Tana.

These forests are considered to be of exceptionally high conservation importance as they not only contain rare and endemic plant species, but are also home to two endemic and critically endangered subspecies of primates. However, there has been a gradual reduction of these forests in the past due to increased demand for land from a rapidly expanding human population. Lack of proper project implementation in the Bura and Hola irrigation schemes has also contributed to a significant loss in forest cover. In order to conserve biodiversity, several localities downstream of Kora are now protected as National parks and Reserves. The Tana river Primate National Reserve (TRPNR) was established in 1976 in order to preserve the best remaining patches of this riverine forest.

The lower Tana riverine forests have been the subject of detailed research work because of their conservation importance, with most of the studies concentrating within TRPNR. All studies have recognised the importance of the river's hydrological regime to the survival of the forests. Forest regeneration is dependent on overbank flooding and its growth and phenology are closely related to the rise and fall of the river level. Natural forest regeneration depends entirely on overbank flooding, which usually occurs at flows above 500 m^3/sec measured at Garissa.

Chapter 19 of the Supporting Report (2) includes additional details on these important forests as well as information relating to the mangrove forests in the Tana Delta, together with an assessment of their importance and their dependence on the Tana river floods.

Downstream Protected Areas

Protected areas should receive special attention during environmental impact assessments of major development projects in Kenya. These areas are becoming increasingly isolated from the larger ecological units within which they developed. This isolation inevitably alters the ecological balance of the area and, in order to maintain ecological health and function, requires increasing levels of human intervention and management. External stress imposed by direct and indirect impacts of development projects can add greatly to these management costs.

A total of 8 existing or proposed protected areas fall within the limits of the area of potential impact of the proposed Grand Falls dam. Each is described by chapter 19 the the Supporting Report (2), although the level of ecological detail available for each site varies considerably, as does the likelihood of significant impact from proposed dam development.

(3) Downstream Production Systems

Production systems in the Tana river basin are multi-faceted. The more common components are rain-fed agriculture, flood recession agriculture, livestock management, fishing and, more recently, irrigated agriculture. Of these, only rain-fed agriculture has no direct relationship to flooding. All other economic production systems are closely tied to the nature and timing for the flooding regime, whilst their relative importance is responsive to changing conditions, embracing changes in precipitation and river flow.

Along the coastal strip where rainfall is higher, riparian farmers emphasise extensive rainfed agriculture. Elsewhere downstream, poor rainfall effectiveness leads to reliance on flood recession and irrigated agriculture, or on alternative production systems. Where both rainfall and flooding are restricted, the people turn to wage labour, and especially labour migration to external locations. Labour migration in turn is a constraint, particularly on irrigated agriculture downstream. Reduced labour availability, leading to reductions in land cultivated, often results in food deficits.

A great majority of livestock management strategies within the lower Tana basin depend on the Tana river, and particularly on flooding to a greater or lesser degree. Pastoralists respond to periods of drought through temporary or even permanent sedentarisation. Along the middle and lower Tana river, some pastoralists are increasingly changing to arable agriculture. Others marginalised by drought, conflict and insecurity due to banditry, hire themselves out to herd the stock of agriculturalists, wealthy pastoralists, and co-operative ranches. Subsistence fishermen in the downstream environment have been increasing despite the frequent failure of floods to replenish the ox-bow lakes and the breeding grounds in the wetlands of the delta.

One or more ethnic groups within a single diversified production system incorporate the various components of the above systems. Alternatively, they are associated with different ethnic communities through occupational specialization in which case the various groups are intricately related through a complex of economic, social, and political links. The most flood-dependent components of production systems are analysed and described in greater detail by chapter 17 of the Supporting Report (2), including discussions of:

- Downstream Sediment Load
- Downstream Water and Sediment Quality
- Downstream Fisheries, including subsistence, delta and marine fisheries
- Field crops, Tree crops
- Livestock systems

- Small-scale and Larger scale irrigation

as well as constraints to these systems.

(4) Economic Value of Downstream Systems

Four alternative scenarios were assessed in terms of their economic impact on downstream values, and compared with the present situation as a baseline[1]:

Flood Release:

- Alternative **MR** Maximum flood and sediment Release[2]
- Alternative **R** Flood and sediment Release

Flood Control:

- Alternative C: Flood Control
- Alternative MC: Maximum flood Control

The systems that have been included in this assessment were as follows:

Agricultural systems	Fisheries	Wild habitats and species	Urban and rural infrastructure
Pastoralist production	Freshwater fisheries	Wildlife resources	
Flood-recession agriculture	Marine fisheries	Protected areas	Water supplies
Irrigated agriculture	Prawn farming	Forests, Lakes and Wetlands, Mangroves	Roads and bridges

The project alternatives represent a range of possible scenarios which will have differing impacts on downstream systems. These range from:

Best-case scenario with dams implemented with maximum flood release measures (Tana flooding regimes will be reinstated, and downstream systems will actually improve as a result of this),

to

Worst case scenario with dams implemented with maximum flood control (Tana flooding regimes will decrease still further, and downstream systems will be rapidly degraded or destroyed).

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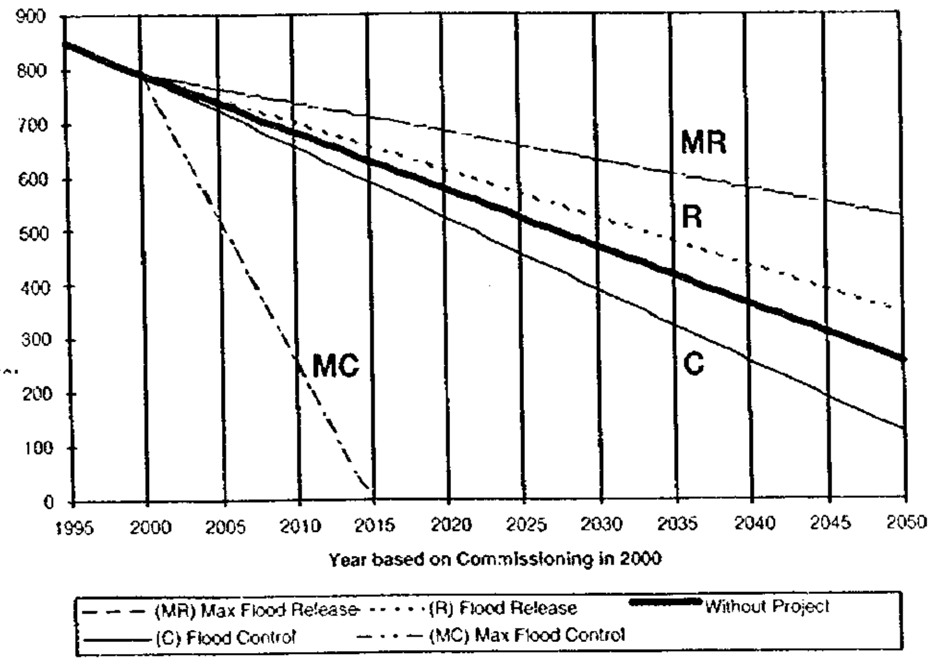
[1] This baseline reflects the average hydrological conditions represented by the 25 year flow series used in the hydrological analyses during Phase 2, and includes both drought years and years with above average rainfall and river flow conditions.

[2] It is considered that the proposed dam(s) will have the capacity to improve downstream conditions, namely: minimum flows will be increased, whilst controlled release of artificial floods during the wet seasons also has the capacity to improve downstream conditions from the current situation.

These project alternatives were compared to a baseline of the current "without project" situation, of existing dams only. It should be noted that the Tana flooding regime has already been affected as a result of the existing dams, and downstream values have been degraded.

Under a continuation of the present situation, this degradation will progressively worsen. Construction of additional dams without any flood release measures will aggravate and hasten this destruction (alternative C and MC). However, implementation of additional dam construction with flood release measures has the potential to, at least partially, reverse these negative impacts (alternative R), and at best significantly improve downstream values above the current situation (alternative MR). These results are presented schematically below.



A project implemented with flood release measures implies significant economic benefits in terms of positive effects on downstream systems and values. With flood control, dam construction will impose a considerable economic cost on already degraded and vulnerable downstream systems.

Mitigation Measures

Overall, it is concluded that existing dam developments on the Tana river have imposed costs on downstream systems, and that these changes will be exacerbated and hastened by additional dam construction. Unless the facility for releasing artificial floods and the maximum release of mud and nutrients are built into the Project, comments should be specific to project – not any dam. There is a very real danger that a range of economic benefits will be irreversibly destroyed, constituting a significant, and to some extent unquantifiable, social and economic cost on downstream systems and populations.

