Chapter 17

DOWNSTREAM PRODUCTION SYSTEMS

17. DOWNSTREAM PRODUCTION SYSTEMS

17.1 NATURE OF RIPARIAN PRODUCTION SYSTEMS

Riparian 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 a reliance on flood recession agriculture 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 (Nippon Koei Co. Ltd., 1993). Reduced labour availability, leading to reductions in land cultivated, often results in food deficits (Scudder, 1991).

A great majority of livestock management strategies within the lower Tana basin are currently dependant on the Tana River, and particularly on flooding to a greater or lesser degree. Transhumant pastoralists usually 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, while others marginalized by drought, conflict, and insecurity due to banditry hire themselves out to herd the stock of agriculturalists, wealthy pastoralists, and co-operative ranches. Conversely, 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.

The various components of the above systems are incorporated by one or more ethnic groups within a single diversified production system, or 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. For simplicity, the most flood-dependent components of production systems are isolated for the purposes of analysis below:

17.2 SEDIMENT LOAD AND WATER QUALITY

17.2.1 Downstream Sediment Load

Sediment deposited as a result of flooding on the floodplain is the major source of nutrient and material input to these ecosystems as well as to agricultural and livestock systems dependant of the floodplain ecosystems. Any decrease in sediment load, or change in sediment quality, carried by the Tana will ultimately effect the productivity of all floodplain systems. Systems will be effected both physically, as a result of a decrease in materials building up the floodplain and delta regions, as well as through loss of nutrient input. Whilst some of these impacts may be slow to show any noticeable effects, and are difficult to quantify, they will nevertheless occur.

The effects of any decrease in fine sediments carried to the marine ecosystems are at present unquantifiable. However, lessons from other dam constructions, notably the Aswan Dam in Egypt indicate that the long term effects could be considerable.

17.2.2 Downstream Water and Sediment Quality

It is clear the existing dams will have led to ecological disturbances due to silt trapping. The silt, which is rich with feldspar nutrient compounds and organic matter has been and will continue to be trapped in the reservoir area and therefore be prevented from getting out to the flood plain and delta area where it supplies a major component of plant nutrients.

During the 1994 rainy season samples of fresh alluvium were collected at the Grand Falls dam site (4F13), at Garissa at the bridge, at Hola, at Garsen at Idsowe bridge and at Ngao. These were analysed for Nitrates, Phosphorus, Potassium and organic matter. The results of the nutrient analyses are summarised in Table 17-1.

Table 17-1 Nutrient Concentrations of Alluvial Sediments

	Grand Falls	Garissa	Hola	Garsen	Ngao
Total Nitrogen- No_2^--N + $N0_3^-$N(PPM)	4.95	4.06	0.22	1.7	1.47
Phosphates $P0_4^-$P (PPM)	0.018	0.0154	0.083	0.130	0.160
Organic Carbon Mg/gm	56.2	62.2	59.93	72.00	60.05
Potassium ppm	6.5	6.6	6.9	7.6	7.2

The results of the analysis of the fresh alluvial silt deposits show that the river silt is very rich with alluvial nutrients and organic matter. The total amount of nutrient transfer to the downstream flood plains and the sea cannot be computed from the available data, in the absence of full seasonal sediment and water quality information. In terms of assessing the value to downstream farming systems through the provision of fertiliser, the same constraints apply. However, the traditional systems have been maintained at stable productive levels without the addition of organic or inorganic fertilisers as a required management input. The present small-scale irrigation systems are currently relying on mining the residual soil fertility, a practice that is not sustainable.

The management of flood waters will be particularly critical; if low level release structures are used to release the sediment laden cold density currents during peak flood events, then the nutrient rich silts may remain available to the flood plain areas. However, the long term effects on the mangroves, which at present receive the fine particle load throughout the year, will not be mitigated through this release.

It is significant that the intensified crop packages recommended by the Coast ASAL Development Project require the supply of fertilisers for the long term production of most staple and cash crops, including maize, rice and cotton.

17.3 FISHERIES

The Tana River supports a diverse fisheries industry, which, although largely un-commercialised, provides a considerable income to populations adjacent to the river and upstream dams as well as a major and vital nutritional input. In terms of the fisheries, the river basin can be divided into four areas:

- The Upstream Dams - in particular Kiambere, Masinga and Kamburu;
- The Riverine Corridor;
- The Delta;
- The Mangroves and Coastal areas.

The potential impact of the proposed dams will affect fisheries in two ways: it will create a new reservoir environment with its own inherent fisheries capacity; and it will change the river flow regime with possible affects on downstream fisheries and on marine fisheries. In addition to a review of the available information, fieldwork was carried during November 1994.

17.3.1 Downstream Fisheries

The most complete study of the lower Tana River fish communities was carried out in during 1983, as part of the Kora ecological survey Twenty-one species were caught over a 90 km stretch of the Tana River spanning the Kora Rapids above Garissa (Table 17-2). As part of the study carried out for this report, fish were trapped within the delta area but the number of species identified is clearly an underestimate as it is based on only a single sample period in November 1994. Fish species recorded in the upper and middle reaches of the river are considered in chapter 12.

Table 17-2 Lower Tana Fish Communities

	Kora[1]	Delta[2]
Alestes affinis	✓	-
Anguilla bicolor bicolor	-	✓
A. nebulosa	✓	-
Barbus zanzibaricus	✓	-
B. oxyrhynchus	✓	-
Barbus sp.	✓	✓
Chiloglanis brevibaris	✓	-
Clarias mossambicus	✓	✓
Clarotes laticeps	✓	-
Discognathus sp.	✓	-
Engraulicipris fluviatilis	✓	-
Eutropius depressirostris	✓	-
Glossogobius giuris	✓	-
Gnathonemus macrolepidotus	✓	-
Labeo cylindricus	-	✓
L. gregori	✓	-
L. mesops	✓	-
L. victorianus	-	✓
Lebistes reticulatus	✓	-
Momyrus kannume	✓	✓
Petrocephalus catastoma	✓	-
Protopterus amphibius	-	✓
Sarotherodon spilurus	✓	✓
Schilbe moebiusii	✓	✓
Synodontis multipuntatus	✓	-

Source: (1) Campbell et al., 1986), (2) This Study

Annual flooding significantly increases the productivity of riverine fisheries through the provision of a rich source of food and protection for spawning fish and for the developing fry. Flooding is accompanied by a significant release of nutrients from the terrestrial habitat, resulting in a surge of production centred primarily on the growth of higher plants. These provide support for both epiphytic organisms and dense colonies of creatures in their root masses, which in turn provide both food and shelter for developing fish.

Elsewhere in Africa, decreased flooding on floodplains as a result of reservoir development for either hydropower or for irrigation has universally had negative impacts on freshwater fisheries. This is a direct result of the decrease in flooding. Any decrease in the extent and frequency of flooding on the Tana River floodplain and delta will be accompanied by reduced fisheries productivity, and in some cases may result in the complete collapse of fisheries over limited areas.