(5) Opinions of Institutions, Organisations and Downstream Communities

The study conducted interviews with local communities and people at typical locations (Garissa, Hola, Garsen and Kipini and/or appropriate places) who are engaged in flood recession agriculture, pastoralism, and fisheries. The study also sought the experience of specialists from government organisations, international organisations, international and local non-governmental organisations (NGO's), based on their investigations with regard to the production systems and biodiversity embracing flood plain grasslands, floodplain forests, delta grasslands, delta forests and mangroves.

Heavy floods have often led to changes in the river course. Such changes have led to changes in cultivation and settlement sites, thus contributing significantly to the spread of Wapokomo over an enormous length of the river frontage: the sand-spits, the swamps, lakes and old river bed. It would appear that the dynamic changes make the river both destructive and useful. Because of the alternating floods and drought occurrences since the last century (NES 1985), the Wapokomo have been under great difficulties in sustaining their livelihoods. It is quoted from the archives that the river is both their salvation and their destruction. There is also evidence to suggest that the failure of flooding has in the past contributed to land use conflicts between the pastoralists, agriculturalists and wildlife.

The local communities suggested that a project to help deal with the threat of drought, floods and famine would be welcomed and that the communities would be co-operative if they are consulted and involved in the project management, monitoring and evaluation. Chapter 19 of the Supporting Report (2) includes further details of the consultation with downstream communities.

Biannual flooding helps in increasing the productivity of the delta through the deposition of the silt. Additional dams will reduce siltation and lead to decline in the biodiversity, livestock and agricultural production. Consequently, this is perceived to lead to the chronic famines and diseases in the region. What the downstream communities want is a project that would alleviate such problems and improve their welfare.

There is divergence of opinions regarding the effects of the existing and upstream dams on the flooding of the downstream environment. The local people would like to know how the proposed project would interfere with the flooding, siltation and utilisation of the Tana river basin resources and the benefits expected from such a project. Even the district headquarters and other development centres have no electricity. Because of this difficulty, the local communities are wondering whether they would benefit from the project that they consider will exacerbate their suffering. To some local residents, it is the change in the river course that has brought problems and not the existing dams. For example, the change of the river course has affected the Hola, Bura and Tana Delta Irrigation Projects. Such changes have precipitated conflicts in resource utilisation downstream.

It is emphasised that unnecessary rumours that the project is intended to control floods are worrying the local people. This implies that there is urgent need for participation of the local communities in the project planning right from its inception so that the people are clear about how the project would improve or interfere with their lifestyles. Proper communication is essential to alleviate the fallacy that the project is intended to control flooding and to educate the people on the significance of the project in regulating the river flow regime and with proper management, would release water for flooding downstream environment at the critical crop growing seasons. The problem is lack of proper explanations of the benefits of the projects in improving the deteriorating downstream environment. If the local people are involved in the project and they realise its benefits, they would be willing to support the project.

There is urgent need for sensitisation and education of the downstream communities about the proposed Mutonga/Grand Falls Hydropower Dam. It is also important to conclude that the local people attach great significance on the flooding and utilisation of the downstream resources. Both agriculturalists and pastoralists as well as fishermen would suffer if the flooding is interfered with. Ultimately, we should not ignore the local people's perception of their environment and the upstream dams.

5. FLOOD AND SEDIMENT RELEASE

(1) Literature Review

Throughout the World, floodplains form a highly productive and yet inherently fragile component of the environment, providing a niche in which certain species and habitats have evolved, and in which farming systems have adapted to natural flooding patterns.

As a result of perceived problem of flood damage, attempts have been made to regulate rivers to stop flood damage. Paradoxically, the more successful these attempts, the more damage has occurred, for although the frequency of flood events is reduced, farming systems and settlement patterns develop that no longer incorporate risk avoidance strategies whilst at the same time the considerable benefits of smaller regular floods are lost. The high population growth rates that typify tropical and sub-tropical countries have encouraged permanent settlement in these flood plains, as if they were no longer at risk from floods, and as a result when the unavoidable random one in a hundred year flood occurs, there is a major catastrophe.

From the review of the literature on existing and proposed reservoir management, there are only one or two cases where the concepts of flood release have been considered. In March 1996, an artificial flood release was carried out by the Glen Caynion dam on the Colorado river in USA as an experiment.

Flood Release Planned and Implemented	e.g. Colorado river in USA, Glen Canyon dam, Artificial flood release of 1,300 m^3/sec peak discharge, totalling 900 million m^3 was carried out for one week in March 1996 as an experiment which would improve the present deterioration of downstream environmental condition.

Flood Release Planned, but Never Implemented	e.g. Sokoto river in Nigeria. Although the benefits of downstream flood dependent systems were recognised, by the time final designs were completed deliberate flooding management had been abandoned in the face of other requirements such as maximising hydropower;
Built for Flood Release, Inadequately Implemented	e.g. Kafue Flats in Zambia. Final designs included flood release, however the planned amount and management was inadequate and the system largely collapsed;
Modified for Flood Release, Changed Management Objectives	e.g. Pongolo river in South Africa. Following a failure to develop irrigation, management was changed to include specific flooding requirements for downstream communities;
Sediment Release, for Reservoir Management	Effectively only ever attempted to protect dam structures, not for downstream benefits. e.g. proposed sediment release from the Three Gorges Reservoir in China to protect turbine operation will only clear sediment within one hundred metres of the dam wall, initially trapping over 70% of all sediments.

As a result there are no examples where the positive benefits of regular flood release on the environment can be fully assessed, only the negative effects of halting the natural flooding cycle. These have been shown to include widespread disruption of the floodplain environment and the communities that have evolved systems dependent on natural flood cycles. The benefits of upstream development have been at an often considerable social and environmental cost to the downstream systems and communities and there has been little or no attempt at mitigation or compensation for these losses. In most cases this mitigation could only be done through the deliberate management of flood and sediment release to replicate a degree of natural flooding conditions.

Recently, in the face of widespread recognition of the potentially damaging effects of major development projects, all major donor agencies and many national countries have enacted legislation to ensure that environmental and social development considerations are included as an explicit component of such projects. In addition, it is the direct responsibility of the financing agency and those responsible for implementing the programme to show that due consideration has been paid to environmental concerns.

The concept of environmental tradeoffs has resulted from the acceptance among environmentalists and engineers that there are arguments on both sides of the development equation. The serious negative environmental impacts of large water projects have been clearly demonstrated, but so have the environmental and social benefits. The increasing demand for energy will have to be met by increased generating capacity; the increasing demand for water will have to be met by increasing storage capacity; and hydropower through the development of reservoirs provides a renewable and relatively low polluting energy source.

If potential negative environmental and/or social impacts are identified at the start of a programme, there is then the possibility of negotiating mitigation through alternative or additional developments as part of the overall hydropower programme. The early negotiation of tradeoffs will avoid delays in project implementation and, in the long term is likely to reduce overall project costs. Environmental tradeoffs can include both mitigatory development within the project area and parallel development outside the project area.

The downstream environment of the Tana river basin is composed of ecological and production systems which depend on both flooding and precipitation. Because of the inadequate precipitation in the region, these systems rely heavily on biannual flooding. Theoretically, the communities in the downstream environment are at risk from the proposed large dam on the Tana river, but in practice proper integrated management of the entire river basin may alleviate the undesirable impacts. The different ethnic communities of the downstream region practise a complex set of production strategies sustaining an overall low density through intense but seasonal use of the floodplain resources. If the dam is built without appropriate management to release water during the demand periods, it will adversely affect downstream production systems.

Recent studies show that large dams designed for hydropower generation adversely affect downstream production systems, income and employment. These studies demonstrate that such dams would restrict the natural flood, causing:

- Drastic reduction of flood recession agriculture;
- Heavy reliance on costly irrigated production;
- Decline in the quality of riverine pasture and in the number of stock that can graze during the long dry season;
- Reduction in fish capture;
- Transformation of the natural floodplain, reducing its capacity to support migratory birds and other wildlife, thus resulting in reduced biological diversity;
- Fluctuations in river fishery due to changes in flow regime, effect of dam blocking fish migration, changes in water quality resulting from loss of nutrients trapped by dam; and
- Decline in estuarine and marine fisheries and marine biota, including endangered species, through changes to flow regime and water quality and through loss of nutrients.

The above lessons indicate that there is an urgent need for new approach to the Tana river basin development whereby dams combine hydropower generation with the release of controlled floods, synchronised with reservoir drawdown, for the benefit of riverine populations and ecosystems.

Annual flood regimes have sustained the economies of downstream communities and production systems without environmental degradation. Furthermore, not only are those producers dependent on annual flood regimes, but their productivity, with associated multiplier effects could be significantly increased by low resource development strategies, embracing the improved water management that controlled flooding would provide.

These issues are reviewed in more detail by chapter 21 of the Supporting Report (2). In addition, the annex to the Supporting Report (2) includes an extensive annotated bibliography relating to downstream flooding.

(2) Flooding Patterns and the "Normal" Flood

The pattern of flooding on the lower Tana river was examined through an analysis of discharge and rainfall records during flood events. Flood events with at least one day of flow greater than 500 m^3s^{-1} at Garissa were analysed, with this figure taken to be the best estimate above which out of bank flow occurs. The "normal" flood was found to be best represented by the event with median characteristics in terms of its duration, peak flow and total volume. The median flood at Garissa has an estimated duration of 6.5 days, a peak flow of 785 m^3s^{-1} and a total volume of 394 MCM. It is assumed that a flood of this magnitude will inundate the floodplain both upstream and downstream of Garissa for a period sufficient to maintain the environment and level of economic activity currently supported by the current river regime.

Flooding on the lower Tana occurs on a bi-annual basis, usually during April / May and November / December. However, out of bank flooding does not occur in all wet seasons and some years, particularly during the 1970's, have suffered from a lack of such flooding in both seasons. The release of flood discharges to guarantee out of bank flooding at Garissa and the inundation of the floodplain both upstream and downstream would represent a significant improvement on the current situation.

Further flood event analysis revealed that the relationship between floods at Grand Falls and those at Garissa is not constant but varies in one of four ways. The flow records at the two sites were compared graphically for each of the 34 flood events From this comparison it was evident that the relationship between flooding at Grand Falls and that at Garissa is not constant. There appear to be four distinct types of flood, each one characterised by differences in the relationship between discharge at the two sites. Each of the four categories is illustrated graphically in Figure SE.3 and summarised below.

Type	Characteristics	No.of events
A	Flood attenuates as it moves downstream. Peak flows and total volume significantly less at Garissa than at Grand Falls.	11
B	Massive flooding at Grand Falls with much greater attenuation than in type A. Flood at Garissa appears insignificant in comparison.	5
C	Little change in flood as it moves downstream. Flood at Garissa very similar in terms of peak and/or volume to that at Grand Falls.	11
D	Flood increases as it moves downstream. Peak flows and total volume significantly more at Garissa than at Grand Falls.	6

During type A events the flood attenuates as it moves downstream with a reduction in both peak flow and total volume. In contrast, the flood hydrograph appears to undergo little attenuation as it moves downstream during type C floods whilst peak flow and total volume increase between Grand Falls and Garissa during a type D event. Type B events, during which massive attenuation occurs between Grand Falls and Garissa, were excluded from detailed analysis as they do not appear to be a current feature of the flood regime of the river and, moreover, there is some doubt as to the validity of these events.

The analysis of rainfall identified variations in the pattern of rainfall corresponding with each of event types A, C and D. These differences in rainfall appear to play an important role in determining the additional runoff to the Tana between Grand Falls and Garissa and hence the relationship between floods at the two sites. Rainfall during a type A event is concentrated on the Nyambene Hills and results in relatively large losses as runoff is carried to the main river via various tributaries. The impact of these tributary inflows on the flood flows of the Tana are relatively insignificant and the flood attenuates as it travels downstream. During type C and D events rainfall is more widespread over the top end of the lower Tana catchment. The mean travel time of runoff between source areas and the main river is less than during a type A event with a consequent reduction in losses. Inflows from tributaries between Grand Falls and Garissa during these events can help to sustain a flood or even boost it to as it moves downstream. As floods move downstream beyond Garissa they appear to attenuate in a consistent fashion with flood peaks and total volumes falling significantly as they reach first Nanigi and then Garsen. There appears to be no real difference in flood behaviour downstream of Garissa resulting from floods of type A, C or D. This confirms that runoff generation at the top end of the lower Tana catchment is the critical influence on the characteristics of floods as they move downstream.

The estimated release, and hence the reservoir storage, required at Grand Falls to support the normal flood at Garissa varies according to the different types of flood. In the case of a type A flood, with relatively low tributary inflow, the estimated release required from Grand Falls is 490 MCM. A release of this size should be able to guarantee normal flooding at Garissa regardless of inflows below Grand Falls, although there would be a risk of generating large downstream floods in certain circumstances with this type of release pattern. With relatively more runoff from the tributaries of the lower Tana (type C and D floods), the release from Grand Falls could be reduced by 17-26% depending on the extent and intensity of rainfall.

(3) Flood Release from Grand Falls Reservoir

The "normal" flood at Garissa, defined and estimated from the analysis of flood events with discharge greater than 500 m^3s^{-1}, has a total volume of 394 MCM. The corresponding flood volume at Grand Falls was estimated to be 490 MCM during a type A event (floods driven exclusively by rainfall in the upper catchment), 406 MCM during a type C event (floods supplemented by rainfall in the catchment between Grand Falls and Garissa) and 364 MCM during a type D event (floods including significant rainfall in the catchment below Grand Falls). Figure SE.4 shows the flood pattern and peak discharge of each type. These values may be assumed to represent the release, and hence the reservoir storage, required at Grand Falls to support the normal flood at Garissa. The findings of this study suggest two alternative strategies for the release of flood flows from Grand Falls. These are described briefly below, and in greater detail by chapter 22 of the Supporting Report (2).

Predefined Fixed Flood Release

The first, and more straightforward, strategy is to release the flood flow which will guarantee the normal flood at Garissa regardless of other inflows (type A release). A possible concern with this strategy is that it could result in more extreme, and potentially hazardous, flooding than required at Garissa if coinciding with large inflows from the catchment downstream of Grand Falls.

Variable Supplementary Flood Release

The alternative strategy is to deliberately release flood flows to coincide with tributary inflows. This strategy would require a smaller release from Grand Falls, but is reliant on an ability to forecast runoff generation from the top end of the lower Tana catchment, particularly from the Nyambene Hills. Although not analysed here in detail, the lag time between rainfall in these areas and flow at Garissa appears to be around 3-4 days. The lag time between flows at Grand Falls and Garissa was estimated as 1-2 days. This difference in lag times suggests that a strategy of flood flow release which takes into account rainfall on the Nyambene Hills and lower slopes and in the area downstream of Grand Falls over the previous 1-2 days would indeed be feasible. This strategy would require a system of instrumentation to monitor rainfall in the critical areas of the catchment and a set of release control rules governing the volume of flows released in relation to threshold rainfall values. The release of flows in accordance with these control rules could ensure that extreme flooding would not occur at Garissa because inflows downstream of Grand Falls were always taken into account.

A critical benefit of this supplementary release strategy is that the minimum volume of water is released to provide a downstream flood event, and hence maximising the storage volume for power generation. Initial estimates indicate a saving of at least 12 % of the flood volume that would then be available for power generation. Clearly if the entire upstream system of 7 reservoirs were managed according to upstream rainfall events to maximise use of seasonal flows, the potential to increase power output from the whole system would also be increased.

One further comment relates to the frequency of the normal flood at Garissa. Floods of greater than 500 m^3s^{-1} currently occur in at least one of the two wet seasons in 8 out of every 10 years. However, the chance that a flood of greater than 500 m^3s^{-1} will occur in only one wet season of any year is estimated to be 0.5. The release of flood flows, by whatever strategy, to allow out of bank flooding at Garissa in every wet season would therefore represent a marked improvement on the current pattern of seasonal flooding.

(4) Optimum Reservoir Operation

Optimum reservoir operation will be aimed at maximising power output while maintaining enough excess storage capacity to allow for flood release. The design objective of a storage reservoir is to provide enough storage capacity to hold the excess wet season flow for release during the dry season, aimed at providing a consistent power output throughout the year. This aim has to be balanced against the cost of providing storage for both seasonal and longer term variations.

The total volume of water that needs to be released at Grand Falls to generate a single flood event is typically between 6 and 8% of the total annual flow, depending on the downstream rainfall contribution. Bi-annual floods therefore would be equivalent to between 12 and 16% of the total annual discharge past Grand Falls.