Subsistence Fishing

Subsistence fishing is practised by over one third of the non-pastoralist households living near the Tana River and Delta, and nearby lakes and wetlands. The major fishing period within the corridor above the delta is during the floods and in particular in the adjacent flooded areas. The fish move into the flood plain, reaching full size in the flooded areas. The fish potential is considerably reduced during low or no flood seasons. The main freshwater fish species caught are tilapia (*Sarotherodon mossambicus*), catfish (*Clarias mossambicus*) and lungfish (*Protopterus amphibius*). For many of the fish species, breeding occurs in flooded areas at the start of the rainy period and growth is rapid. Oxbow lakes and the main river itself serve as refuges during the dry seasons, but the productivity of these areas on their own (i.e. in the absence of flooding) is minimal.

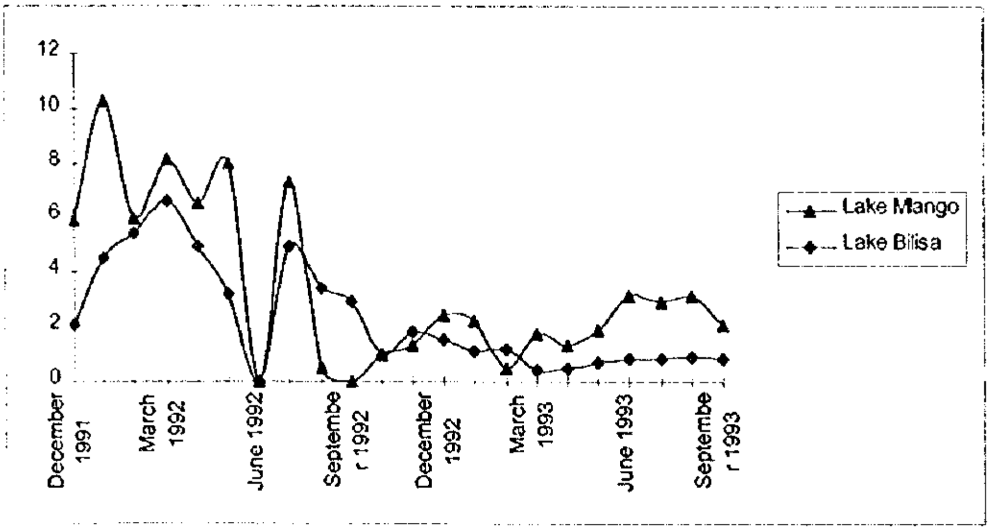
Although few households depend on fishing as their sole source of subsistence or livelihood, the Tana River supports both subsistence and commercial fisheries, which are an important source of domestic protein and income for surrounding households. Subsistence fishing is practised by just over a third of non-pastoralist households living near the Tana River and Delta and nearby lakes and wetlands The Pokomo fish using traps, lines and fish drives, and the Bajun engage in subsistence fishing in lower parts of the river.

Delta Fisheries

The major commercial freshwater fisheries in the lower Tana are centred on the delta. The principle commercial species again include catfish (*Clarias mossambicus*) (36%), lungfish (*Protopterus amphibius*) (30%) and tilipia (*Sarotherodon mossambicus*) (20%). Other species including *Labeo spp., Momyrus kannume, Synodontis spp., Barbus spp.*, and Schilbeid catfish combined contribute the remaining 14% of the fish landings. For many of the fish species, breeding occurs in flooded areas at the start of the rainy period and growth is rapid. Oxbow and other lakes and the main river channel itself serve as refuges during the dry seasons, but the productivity of these areas on their own (i.e. in the absence of flooding) is minimal.

The primary commercial fishing sites are the ox-bow lakes, in particular Lake Bilisa and Lake Mlango, near Garsen. The fisheries of these lakes rely on maintaining their water levels. This has been shown by the changes that have occurred since the early 1990's when the Tana Delta Irrigation Scheme was started, at which time part of the flow of water was diverted from some of these lakes. The available statistics indicate that both the Lake Bilisa and the Lake Mlango fisheries may be in danger of collapsing. There have been two major drops in the fish landings from the lakes, the first in June 1992 and the second in March 1993, and these drops appear to be part of a consistent downward trend. Further reduction in flooding as a result of additional upstream dams is likely to exacerbate this situation and most likely prevent any recovery from the existing situation. The most recent development has been the more or less complete drainage of Lake Bilisa as a result of changes in the course of the Tana River at this point. Fish catches from this area will therefore be severely affected.

Figure 17-1 Lakes Bilisa and Mlango Monthly Fish Catches (Tons)



Overall, in the Tana Delta region an average of about 340 tons of fish are commercially marketed each year. The annual fluctuations in the commercial fish landings indicate that after an increase from about 296 tons landed in 1989 to 366 tons in 1990 the landings have remained fairly static.

Table 17-3 Fish landings from the Tana Delta (Tons).

SPECIES	1989	1990	1991	1992	1993
Tilapia	74	72	89	101	67
Clarias	106	128	119	121	212
Kamongo	72	104	117	97	118
Others	44	62	58	35	31
Total	296	366	382	535	360

Source: Statistics Section, Fisheries Department - Kenya

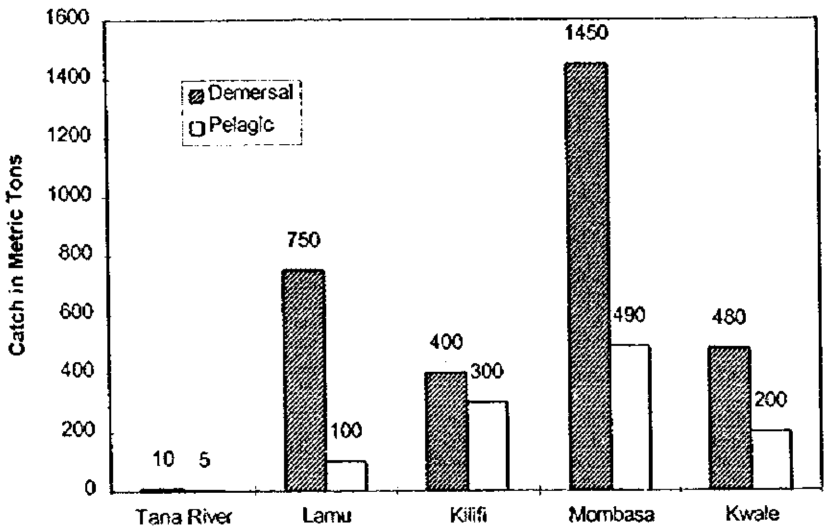
Marine Fisheries

Between 1988 and 1992 the average annual production of marine fish at the Kenya coast was about 6,900 metric tonnes excluding deep sea fish, game fish and marine shells. The production from each of the Districts along the Kenyan coast in 1989 for the demersal and pelagic species is shown in Figure 17-2. It is clear that Tana River District is poor in marine fish landings. However this is not a clear picture of the value of marine fisheries in the area, as much of the offshore trawled catch will be landed direct at Mombasa, rather than within the Tana River District.