However this does not equate to the same loss of power potential. Flood discharge will be split between: discharge through the turbines, discharge through an undershot or other offtake and discharge over the spillway which would occur at peak flood flows however the reservoir system was managed. Floods requiring little or no compensatory release will still occur naturally. In practice, the actual power cost is likely to be minimal and could be compensated for by the integrated management of the combined power generating capacity of the seven dam system.

The optimum management of the reservoir will therefore require the ability to predict and monitor rainfall patterns in the upper catchment as well as in the lower basin to guide flood release for downstream benefits. The use of longterm forecasts would improve dry season management in the drawdown period prior to the rains to equate to the expected rainfall patterns. The use of rainfall prediction, combined with real-time measurements of actual streamflow, could significantly improve the management of the combined upstream dams. This combined management therefore has further implications on future institutional arrangements for the management of the power generation industry.

(5) Management Operation Requirements

Clearly, the optimum management of the system will rely heavily on the capacity to monitor and predict the rainfall events within the basin, to provide the information that will allow flow rates to be adjusted for future events and to maximise the benefits of power output and the release of downstream floods.

There are two aspects to the improved management of the Mutonga-Grand Falls system that have not been reflected in any previous phases of hydropower development in Kenya;

- Reservoir operating decisions will need to be made by the power engineers with the support of **additional expertise in establishing and managing a basin wide real-time monitoring system** covering actual flow and sediment rates in the tributaries and main channel, and monitoring and predicting rainfall both in the source of the upper catchment and in the downstream flood area; and
- The management decision making process, supporting the release of floods to the downstream systems, must include **representation from the downstream communities**, extending beyond consultation to active participation planning and management.

The necessary expertise to manage an effective monitoring system could be established as part of the institution responsible for the day to day management of outflow release and hence power generation. As an alternative the management of the monitoring system could be taken on by an independent institutional arrangement building on expertise found in other government and parastatal institutions, the universities and private companies. Whichever arrangement is preferred, there will still be the need for a major capacity building exercise as neither the necessary equipment nor the expertise is presently available.

The second requirement is possibly even more critical, in that it reflects the willingness of management authorities that consider themselves to be specialists, to delegate part of their present executive decision making role to other (non-specialist) organisations. However, given the critical demands for management that are defined by the release of floods rather than the traditional maximisation of power output, the structure of the management institution must reflect the multi-purpose objectives of the project. This therefore includes representatives from the traditional pastoralist and arable farming and fishing communities, as well as the more established formal structures of the irrigation schemes. The concerns of the "conservation" bodies will also only be met by their direct inclusion in the decision making process. There will therefore be a need to incorporate representation from KWS, NMK and national and possibly international NGOs.

Again it needs to be stressed that this broadening of the institutional scope is more than a consultation process and provides the capacity to negotiate acceptable management decisions between users with potentially conflicting demands for timing and extent of flood release. Only if the communities can be assured that their views are incorporated will there be a possibility of avoiding conflict, this assurance must be given by their own representatives involved in the decision and negotiation process.

Given that the maximised benefits of the project will only be met by extending that management to include the upstream reservoirs, a new institutional arrangement would appear necessary that has executive authority over the previous phases of hydropower development. In addition, as upstream demands for water abstraction increase, the upstream users should also be included as part of the institutional arrangements. This would provide an overall basin management capacity representing the views of all users within the basin, as well as the wider national demands for power and water.

6. DOWNSTREAM RIVER MORPHOLOGY

A numerical model study was carried out to determine the morphological impact of the proposed Low Grand Falls and Mutonga dams. The study assumed that due to the nature of the river between the proposed dam site and the Kora Rapids no significant morphological change will take place in this reach. The numerical model indicates that downstream of Kora Rapids significant, and potentially serious degradation will occur.

After 34 years the degradation will be of the order of 11 metres immediately downstream of Kora rapids. The degradation will extend approximately 40 km downstream, reducing in magnitude as one progresses downstream. Further degradation will take place after 34 years.

It is currently proposed to release artificial floods from the reservoir. This will not have a significant impact on the morphology in comparison with the normal dam releases.

It has been suggested that the sediment from the Kathita catchment could be diverted around the reservoir to enter the river downstream. The impact of this is to reduce the amount of degradation from approximately 11m to approximately 9m. However, in this study the feasibility of diverting the sediment from the Kathita by direct diversion structures was not considered to be feasible.

The reduction in bed levels would tend to destabilise the banks of the river, leading to changes in the shape of the channel cross-section and the injection of sediment into the river. Neither of these effects have been included in the present model. They are likely to slow the actual rate of change in comparison with the model predictions but are unlikely to affect the final equilibrium value.

The reduction in bed levels leads to a corresponding reduction in water levels. This will reduce lead to a reduction in the groundwater levels adjacent to the river. This is likely to have an impact on the local environment.

The change in the equilibrium conditions of the river will also induce plan form changes. Those reaches which are presently braided are likely to become less braided and may change to a meandering plan form. The sinuosity in those reaches that are presently meandering may reduce. This will have an impact on any infrastructure along the banks of the river.

These findings suggest that construction of the proposed dam at Grand Falls will:

- Lead to a degradation of the bed of the Tana river of up to 11 metres in a 40 km reach downstream of Kora Rapids.
- Lead to a corresponding reduction in water levels.
- Lead to a reduction in groundwater levels.
- Result in plan form changes of the river channel itself. This will have an impact on any infrastructure along the banks of the river.

7. POWER TRANSMISSION SYSTEM

Electric power transmission systems include the transmission line, its right-of-way (ROW), switch yards, substations and access or maintenance roads. The main structures of transmission line include the line itself, conductors, towers and supports. The ROW in which the transmission line is constructed can range in width from 50 m or greater depending upon the size of the line and the number of transmission lines located within the ROW.

Electric power transmission systems are linear facilities that will affect both the natural and socio-economic resources of the study area. In general the environmental impacts pertaining to either natural or socio-cultural resources increase with increasing line length. As linear facilities, the impacts of transmission lines occur primarily within or in the vicinity of the right-of-way. Negative impacts of the transmission line will mainly occur during the construction and operation phases of the power transmission lines. Chapter 23 of the Supporting Report (2) describes potential impacts during each of these phases along with mitigation measures. Environmental assessment of the transmission line from Kiambere is considered by previous studies for the planned KPC transmission line and any additional facilites required will have similar impacts.

8. MANAGEMENT

(1) Environmental Monitoring and Evaluation System

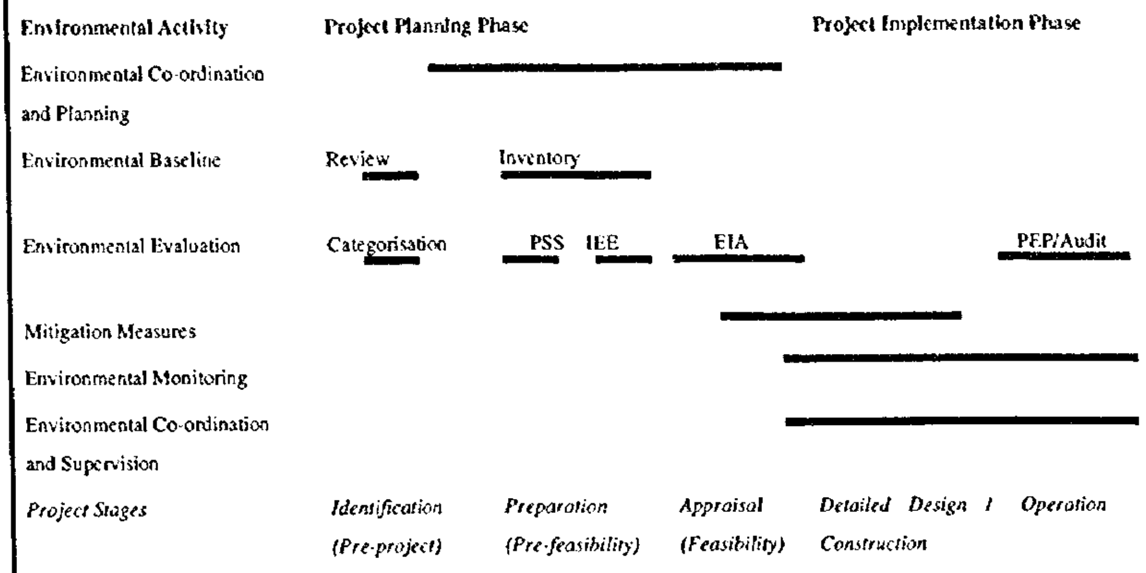
The establishment of an Environmental Monitoring and Evaluation System (EMES) will provide ongoing monitoring for the agency administering reservoir and operations and hydropower generation and for other agencies. These data will provide information relevant of the project's environmental and socio-economic impacts and assist in supporting improved environmental management of the Project itself (i.e. dam operations). This will also provide a basis for appropriate and timely mitigation measures during the project's life. As can be seen in the following diagram, Environmental Monitoring is an integral part of the Project Implementation phase.

Monitoring will need to assess the *biophysical* and *socio-economic changes* that occur in representative and important portions of the lower Tana valley, and upstream, in the reservoir and resettlement areas. It is assumed that separate biophysical and socio-economic monitoring teams will be appointed, from appropriate local or regional institutions.

A full baseline survey, to complete available information on the downstream river basin is an essential basis for subsequent monitoring. This will draw upon existing secondary sources, covered and referenced in the EIA, phases 1 -3, and where necessary, field survey to determine the baseline status of the key recommended monitoring parameters. Baseline assessment should take place well before construction commences so that several years of records for the upstream and downstream locations can be obtained.

Chapter 24 of the Supporting Report (2) details the different monitoring programmes required, including socio-*economic* monitoring and bio-physical monitoring of conditions in the upper and lower catchments.

Environmental Management Plan Framework



PSS - Preliminary Screening and Scoping; IEE - Initial Environmental Examination; EIA - Environmental Impact Assessment; PEP - Preliminary Environmental Post-Evaluation.

(2) Institutional Requirements

The success of the proposed Mutonga and Grand Falls Hydropower Project, in terms of its economic and social benefits, will greatly depend on constant assessment and efficient management. A vital element of management is environmental monitoring. Such monitoring will entail the following courses of action:

- Measuring the effects of the hydropower operations on the environment.
- Reporting to the competent authority, regularly and upon request, on such effects on the environment.
- Effecting such reporting in accordance with established procedure, so as to facilitate appropriate responses.
- Regular inspection by the competent authority, of the hydropower installations, with the object of ensuring that the conditions on which the project was authorized, are complied with.
- Ensuring that the conditions referred to in above are complied with.

This monitoring function cannot be performed without suitable institutional arrangements. Schemes of this kind will range from organisational systems through to governing laws and other regulatory norms, and to operational management practices and policy orientations.

In this consideration of institutional arrangements, recognition must be made of the agencies which perform the various roles, the law or administrative arrangements regulating such agencies, the functions and powers of such agencies, the environmental monitoring and reporting procedures, and the role of sanctions in the operation of arrangements for environmental protection.

Institutional requirements are discussed in chapter 25 of the Supporting Report (2) which, apart from addressing these points, also reviews existing arrangements, considers present institutional requirements, and makes recommendations in respect of the environmental monitoring process for the hydropower project.

While the EIA document alone can, in theory, serve as a foundation for effective environmental monitoring, in practice it is desirable that there should exist a working relationship between those primarily involved in the EIA process, and those who will principally be responsible for the monitoring process.

(3) Recommendations

<u>**Legal and Administrative Aspects**</u>

- In the event of the proposed central environmental statute being passed soon, the task of environmental monitoring will be regulated in detail under the new law. The most notable aspect of the new law would be the establishment of a national environmental agency, with responsibility for the setting of quality standards, and the monitoring, in co-ordination with relevant lead agencies, of the compliance of projects with the safety measures proposed under environmental impact assessment.
- Without the enactment of the proposed central environment statute, the Mutonga and Grand Falls Hydropower project would have to be operated under the existing state of the law. As the current state of the law has certain notable shortcomings, it is recommended that an administrative arrangement be established which would facilitate the conduct of environmental monitoring.
- In the proposed administrative arrangement, the primary responsibility for environmental monitoring should fall on the Tana and Athi rivers Development Authority (TARDA), the legal entity entrusted with the co-ordination and control of development projects in the Tana river Basin. While TARDA takes the primary responsibility for environmental monitoring, it should work closely with the National Environment Secretariat (NES), the various Ministries having a stake in the development of the Tana river Basin, and the donor agencies.
- Effective environmental monitoring will have to be conducted on the basis of recommendations contained in the environmental impact assessment. It is therefore important that agencies responsible for monitoring, should be introduced to the formulation of the project at the earliest stage possible.
- The current state of the law, in which neither the conduct of EIA nor of environmental monitoring has a statutory basis is highly unsatisfactory. It leads to a position in which monitoring agencies have no sanctions to buttress their decisions in the enforcement of the prescribed safety measures. The government, along with all stake-holders with an interest in the enforcement of environmental safety measures, should consider what measures they can take to facilitate the enactment of a law giving legal validity to the processes of EIA and of environmental monitoring.

- In the absence of a specific law sanctifying the environmental monitoring process, the statutory framework of TARDA may be employed to create calculated disincentives against non-compliance with the environmental and socio-economic safety requirements attached to the Mutonga and Grand Falls Hydropower Project.

(4) Technological Requirements

The proposed institutional arrangements will not by themselves lead to the realisation of an effective environmental monitoring process. The actual conduct of the monitoring process will require expertise and appropriate technological aids. It has to be determined where these resources are to be based - whether at TARDA, at KPC, at NES, at the respective stakeholder Ministries, or through contract to other capable bodies. The location of these resources may not be the most important thing, provided that they are assuredly available and are managed under the direction of a central agency or committee. This particular agency will have to take responsibility for keeping technological needs under constant review, and ensuring constant availability. Such appraisal of technological capacity should be done as far as possible in consultation between relevant stakeholders.

(5) Capacity Development

In order to carry out the task of environmental monitoring with regularity and effectiveness, the agencies responsible will have to undertake specialised training for technical staff. Such training may be conducted either locally or abroad. There will have to be a clear training policy, to ensure that the monitoring process is not impeded by shortage of knowledge and experience.

The required expertise falls on two levels. Firstly, it will be important to have knowledgeable scientists, some of whom may be irrigation engineers, water engineers, botanists, zoologists, ecologists, environmental auditors, environmental economists, soil scientists, social scientists etc. This category of staff will provide the scientific knowledge required for monitoring the various impacts of the hydropower project on human life, fauna and flora. Secondly there will need to be qualified technicians who will conduct the actual sample tests on water, soils, etc. They should be knowledgeable in the use of scientific equipment and in the derivation of data and essential information.

It is therefore a logical evolution of the above that donor agencies should be especially concerned with the development of the necessary skills and technical capacities both to carry out the monitoring process and to manage and evaluate its findings.

(6) Sustainable Management of the Hydropower Project

A careful monitoring of the operation of the hydropower project will facilitate enlightened planning adapted to the continuing needs of humans, fauna and flora. The success of such monitoring depends on the practicality of the management institutions put in place, and on the development of appropriate skills for ensuring the stability of the affected ecosystems as much as possible. This approach to management would promote the sustainable utilisation of the hydropower project.

9 ADDITIONAL STUDIES

(1) Background

Taking into consideration the adverse effects on the downstream environment due to the existing dams, potential impacts of planned reservoirs and the impacts caused by increasing population pressure and conflicting development activities, it is deemed necessary to carry out without delay an integrated and overall assessment of the environment of the Tana river floodplain, including socio-economic aspects.

Studies carried out during Phase 2 of the environmental assessment indicated approximate values of downstream production. Though it is currently not possible to value all the benefits, an attempt was made to quantify approximate values of goods and services (or environmental benefits) supported by the Tana river, as shown below in 1995 prices:

Item	Annual Value (million Ksh/y)	Remarks
Agriculture	580	Pasturage, flood recession agriculture, irrigation
Infrastructure	140	Public water supply
Fisheries	40	Fresh/marine fisheries and prawn farming
Wild habitat	260	Hunting and forest/mangrove uses
Total	1,020	

Annual benefits of one billion Ksh (or about 20 million US$) are therefore expected as a quantifiable benefits from the downstream environment. However, this is considered as a minimum estimate because values such as biodiversity, unique ecosystem, future options and intrinsic existence are currently intangible and yet to be quantified.

A comparison was made of 25 years daily runoff records to compare flood regime (measured at Garissa) between natural condition (before construction of any dam on the Tana river) and present conditions (after construction of the five existing dams). These simulation results, given below, indicate that natural bi-annual flooding has already been effected, or decreased, at present due to socio-economic development in the upper basin including the construction of the dams with reservoirs.