The species that contribute to Tana District landing include scavengers (*Lethrinidae*), mullets, kingfish, queenfish, bonito, sharks and rays, lobsters, prawns and crabs. In addition a very small amount (less than 0.5 metric tons) of rabbitfish, parrot fish, rock cod and cavalla jack are also exploited. It is interesting to note that there is no exploitation of molluscs such as oysters, sea cucumbers, octopus and squids in this area.

Sediment deposited offshore by the Tana River is likely to form an important component of the near-shore and offshore ecological systems. Any significant reduction in sediment deposition, as a result of additional reservoir construction, is likely to have a negative impact. Here it is worth noting the serious impact on marine fisheries off the Nile delta following the construction of the Aswan Dam in Egypt. The Tana is likely to be the largest source of land-based sediment over this section of the East African coast. Changes in the nature of the sediment reaching the ocean as a result of construction of additional upstream dams may therefore have an impact on marine fisheries.

Figure 17-2 Marine Fish Landings: 1988/89



17.4 ARABLE SYSTEMS

The growing of crops has been and is practised along the river flood plain from Mbalambala down to the delta by the various groups - Korokoro, Wanyoyaya, Wasanya, Malakote and Pokomo. The basic difference between these groups is that whilst the first three also keep cattle, the Pokomo do not although they may have small numbers of sheep or goats and some poultry. The range of crops is much the same for all groups with the exception of bananas which are not seen above Garissa although the Korokoro claim they were planted in the past.

The essential similarity of all these arable systems is that in the past they have relied on flood irrigation for their crops, and the deposition of silt and nutrients from the flood for maintaining soil fertility (there is a parallel here with the Nile delta). Prior to the building of dams and reservoirs in the upper Tana, the river "normally" flooded twice a year in May and November, often flooding the river plain to a depth of 3-4 metres in places. Planting takes place after the flood subsides, usually in June and November-December.

17.4.1 Field Crops

With the Pokomo each household has at least 2-3 plots on the floodplain, scattered so there is always the chance that at least one will get sufficient water. There is little attempt at any management of the flood water, no channels are dug, no bunds to hold the water on the plots are made. The average household planted 1.4 ha each season, but this could go up to 6 ha in better off families. Rice is planted in areas where good flooding is expected and the rest of the land is planted with maize, green grams and cowpeas. With the poor record of floods both from the river and laghas, the area planted under rice has drastically declined in recent years.

Rice is still the preferred crop as it is used in ceremonies but yields are low (at a maximum of 2,000 kg/ha) compared to the 5,000 kg achieved at Mwea. Generally seedlings are raised in a nursery so that planting can take place immediately the floods go down. Maize is planted in shallow holes at random spacing with approximately 7,000 holes and 24,000 plants per hectare. This is often interplanted with cowpeas. Maize varieties planted vary, and often inappropriate varieties are planted including relief maize intended for consumption. Green maize is harvested after two months and mature maize after three. Average yields are again low with a range of 0 (crop failure) to 2,500 kg per hectare. Other crops include pigeon peas, amaranthus, beans, cassava, tobacco and sweet potatoes, with pawpaw, cashew and coconuts augmenting the mangoes along the levees. However the latter are few, for reasons unknown.

Prior to the current security problems in the area, cropping was done on both east and west banks of the river, but the area to the east is now greatly reduced due to the shortage of river transport (canoes were reduced to one per village by the administration as a security measure) and by the security situation itself. Essentially it is a subsistence form of agriculture, and even before the upper Tana dams and reservoirs were built the chances of crop failure was two or three in ten years. Game damage is a problem, with elephants and buffalo active on the east bank and baboons, monkeys and wild pig raiding plots on the west side of the river. During the harvest season farmers live on their plots, sleeping on raised platforms to scare animals.

Flooding is usually better, in terms of the agricultural potential, on the eastern side of the river compared with the western side. A survey of the village of Lenda, a small village 10 km south of Hola in Mikinduni Sub Location of Galole Division, found that there had not been a good flood on the western side of the river for nearly ten years. The survey also found that flooding on the eastern side had been better but that insecurity had not allowed much planting there. This village like many others in the central Tana area was relying more on lagha flooding, which took place in December-January and April-May from the Galole lagha. These floods, also unpredictable and often inadequate, cover less land than a good river flood, only 33-50% of the potential arable area of the village was planted during the lagha floods.

17.4.2 Tree Crops

There is a thirty metre conservation area along the river bank (levee) which is planted with trees - mangoes, and other fruit trees, and otherwise usually kept free of cultivation. Mangoes are an increasingly important crop along the Tana as fruiting takes place in October-November, which gives them a useful niche in the regional and world markets. However with poor communications, distance from the airport and the mango seed weevil, this industry is in jeopardy. The margin of the thirty metre area is marked with a planting of sugar-cane, and then within this, bananas are planted on old levees away from the normally flooded areas.

17.4.3 Livestock

Only 2.5% of Pokomo keep cattle so virtually none of the plant residues are used, although banana leaves may be used for thatching. Most of the residues will be heaped along plot boundaries or burnt, although in some areas the Orma are allowed to graze their stock over the arable fields after harvest.

There are now plans now to introduce Napier grass as a conservation crop for feeding to zero grazing units which are hoped to be introduced as an extension package to the Pokomo. This is as yet largely untried and does not promise to be generally successful except in areas close to the two urban centres.

15-20% of men own bee hives, each having between 8-10 hives. Many of the hives are kept in trees on the eastern bank of the river. Virtually all are traditional log hives, and the Kenya Top Bar hive has yet to find favour here. With the establishment of honey refineries in TARDA managed areas, local farmers may be encouraged to diversify their income producing activities.

Crops are augmented by fish, caught by hook and line, by traps and by dredging, and meat is also eaten but in small quantities.

17.4.4 Constraints to the System

Lack of seed and crop inputs and, for many crops, basic recommendations on varieties, spacing and plant populations and pest and disease control, game and bird damage, poor husbandry and lack of adequate tools, lack of marketing infrastructure, all combine to limit yields on this system. However by far the greatest cause of concern for food security in these riverine communities is a lack of flooding from the river, and now from the laghas. River flooding has been affected over the last ten years, and could virtually disappear altogether with the new project. There is also concern on the frequency and size of the lagha floods that are expected to become less frequent and smaller as soil and water conservation, water storage and utilisation measures increase in the upper catchment area.

17.5 PASTORAL SYSTEMS

Pastoralist production systems bordering the river below the Grand Falls sites include those in Isiolo, Garissa and Tana River Districts, as well as the Tana Delta.

17.5.1 The Orma Pastoral System

The Orma are found in Tana River District along the riverine flood plain, in the hinterland on the eastern side of the Tana and also in the Delta. They are semi sedentary, and their settlements of beehive shaped huts can be found on the edge of the flood plain, along the laghas and in the delta. More permanent brick buildings are found in more established settlements such as Wayu on the Galole, and Assa on the Kokani laghas. Their settlement and movements are governed by the availability of grazing and water for their herds.

The Tana river, and particularly the delta, are central to their annual cycle of movements. Even though the Pokomo occupy most of the riverine plain adjacent to the river, there are traditional access paths to watering points left for Orma and Somali livestock called 'Malka'. By agreement the Orma will also graze crop residues which are not used by the Pokomo.