Flood regime	Natural condition	Present condition
Number of times with discharge > 500 m3/s	87	70
Number of flood seasons with discharge > 500 m3/s	29	28

Note: Natural flooding of downstream river corridor occurs when Garissa discharge exceeds 500 m3/s.

Phase 3 studies have indicated the nature of the naturally occurring "normal" floods, and have suggested ways in which these can be artificially produced from the proposed Grand Falls (LGF) reservoir. It is suggested that this proposed controlled flooding will have significant beneficial impacts on downstream environments and production systems. Moreover, it is also indicated that without such controlled flooding, the value of downstream production will rapidly decline - with consequent social, political and economic disruption. However, there is insufficient information on the downstream riverine corridor, floodplain and delta with which to fully assess and to quantify the environmental impact of reduced flooding, or of the proposed artificially controlled floods on the downstream environment and production systems.

During a workshop held in March 1995, participants concluded that there were important requirements for an integrated and overall assessment of the downstream environment including the floodplain along the lower river corridor and the delta.

(2) Objectives

The proposed Additional Environmental Assessment Study will aim at implementation of a long-term and overall environmental management plan in the Tana river flood plain and delta, which will be realised through the following procedure:

a) implementation of an environmental assessment,

b) development of a management plan based on the assessment, and

c) implementation of the management plan.

The objective of the Study covers the first step, above a), of the procedure, which is to implement an environmental assessment on the Tana river floodplain and delta, paying due considerations to the cross-linkages among natural resources, human activities and river flow regime, and will include:

1. Review and compilation of data and information
2. Survey and investigation of physical and environmental conditions
3. Identification of values, functions, sensitivities and constraints
4. Identification of uses and dependencies on natural resources
5. Investigation of impacts of socio-economic activities
6. Identification of development opportunities and constraints
7. Identification of management issues
8. Development of management policy

The study area will cover:

- the Tana river floodplain downstream of Garissa and the Tana delta including all permanent and seasonal wetlands and the coastal resources, as well as marine resources off-shore of the delta to a depth of 15 meters, and
- in relation to flow regime (including sediments), the Tana river upstream of Garissa.

(3) Scope of Work

Review and compilation of data and information

Collect and review all available data and information which are concerned to the Study, and compile:

- overall list of all data and information,
- categorised list of data and information according to the items listed in this scope of work, and
- summary, or regime, of the categorised data and information.

Survey and investigation of physical conditions

Investigate physical conditions in the Study area, through:

- Preparation of topographic survey of cross sections including the main channel and floodplain of the Tana river, at average distance 5 km along the river course for a distance of about 800 km between the proposed damsite of Grand Falls and the coast.
- Runoff measurement on the major four laghas located west of the river in the downstream of Garissa, through installation of automatic gauging stations, measurement of water levels, and preparation of stage-runoff curves.
- Measurement of suspended loads on the Tana river, tributaries and laghas.
- Tests of quality and chemical composition, especially in relation to pollution and nutrients, of water and suspended loads on the Tana river, tributaries and laghas.
- Hydrodynamic, morphological and sediment models of Tana River and Floodplain
- Survey of groundwater levels and sources at existing wells and newly drilled boreholes.
- Test of water salinity within the delta and in coastal areas.
- Vegetation and land use map with use of remote imagery (scale 1: 50,000).

Identification of values, function and sensitivities of ecosystem

Identify and explain the values and sensitivities of the ecosystem in the Study area, through:

- In-depth literature survey and analysis on local and international information.
- Assessment on freshwater wetland resources and marine and intertidal resources in terms of floral and faunal density, diversity and current uses.

- Assessment of interrelationships of the resources and the flow regime in the floodplain and Tana delta.

Identification of uses and dependencies on natural resources

Identify the uses and dependencies which people have on the natural resources in the Study area, through:

- In-depth literature survey and analysis on demography and resources uses.
- Land tenure survey.
- Resource use study with questionnaire survey, participatory rural appraisal and specific resource use survey.
- Assessment of the dependency of floodplain production systems, including flood recession agriculture, irrigation, fisheries and livestock systems, on the environment and on the flooding regime.
- Assessment of relationships of resource use to the flow regime in the floodplain and Tana delta.
- Assessment of costs and benefits, including environmental and existence values, of resource use and production systems in relation to the flooding regime on the floodplain and Tana delta.

Investigation of impacts of socio-economic activities

Investigate the impacts which the existing and proposed human actions and development activities have upon the Study area, through:

- Investigations of impacts on small scale development projects for irrigation, prawn farming and salt extraction; large scale irrigation projects such as Tana Delta, Bura and Hola; and Tana River Primate Reserve.
- Assessment of relationships of these impacts to the flow regime in the floodplain and Tana delta.
- Assessment of costs and benefits in relation to the flooding regime on the floodplain and Tana delta.

Identification of development opportunity and constraints

Identify development opportunity and constraints in the area, through:

- Investigation of development opportunities on tourism, agriculture, fisheries, wildlife, forestry, livestock and industries.
- Assessment of relationships of development opportunities to the flow regime in the floodplain and Tana delta.

Identification of management issues

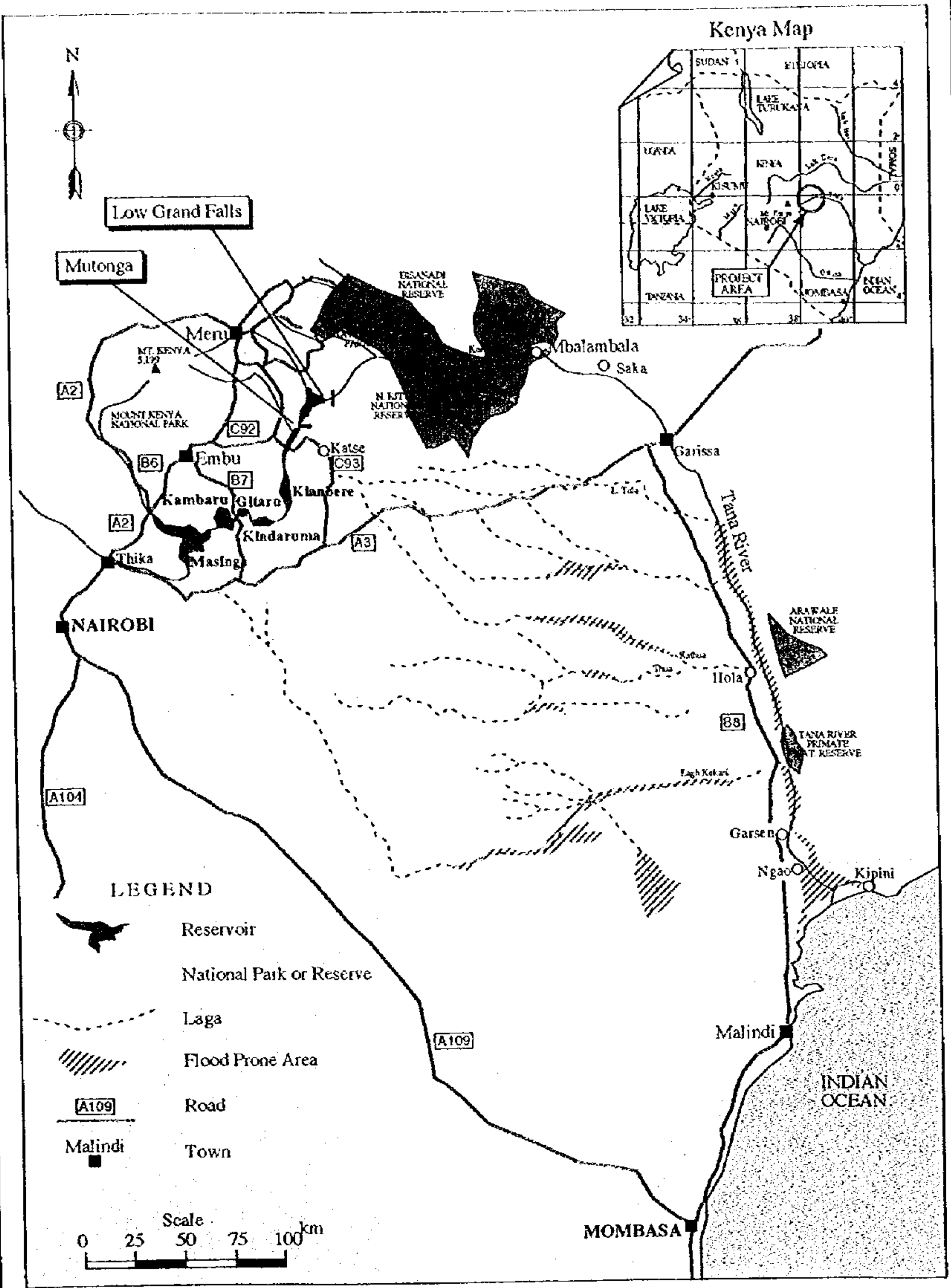
Identify principal management issues and resource use conflicts of existing and proposed developments in the area and recommend solutions to such conflicts, through:

- Investigation of methods for co-ordination of government administration with regard to water resource use and management of the protected areas.
- Investigation of rules of operation for the existing water use facilities and operation and capability of the existing monitoring facilities.

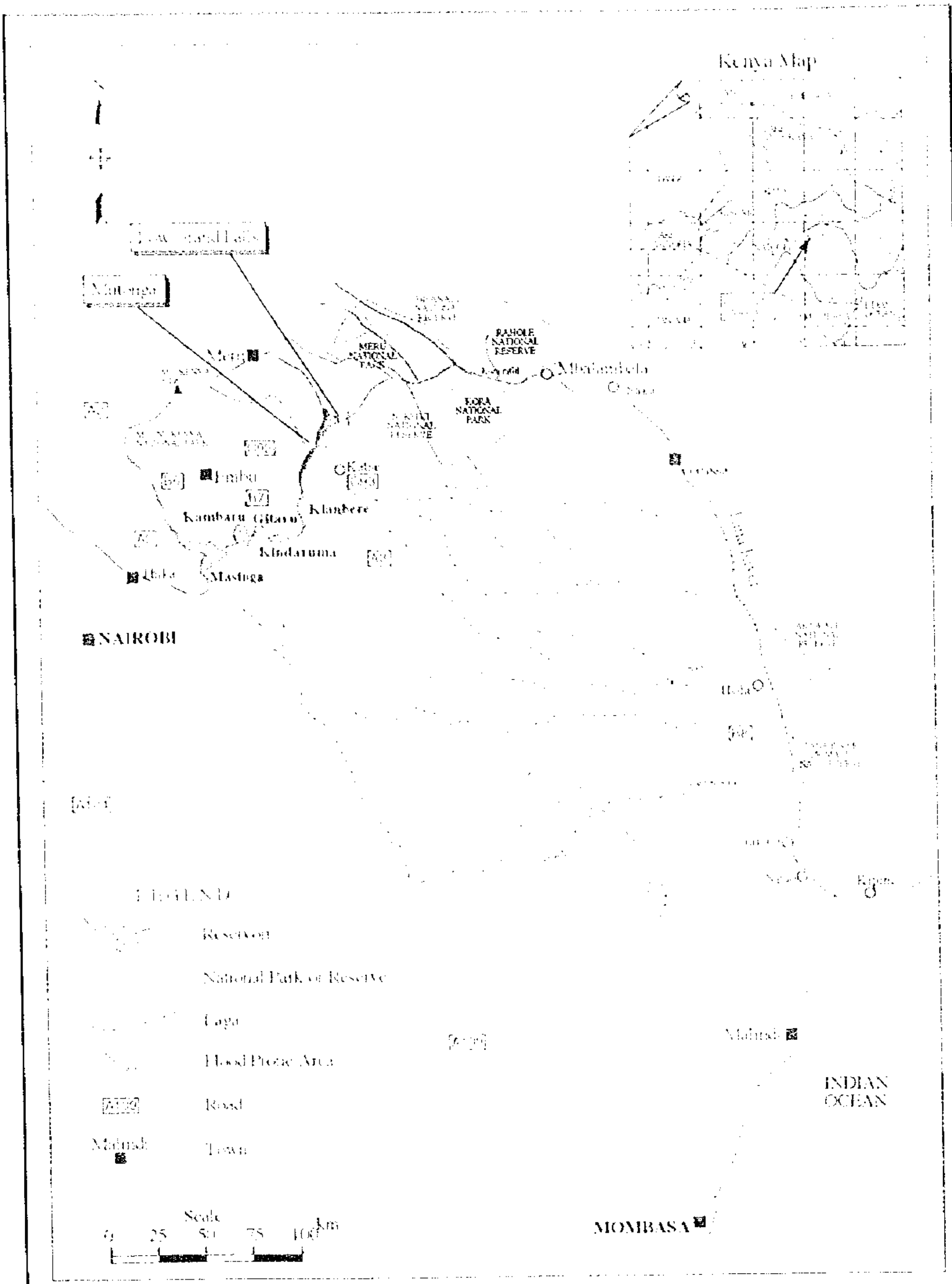
Development of management policy

Develop management policies designed to safeguard ecosystem functions, diversity values and sustainable utilisation of the floodplain and Tana delta and the natural resources and mitigate threats to the environment, through:

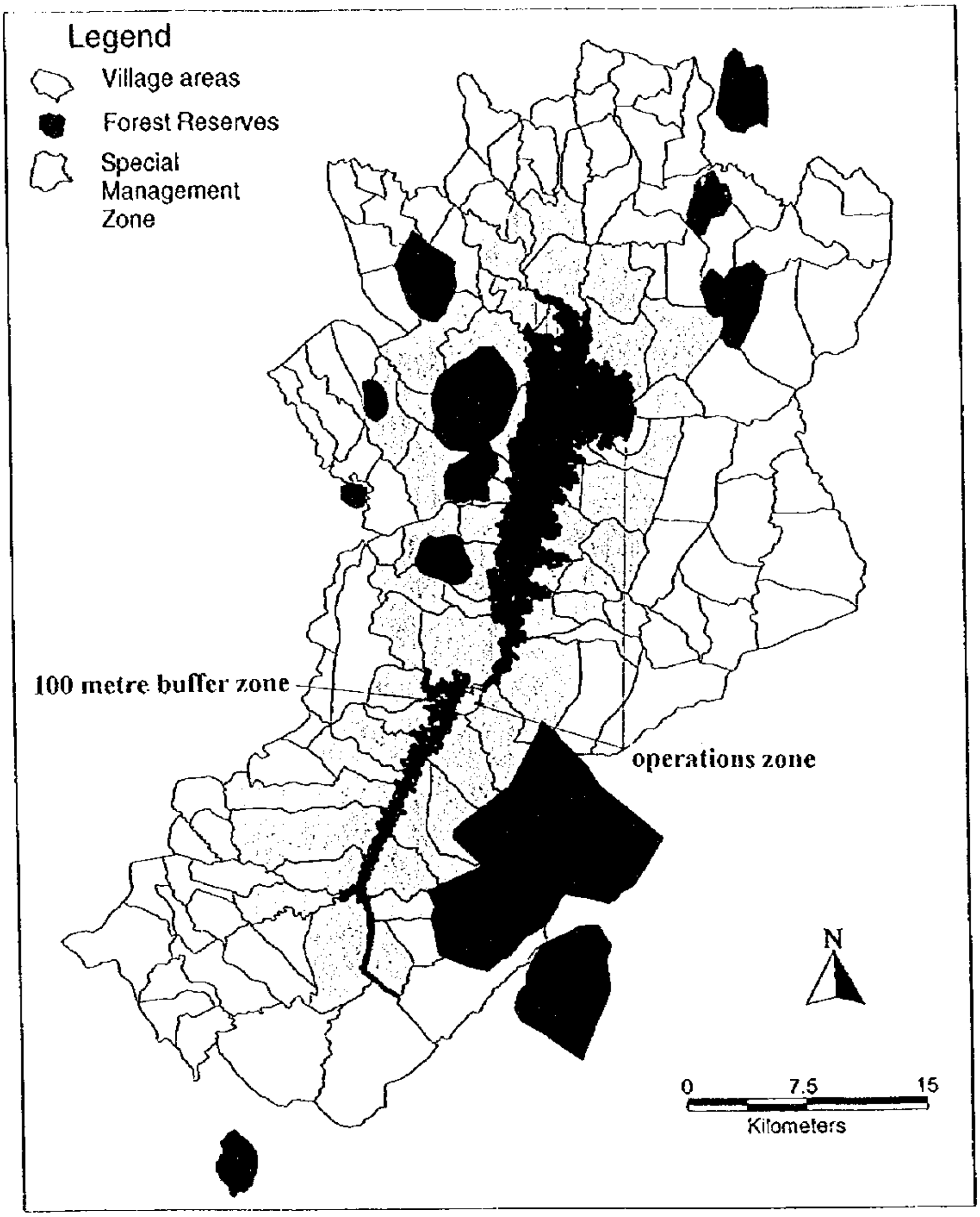
- Analysis of the operation of water use facilities (dams and intakes) to optimally contribute to the maintenance and/or enhancement and sustainable utilisation of the environment.
- Development of methodology for runoff and flow forecasting. Development of a real-time monitoring system.
- Development of preliminary plans of monitoring and operation. Investigation of the institutional and training/capacity building requirements for implementation of an integrated management system.