The rangelands of the Orma are held and used communally, although families or groups generally control water resources such as wells and permission is needed by outsiders before they can use them. Water supplies are limited at the best of times and their cattle do not realise their full potential because of this.

The Orma organise their family flocks and herds in two groups (Table 17-4). The Manyatta or 'Awicha' herd is composed of the in-milk cows, heavily pregnant animals and young stock. These are grazed in proximity to the manyatta or settlement and return there each evening. The 'Urene' herd is composed of the non-productive 'dry' animals and breeding stock. These are not allowed to graze in manyatta grazing areas, but instead are taken out onto the rangelands by the young men. This latter herd gets less veterinary attention but often is in better condition, as they are always on new grazing. Manyatta grazing areas are often overgrazed particularly during the dry seasons.

Table 17-4 Orma Herd Percentage Composition

	Manyatta	Urene
Milk cows	36.0	8.6
Dry cows	19.0	67.8
Calves	36.0	5.3
Heifers	4.0	12.0
Bulls	3.2	3.3

Mortality in calves is high, probably in the region of 30%, brought about by competition between calf and family for milk, the former losing in this contest. Adult mortalities are about 8% mainly from Trypanosomiasis. Mature females make up 46% of the total herd. Milk is an important part of the diet for the Orma constituting 75% of total nutrient intake.

Movements of Orma livestock are completely governed by the presence or absence of water. Total water resources in the District are adequate for the Orma herd, but distribution in both space and time is poor.

Seasonal Movements of Livestock

Water is the main constraint of Orma herds. In the wet season the Urene herds will rely on pans and ponds in natural depressions, called 'alango' away from the permanent water sources. The manyatta herds will water from the laghas, or the river Tana and when water becomes scarce they will dig wells often up to five men deep in the sandy lagha beds. Urene herds will return here in the dry season for water when other sources dry up. As well as the larger laghas - Hirimani, Kokani, Galole and Dakaji, there are smaller ones - Kitole, Lawani, Woltima all of which will carry surface water in ponds after the main flood has finished.

As the dry season progresses, livestock tend to congregate closer to waterholes along the Garissa - Hola road which were made by the Youth Service during the construction of the road, near the Bura and Hola irrigation schemes where water is taken from the canals, and of course near the river Tana itself. This concentration leads to overgrazing and eventually if there is no let-up from the dry weather, Urene herds from the Idi-Assa area and lagha Kokani will move into the Tana Delta.

The Tana Delta is the main fall back area of dependable grazing during the dry season and provides a total of 100,500 ha of grazing including 67,000 ha of seasonally inundated grassland, 24,000 ha of bushland and 9,500 ha of marshland. In a normal dry season this area may carry a cattle population of 156,000 which can be increased to 373,000 or more in drought years with animals from Bura, Madogo Divisions and Garissa District[1].

It has been calculated that the total water requirements of the Tana River District herd, essentially the Orma herd, was 3 million m^3 per year, 1.4 million m^3 of which was needed in the six dry months of the year and 75% of which would be needed from the Tana River itself.

Diseases

Diseases are a particular problem in the Delta and the flooded areas. Trypsanomiasis, Contagious Bovine Pleura Pneumonia (CBPP), Contagious Caprine Pleura Pneumonia (CCPP), Anaplasmosis, Lumpy Skin Disease and Helminthiasis are all common.

Trypanosomiasis is particularly bad in the Delta and for this reason camels are rarely taken there. It is also not a good place for sheep and goats which suffer foot problems in

[1] In the recent drought, livestock are reported moving into the Tana Delta from as far away as Mbalambala, north of Garissa. This emphasises the vital importance of grazing lands in the Tana Delta.

the wet ground. Detailed surveys of tsetse in the area were carried out in 1968 and results are given in the National Atlas of Kenya (1970). There are four species of tsetse found in the area as follows:

G. longipennis	found in the arid Acacia-Euphorbia bushland in the west of the District
G. pallidipes	adaptable species and widespread
G. austeni	forest edges
G. brevipalpis	dense ticket and forest edges

Introduction of Cultivation

The Orma have planted crops for a long time, generally in bad years when they have lost cattle, but cropping has expanded considerably since the 1984/85 drought. Most cropping is done post flooding on the laghas that flow from the Kitui hills down to the Tana river.

The floods can come twice a year in November-December (Haghea or Kilimo flood) and a lesser flood in April-May (the Ghara or Mwaka flood). At their best, the laghas can flow at the rate of 75 m^3 per second and can be 1-1.5m deep and last from a few days to a month or more. At worst there is nothing. Generally the lagha flows can be expected to become less as water conservation improves in the Kitui area.

In the flood plain of the laghas crops such as maize, green grams, cowpeas and cotton are planted on the accumulated silts with little pre and post planting cultivation or husbandry. On the lagha banks, mangoes, bananas, cassava, sugarcane and woodlots are being planted. Yields are poor and problems are evolving such as *Cyperus* spp as a weed in arable plots.

These developments are currently unplanned and are already exposing environmental problems. Some tree species are dying possibly due to impounded water on plots, there is more erosion due to cultivation, and the fore sedges are increasing. However the development is expanding and will be permanent particularly in areas such as Wayu where permanent Orma settlements have been established.

Livestock Marketing

Cattle are sold from the Orma herds are generally infertile heifers, and old culled cows; but sometimes young heifers and males are sold depending on the need for cash. If marketing was done efficiently there could be a 15% off take from the Orma herd, but in practice the figure is unlikely to be above the present 4%, although it can go as high as 17% in a drought.

Currently the whole marketing system is constrained by the lack of security in the area. Marketing of livestock starts at the manyatta level where local traders buy from pastoralists, and they can resell at the more established secondary markets at Hola, Garsen, Bura, Woldema and Bangale. All sales are by private treaty. Sold cattle are then put into mobs and trekked to either Mombassa or Nairobi through Kitui where prices are better. Cattle bought in Garissa are normally transported by truck to Nairobi.

Orma herds are not managed on a commercial basis. The people have an affinity with their cattle, they have low basic needs for cash, and the poor market infrastructure combines to keep marketing at a low level.

Constraints

The Orma and their system of animal production are under pressure. They have lost considerable grazing land over the last two decades with much of the Galana river area being taken into Tsavo East national park and the Galana Ranch. Dry season grazing in the delta has been seriously cut with the development of the TDIP which will remove 23% of the present flood plain grassland. Possibly most important of all; it will through its off take weir at Sailoni, cause changes in flood dynamics of the delta which can have a profound effect on future settlement patterns and land usage, including dry season grazing.

Water supplies are a constraint, and their lack, together with insecurity problems mean that considerable areas of grazing are under-utilised. Much could be done to develop water supplies and this sector is receiving some attention in the Coast ASAL Development Project.

Veterinary care and marketing also are constraints, both of these two services being constraints by the lack of security in many areas.

Formal Ranching Schemes

There is currently a move to develop commercial ranching schemes in the Orma pastoralist areas. TARDA published plans to set up seven ranches in Coast province in line with the Government policy at that time to develop beef production in the ASAL areas. In Phase I Chakama and Kilifi ranches were set up, and following this Kokani ranch north of the Galana with a proposed area of 300,000 ha and 25,000 head of cattle.

The Orma are recognising the pressure on their lands and there is currently a move to organise grazing associations giving them the right to use areas for grazing. The 1984/88 Development Plan for the District set aside 1.4 million hectares for ranching, and currently the following have been launched. In southern division of Tana River District: Kandertu, Wachu, Kitangale, Dalu, Haganda, Geritu and Ida-saa-Godoma and a further two more, Mpongwe and Wayu, in Galole division. In Bura division there is the Nanighi Ranch, Ska and Anole Ranches in Mogodo and finally Mbalambala ranch in Bangale. Total land covered by these ranches which are either co-operatives or companies is 1,836 m hectares, but there are only 4,000 animals on the Garsen division ranches and less on the rest. The ranches, which are owned by Orma, would appear to be exercises in getting a stake in the land for the future, rather than serious undertakings in commercial ranching.

The most effective use of resources within any semi-arid area is a managed pastoralist system, which allows for maximised seasonal movements of man and livestock in search of water and grazing. However Galana Ranch has proved that commercial ranching is possible although the scale and the cost of water development may not always make the enterprise practical and economically attractive.

In the same plan a dairy ranch was proposed for Bura to be situated between the Chewele branch and the Hirimani lagha where 200 ha would be irrigated for maize, sorghum and legume fodder crops, and 4-6m litres of milk and milk products produced from 2,000 cross bred dairy cattle for the expected population of 50,000 people in the defunct Bura Irrigation Scheme. This proposal was never implemented, although it now appears on the Coast Development Authority list of proposed projects.

The Borana and Somali

The Borana of Isiolo District lead a life style very similar to the Orma, whilst the Somali of Garissa District are true nomadic pastoralists, and are not sedentary, although their migrations have been limited recently by the administration to prevent ethnic clashes, particularly in Isiolo District. Confinement to their own district is resulting in serious overgrazing. The overgrazing has been accentuated by the presence of refugee camps in the Liboni and Dabab Divisions which have virtually destroyed the countryside for a 40 km radius of the camps by the cutting of all bush and trees for fuelwood and building materials.

The problem is again accentuated by the presence of a major tsetse challenge in Bura and Masalani Divisions so that camels cannot go there, and even if Ethidium and Novidium was used the area would not sustain all of the Garissa herd in the dry season.

Many Somali pastoralists who have lost their livestock in the recent droughts are being settled along the Tana together with agriculturalists on minor irrigation schemes growing food crops and fodder, the latter for feeding to grade dairy cattle in zero-grazing units. This development is restricting the use of the river and the flood plain to the pastoralists and could result in serious conflict in the future. Restriction of movement (across boundaries) and access (to the river) will have very serious effects on Somali pastoralists.

17.6 IRRIGATION

The Tana River Basin supports a number of existing irrigation programmes, ranging in scale from the Mwea Irrigation Scheme at approximately 12,700 ha, to small schemes based on pumped systems of one or two hectares. The Irrigation and Drainage Branch of the Ministry of Agriculture Livestock Development and Marketing estimated that the total basin has a potential for 91,000 ha of irrigated land of which 18,800 ha are presently in use. Although the potential for expanded irrigation exists, it must be noted that much of the land is already used for other purposes including traditional production systems. It must also be noted that, in the future, there are likely to be serious water shortages as a result of increasing demands from public water supplies, hydropower and irrigation.

The proposed irrigation can be divided into areas above the dam site (Upper Catchment) and below the dam site (Lower Catchment). The effect of proposed irrigation above the dam site will be a reduction in water flow into the reservoir, compounded by a seasonal variation related to the cropping season, with implications on the possible volume released downstream (especially in dry seasons when a major reduction in flow into the reservoirs can be predicted). The effect of planned irrigation expansion downstream will be an increased demand on the water which is released from the dam. The whole system will be under increasing competition for water resources for public water supplies, largely in the upper catchment areas.

Table 17-5 Planned Expansion of Irrigated Cultivation

Year	Upper & Middle Catchment Areas (ha)	Lower Catchment Area (ha)
1995	14,730	14,100
2005	53,290	18,270
2020	72,320	25,580

The majority of the planned expansion of irrigation is clearly outside of the lower catchment. Only four schemes are classified by the planners as large-scale schemes. These are:

- Mwea, projected to increase to 20,000 ha by the year 2020
- Bura, to be rehabilitated and increased to 8,000 ha
- Hola, to be rehabilitated to the original 900 ha
- Tana Delta Irrigation Project with Phase 1 under construction and a planned increase to 8,250 ha.

This classification is deceptive, as it relates to the scheme being managed as a large scale production unit aimed at the production of a single cash crop. There are many schemes planned for over 1,000 ha, that are not classified as large-scale systems. As an example in sub-basin 4FB, out of a total planned (year 2020) area of 38 000 ha, there are eight schemes over 1 000 ha, with a cumulative total of 18 000 ha. There are, in addition a proposed 95 schemes with an average area of 200 ha, of which at least 42 have not yet been initiated.

The maximum monthly irrigation demand projected for the year 2020 (for October) is 77 m^3/sec, based on a smallholder final water use efficiency of 50% and a large scheme efficiency of 65%. It must be noted that this is greater than predicted average monthly flows in the Tana (at Garissa) during several months of the year following dam construction. There are therefore serious questions about the feasibility of the expansion of irrigation to its full potential.

17.6.1 Small Scale Irrigation

As indicted, this section is primarily concerned with the downstream irrigation systems that rely on the release of water from the proposed Grand Falls Dam Site. The Pokomo peoples have practised flood based inundation irrigation for over 400 years, growing rice and other crops in depressions and oxbows behind the levees of the Tana River. In more recent years they have used lagha floods but even when these are good they offer very limited alternatives to the main river flooding. The Hirimani lagha does not flood any agricultural areas at all, the Galole floods land in villages along a 12 km strip of river flood plain, and the Kokani lagha a little more, but in all cases the area flooded is only 50% of that covered by a main river flood.

Irrigation is not new to Garissa District. Ten to fifteen years ago irrigated farms were set up by individuals and organisations close to Garissa town growing bananas, fruit, vegetables and fodder, the latter for feeding grade dairy cattle.

In all there are a total of 159 schemes, 2,745 ha and 7,206 farmers either in operation or planned. However the land allocated per family is small, only 0.38 hectares.