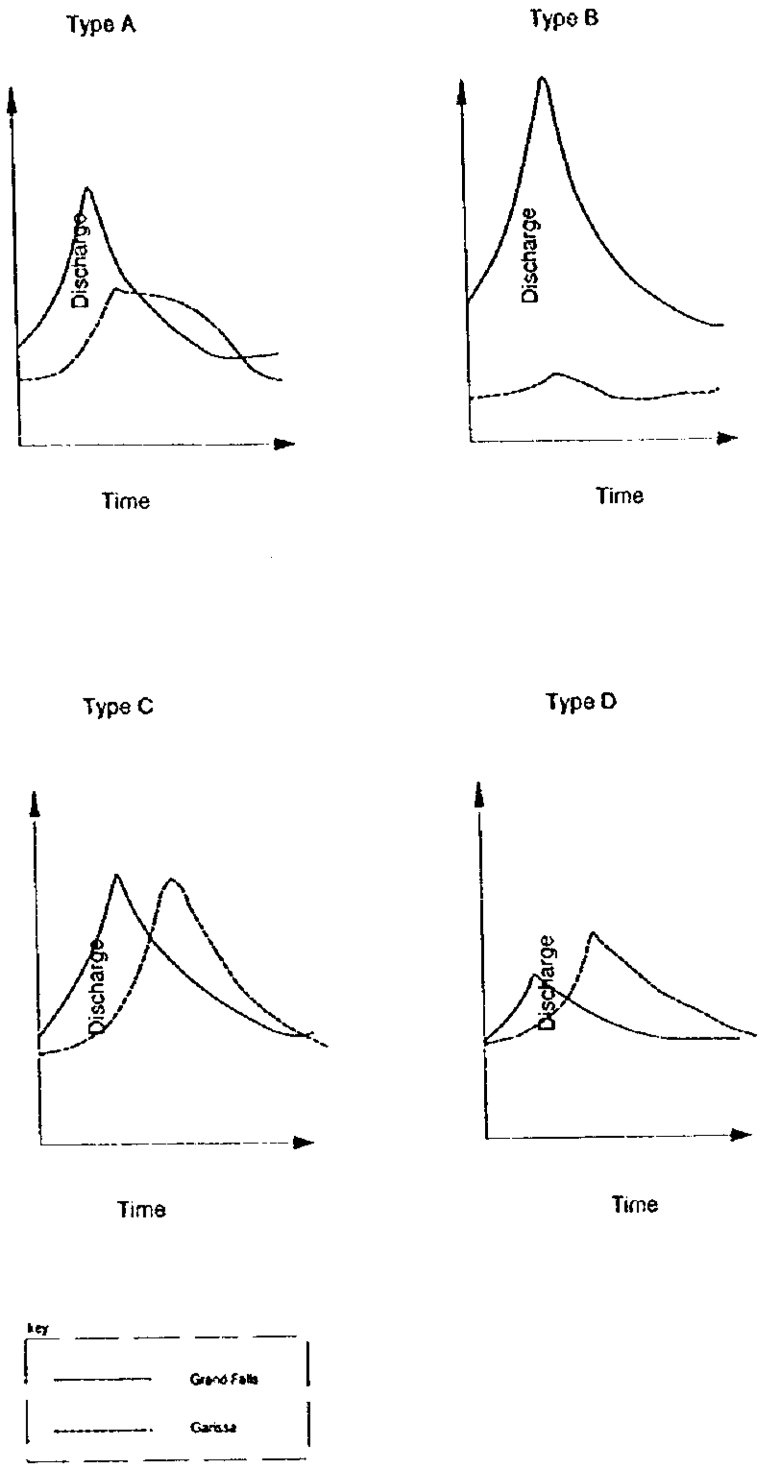
JAPAN INTERNATIONAL COOPERATION AGENCY		Fig. No.
REPUBLIC OF KENYA MUTONGA/GRAND FALLS HYDROPOWER PROJECT	Location Map	SE.1



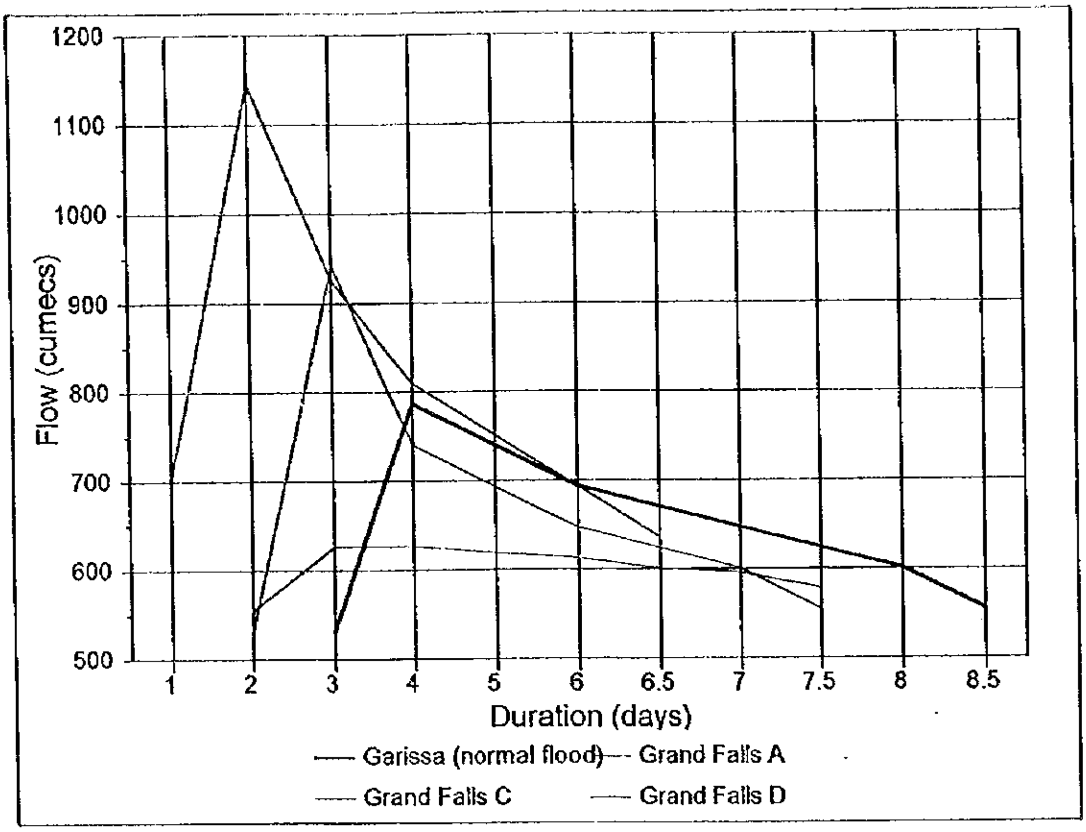
JAPAN INTERNATIONAL COOPERATION AGENCY	Location Map	Fig. No.
REPUBLIC OF KENYA MUTONGA/GRAND FALLS HYDROPOWER PROJECT		SE-1



JAPAN INTERNATIONAL COOPERATION AGENCY	Proposed Special Management Zone for Mutonga and Grand Falls Reservoirs combined	Fig. No.
REPUBLIC OF KENYA MUTONGA/GRAND FALLS HYDROPOWER PROJECT		SE-2



JAPAN INTERNATIONAL COOPERATION AGENCY	Type of Flood Identified from Flood Event Analysis	Fig. No.
REPUBLIC OF KENYA MUTONGA/GRAND FALLS HYDROPOWER PROJECT		SE-3



Flood Type	Peak (m^3s^{-1})	Duration (days)	Volume (MCM)
A	1145.8	6.5	490.3
C	943.4	6.5	406.8
D	627.7	6.5	364.0

JAPAN INTERNATIONAL COOPERATION AGENCY	Flood Hydrographs at Grand Falls relating to "Normal" Floods at Garissa	Fig. No.
REPUBLIC OF KENYA MUTONGA/GRAND FALLS HYDROPOWER PROJECT		SE-4

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