Table 17-6 Small Scale Irrigation Schemes in Garissa and Tana River District

	Garissa Central	Masdalnai	Mbalambala	Bura	Tana River	Total
Operational Schemes						
Number	46	2	4		11	63
Area	476	18	52		350	896
Farmers	990	150	260		895	2,295
Non-operational Schemes						
Number	2	1		1	9	13
Area	39	?		8	470	517
Farmers	?	150		45	694	889
Proposed Schemes						
Number	29		8	9	37	83
Area	632		20	43	638	1,333
Farmers	1817		402	365	1,438	2,205

However, most irrigation schemes along the Tana have been initiated in response to crises. ALDEV originally started Hola Irrigation as a part of the Mau Mau crisis, many lower Tana River schemes were started following the drought of 1984/85 and were designed to bring a greater degree of food security to the area. Many present schemes on the upper reaches of the Tana basin have been started because flood irrigation can no longer be relied upon to provide adequate food security for the riverine population. The decreased reliability of flood irrigation is blamed on the construction of dams in the upper Tana catchment.

Schemes are being supported by Church Groups, NGOs, CADP, the Drought Recovery Programme and Danida through the Rural Development Fund. (Although this source was phased out two years ago). Many of the pumped schemes are small, giving no more than 0.25 acre per family - enough to grow vegetables but totally inadequate for bulk staple foods. Generally it is recommended that schemes are pumped by small moveable 5 Hp engines and pumps costing Ksh 48,000 to buy with an economic life of 10 years. Alternatively they can be hired on a daily basis for Ksh 300. It is estimated that 50% of the agriculturalists in Garissa depend on irrigation. Over 60 schemes are either planned or are in operation and a co-operative has been formed where pump service and repair is available plus the supply of spare parts.

Food for the Hungry International has developed four irrigation schemes in the Garissa area between 1992 and 1993, and has another planned. The tenants are destitute Malakote and Minyoyaya farmers who due to the lack of flooding can no longer practice flood recession farming, and destitute Somali pastoralists who have lost all their livestock in recent drought. 57 ha of land are under irrigation with a total of 224 farmers settled with crops of bananas, maize, kales, onion, dhama, green grams, tomatoes and capsicum being grown. Poultry, goats and bee keeping are also being introduced.

Groups that have been formed to initiate schemes report to the MALDM for assistance, and as well as help with the initial pump and engine purchase, training is given in a range of disciplining including scheme management, financial management, by-laws, the conduction of group meetings, management of structures, crop selection, pump management, crop protection, fertiliser use and marketing.

Constraints

Irrigated agriculture is an advanced technique needing a high level of expertise and management; and it is only under certain conditions and certain crops that irrigation can be completely viable and sustainable. Lack of water, inadequate irrigation techniques, uneven drainage, flooding, pump breakdown, costs of diesel, management, lack of skills, lack of finance, inappropriate crop selection, lack of markets, lack of inputs, lack of credit, no research, and inadequate extension have or will all contribute to failures. Pumped irrigation is expensive. If pumped schemes are to be sustainable then tenants have to be able to find money to pay for fuel, repairs and eventual plant replacements. They have to sell produce. Food production on pumped irrigation schemes are simply not economically viable, unless they are selling high priced, high food crops such as vegetables, soft fruit and other cash crops in order to produce operational funds. A first class back up service is needed to successfully service the large number of schemes that are being contemplated at the moment along the Tana.

Based on observations made in the Districts there must be doubt as to whether the District Irrigation units with problems of transport and funds can possible prepare and service these new units properly, let alone the existing ones.

Despite the failures, the demand for schemes will continue - IFAD and the Drought Recovery Programme alone plan for the provision of 40 pumps in the next two years.

17.6.2 Lower Tana Village Irrigation Programme (LTVIP)

The precursor of this project was initiated by the Church and other NGOs, FAO and the Ministry of Agriculture in the 1970s. In 1979 TARDA and MOA formalised the LTVIP, a six year programme initiated by the NCCK supported by the Inter Church Co-ordinating Organisation of the Netherlands (ICCO). The scheme was to support small village community based, pump operated schemes.

The LTVIP was based at its headquarters at Munyila Hill near Garsen and four existing schemes were rehabilitated at Ngao, Oda, Hewani and Wema, and a co-ordinated approach to the schemes was planned. A reconnaissance report on the schemes was conducted in 1980, and a Technical Study was carried out which covered 1,995 hectares with an accompanying soil survey over 1,670 ha. Eventually the project covered five schemes. Oda had been initiated in 1968 with 150 farmers on 150 hectares, and Hewani in 1969 and Ngao (207.5 ha) added in 1969 in 1972 respectively. Eventually two more schemes - Mnazini (42 ha) and Wema (40 ha) were added all divided into 0.4 ha plots for rice production.

None of these schemes can be described as a complete success and in fact only two are operational at present - those at Hewani and Wema. Oda and Ngao are non operational due to management problems and Mnazini has been isolated and destroyed due to flooding and river channel changes since 1989. There is a possibility that Hewani and Wema may be able to benefit from gravity water supply by taking water off the TDIP intake canal.

An analysis of scheme performance conducted in 1982, concluded that schemes were excessively dominated by Government intervention, and there was lack of participation by the people, with the management committees not knowledgeable and not integrated with Government efforts. In addition, Government assistance itself was not integrated with Government efforts, and was inadequately staffed.

The recommendations of this study were that there should be a tighter selection of tenants, better site preparation, standardisation of pumps, bigger plots, (previous studies had recommended plots of 1.2 ha per family), the formation of co-operatives, move involvement by the people, and more training and better extension.

17.6.3 Large Scale Schemes

The large-scale schemes constitute a significant aspect of the downstream irrigation activities on the Tana River Basin. Large-scale irrigation are represented by the Tana Delta Irrigation Project (TDIP), Bura and the Hola Schemes. The performance of large-scale irrigation in Kenya has been rather disappointing, being characterised by low and declining output and productivity, environmental problems, poor cost-recovery and deteriorating social welfare. Currently all the large-scale irrigation schemes except Mwea depend on the Government for their recurrent expenditure.

This reliance on subventions from the Government strain the economy and deprive other sectors the capital necessary for their development. Therefore it is necessary that measures be taken to redress this situation.

Tana Delta Irrigation Project (TDIP)

The Tana Delta Irrigation Project is a large scale mechanised rice project that was first planned as a 10,000 ha project in October 1982, with the proposal extended to the south by another 6,800 ha in the following January.

The scheme was originally planned to be developed over the period from 1985 to 1992 but is behind schedule with at present only 200 ha under cultivation within the one polder that has been constructed. The scheme has come under considerable criticism from environmentalists through the possible effects it will have on the Delta ecology, the general social unsustainability of large scale mechanised rice schemes, and the upset it will create in the delicate traditional balance of pastoralist, fisherman and farmer activity in the area. As a result the present programme has been reduced to a single polder, although the area information projections for future expansion indicate that the scheme will still go ahead to full development which will enforce the movement and re-settlement of four pastoralist villages (Gubanargesa, Onkolde, Galililifi and Gomesa) and four mixed pastoral and agricultural villages (Hondarako, Kikomo, Arithi and Odhole).

The scheme will excise some 20,000 ha dry season grazing area, and will remove 23% of the total flood plain grasslands, and 50% of the riverine forests. There are 33,000 ha of grassland on the left bank of the Tana, and the scheme will take 48% of this. In terms of the overall delta the scheme will take 3,400 ha or 17% of the total 20,800 ha of grazing available during the flood and 20,000 ha or 26% of the 75,800 ha in the no flood situation, although it has been pointed out that in mitigation, better water and flood control will give longer grazing plus the potential for intensive fattening schemes using rice by products. There will also be available some 2,600 ha of protected all year round grazing within the scheme boundary. The excision will create greater pressure on the grassland that remains and longer grazing seasons may not be good for the long term productivity of grassland due to over grazing.

The project is based on estate mono culture of rice with highly mechanised production including high levels of inputs, including aerial spraying, with correspondingly high management requirements. A small area of 1,000 ha of less favourable soils and areas where mechanisation is difficult will be given over to smallholder cultivation of rice, maize, sorghum and other crops. If the proposal is implemented to it's full planned extent, cultivation will be in 12 ha fields inside four separate polders with water extracted from the Tana by a weir at Sailoni with gravity feed and drainage from north to south. Each polder is surrounded by a protection bank, 2.4m high.

The original plan was to 100% crop in the short rains and 75% crop in the long rains, but it is understood that this ambitious target has been dropped in favour of one cropping per year.

At full development the scheme is estimated to employ 1,000 people compared to between an estimated 5,000 and 10,000 people that were either totally or partially dependant on the area before the development of the scheme. Only 13% of the total employed staff will be enrolled locally.

Environmental monitoring of TDIP conducted by Nippon Koei (1993) suggest that the seasonal biannual flooding may be central in the sustainable operation of the scheme. It was observed that irrigation could bring about increased soil salinity to levels detrimental for crop growth, and that flooding and deposition of sediments could be required to flush out the excess salts. While further investigations are required there is a strong conviction that increased irrigation without benefit of periodic natural flood events and deposition of sediment may lead to increased soil salinity resulting in decreased crop yields and a possible failure of the irrigation schemes.

Analysis of topsoil from seventy five samples in three sites in and adjacent to the Tana Delta Irrigation Project (TDIP) was carried out during October, 1993. Irrigation commenced in 1992 and, after only a very short time, there is already evidence that irrigation in the Tana Delta could trigger increased soil salinity. Figure 17-3 and Table 17-7 summarise pH and electrical conductivity (EC) data from rainfed agriculture, irrigated estate, and uncultivated land measured after the development of TDIP. Over 50% of soil samples from irrigated rice fields indicated possible future toxicity to rice due to elevated EC values. However, high salinity and EC values were not detected in uncultivated areas and land under rainfed agriculture.

Whilst further, more detailed, studies are obviously required, there are strong indications that increased irrigation without benefit of periodic "natural" flood events and deposition of sediment may lead to increased soil salinity resulting in decreased crop yields and a possible failure of the irrigation scheme.

It should be noted that the delta is largely less than 10 metres above mean sea level and that delta subsoils contain significant amounts of salt. If natural flooding events in the Tana Delta are to be reduced, and depending on specific situation and topography, significant areas of the delta could be damaged due to increased soil salinity / sodicity. Reduced flooding may also result in increased salinity / sodicity in grazing lands within the delta, with consequent loss in carrying capacity of these vital grazing areas.

High Sodium Absorption Ratio (SAR) measured in some flows at Garsen may indicate that these waters are unsuitable for large-scale irrigation, especially where regular large-scale flood events are prevented from flushing salts.

In light of these possible effects, the envisaged flood reduction by the proposed Mutonga/Grand Falls dam may lead to build-up of salts in irrigation schemes and reduce their productivity. The dam (especially during the filling) may also cause insufficient irrigation water to flow downstream, which may not even be enough to provide for the leaching requirements and exacerbate the salinity problem. Insufficient irrigation water may also limit the irrigated area and substantially reduce agricultural production.

Figure 17-3 Difference in Average Soil pH Measured Between Three Different Land Uses in the Tana Delta, October 1993.

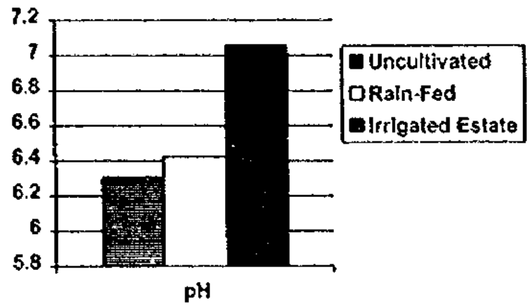


Table 17-7 Difference in soil pH and electrical conductivity (EC) measured between three land uses in the Tana Delta, October 1993.

	Rain-fed Field		Irrigated Rice		Uncultivated Land	
	pH	EC	pH	EC	pH	EC
Average	6.424	0	7.056	0.4	6.304	0
Range	6.0 - 6.8	0	6.4 - 8.1	0 - 2.8	6.1 - 6.9	0

Hola

Hola was inaugurated in 1953 during the Mau Mau emergency but first became operational in 1956. The scheme was later developed as a tenant scheme with 690 tenants on 870 ha, each holding being between 1.2 and 1.6 ha with cotton as the main crop followed by food crops of maize, cowpeas, green grams, groundnuts and vegetables. Cotton yields were high at 2,200-3,500 kg/ha.

In May 1989 during a substantial flood of the Tana, the river changed course at Laini leaving the water intake over two km from the new riverbed. A new intake was surveyed at Makere, and the contract for the new intake and supply canal contracted to the National Youth Service at a cost of Ksh 40m. Work was started but then abandoned in September 1991 after funds ran out.

The cessation of irrigation since 1989 has affected the performance of the scheme and its tenants who have been unable to cultivate. The farms have become over-grown, irrigation canals deteriorated, and the farmers, who were totally dependent on the scheme for their livelihood, have been left destitute without means to feed and clothe themselves and without potable water.

The river diversion as a result of flooding underlines the necessity for water-flow regulation to allow for controlled flooding and ensure continuous running of the schemes. In this regard the proposed Mutonga/Grand Falls project holds positive prospects for helping achieving this.

Bura

Funding for the Bura scheme was signed in 1977 with money from the World Bank and GOK. Modelled on the Hola Scheme it started in 1981 with 320 tenants. Although originally planned for 6,700 ha of farmland and 4,500 ha of forest with 5,150 families in 23 villages it was eventually scaled down to 3,900 ha and 3,000 tenants and 2,500 ha of forests, each family having 1.25 ha including half an hectare for cotton and the rest for food crops.

The scheme is no longer operating and has been described by Horta (1994a) as "...an unmitigated disaster [which is] the result of remarkably poor planning and institutionalized conflicts of interest". There is no cotton grown, no water for irrigation and much of the scheme area is overgrown with thorn vegetation (*Prosopsis fuliflora*) and rusting vehicles and machinery.

The project spent about $55,000 for every settler on the project site. Yet today these settlers and their families suffer abject poverty and drought and famine are daily reality (Horta, 1994a). Although design and concepts were poorly defined, the major problem was with management. Considerable blame for the scheme's failure lies on lack of participation in planning and implementation by the tenants and the rushed top-down approach used by the planners.

According to the World Bank Project Performance Audit Report of 1990, the project has expended nearly $108 Million. This is a huge portion of national capital which may not be easily convertible for other uses. Therefore the only profitable way of using the scheme is to rehabilitate it and incorporate appropriate and environmentally, socially and economically sustainable design, planning and management approaches.

However, the issue of most concern in relation to rehabilitation is availability of water. Projections with RIBASIM during the Phase 2 studies, showed that there may be insufficient water to satisfy the needs of the projects. These simulations indicated that the total flow at Nanigi by 2015 may be seasonally insufficient for the operation of Bura and Hola with a combined irrigated area of 6,000 ha, whilst at the same time allowing for the needs of downstream users. If this is so, then the planned rehabilitation and expansion to a larger area is likely to become increasingly difficult and unsustainable.

Chapter 18

OPINIONS OF INSTITUTIONS, ORGANISATIONS & DOWNSTREAM COMMUNITIES

18. OPINIONS OF INSTITUTIONS, ORGANISATIONS, AND DOWNSTREAM COMMUNITIES

18.1 INTRODUCTION

Within the scope of work provided in the Terms of Reference (TOR) the consultant examined the opinions of:

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

The fundamental starting point of the thinking which led to the undertaking of this study was the recognition of the vital role local communities, institutions and organisations can play in strengthening integrated river basin development, and the belief in the potential of these three sectors as effective channels for the delivery of assistance at grass roots levels and monitoring and evaluation of river basin integrated development. Those beliefs are generally accepted by many involved in river basin development, but there has been very little examination, verification or validation of these beliefs.

Opinions of local communities, specialists from government organisations, international and local NGO's have become increasingly important in project developments (Oldale and Hayata 1993, Nippon Koei 1994), particularly in the context of the impact of the proposed Mutonga and Grand Falls Hydropower Dams on the downstream environment. Participation and knowledge of local communities and different organisations and institutions are a necessary prerequisite in determining the significance of flood and sediment release to the downstream environment, and in management of the riparian natural resources and production systems (Rowntree, 1990, Salem-Murdock, 1991, Scudder, 1991). Although there are limitations to this study the results of the work carried out to date are indicative in terms of:

- Participation of the local communities, institutions and organisations in the project planning and management.
- Involvement of the three sectors in strengthening the capacity for the monitoring and evaluation of the project performance and effect on the environment.

18.2 METHODOLOGY

The methodological approaches anticipated in this study embraced interviewing key informants from local communities, institutions and organisations. The key informants are expected to give representative opinions of the communities, institutions and organisations. However, this must be applied cautiously as:

- The key informant may not be in touch with the members of the communities, institutions and organisations; and
- The key informant might be tempted to give more emphasis on personal opinion which might be quite different from that of the rest of the members of the communities, institutions and organisations.

The field survey to interview local communities and interested parties has been delayed due to insecurity and other technical issues. Preparations are in the advanced stages for the field survey. However, opinions of the communities have to date been obtained from secondary sources. The consultant has also obtained information from the archives which illustrates the impact of past floods on downstream production systems. Ultimately, the research has been able to obtain opinions of selected institutions and organisations through existing literature and discussions with key informants.

18.3 SURVEY RESULTS

The survey results are based on opinions of the institutions, organisations and downstream communities. Although the survey is still incomplete, the communities' opinions collected from secondary sources, particularly archives and development plans are indicative of the significance of the effect of past floods on the downstream production systems.

Archival information indicate that droughts and floods are the most serious hazards in the downstream environment (District Annual Reports 1917-1950). The investigations reveal that lack of flooding was a commonly observed phenomenon by the local communities long before the construction of the upstream dams. This evidence contradicts the popular communities belief that lack of regular biannual floods is a function of the mushrooming dams upstream. However, the lack of flooding often led to migration of the different communities, failure of crops and consequently relief food supply. But the failure of crops, particularly maize, and rice proved that the colonial policy of concentrating on special crops to the exclusion of others was unsound. Therefore, the only sound policy is one based on agricultural diversification with emphasis on mangoes, coconuts, cashewnuts, bananas and citrus fruits where soil moisture content is low.

The archival source shows that 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 their salvation and their destruction. They say "it is our brother and also we are half fishes".

The evidence emanating from archives, indicate that failure of flooding in the past contributed to land use conflicts between the pastoralists, agriculturalists and wildlife.

Despite the above contradictions, the local communities suggest that a project to help deal with the threat of drought, floods and famine would be welcomed and the communities would be co-operative if they are consulted and involved in the project management, monitoring and evaluation.

18.4 DOWNSTREAM COMMUNITIES

Towards the end of January 1996, a field survey was carried out to establish the opinions of the downstream communities on the proposed Mutonga/Grand Falls hydropower dam as well as the existing upstream dams. Because of the insecurity in the region combined with limited sensitisation of the people in relation to the project, the unit of study was the village (headed by elders) where public opinion was assessed. This was found to be more convenient because the communities downstream normally live in clustered villages of approximately 30 - 200 households. This kind of clustering facilitated the discussions which were performed in selected villages of the three zones of the downstream environment, namely:

- The Upper section which starts from Mbalambala to Bura West;
- The Middle section which starts from Milalulu to Gwano locations; and
- The Lower section beginning from Ndera to Kipini along the Indian Ocean coastline.

The above zones are briefly described below. Firstly, the Upper Tana is comprised of both pastoralists and agriculturalists (cultivators). Mostly, pastoralism is taken very seriously in this area, while arable agriculture is carried out on small farms mainly for subsistence. However, the farming activities are dependent partly on flooding and partly on rainfall. Under normal circumstances, the incomes derived from agriculture and livestock production are sufficient to sustain the households. The area is inhabited by three main riparian communities: Munya Yaya (Kororo), Orma and the Malakote. Their opinions have been carefully assessed in the subsequent paragraphs.

Secondly, the Middle Tana is comprised of the Pokomos of the following sub-groups: Milalulu, Zubaki, Ndura, Kinakomba, and Gwano. This area is mainly popular for arable agriculture, but there are some pastoral communities in the vicinity of the area. However, the pastoralists are migrants whose temporary settlements depends on the weather conditions, dictated mainly by drought conditions. Most of them migrated from the adjacent Wayu locations. This kind of migration underscores the significance of the relatively wet floodplains, dependent on biannual flooding.

Thirdly, the lower Tana which includes the entire Tana Delta occupied by different natural ecosystems (forests, grasslands, woodlands, lakes, etc.), Pokomo flood recession agriculture, Orma and Wardei pastoralists. In addition, the area embraces the Primate Reserve, Tana Delta Irrigation project and numerous fisheries. This is an area of immense biodiversity whose sustainability is of interest to many parties. Its sustainability was expressed by the local communities and various officials as a function of biannual flooding.

The downstream opinions of the riparian communities constitute the main theme of this section, and in seeking the opinions of the public, ten basic questions were explored:

1. How have the existing dams upstream affected this zone of the downstream environment?
2. How would the proposed project influence the following activities?
    a) Flood recession agriculture,
    b) Pastoralism
    c) Fishing
    d) Wildlife management
    e) Small and large-scale irrigation.
3. What do you think would be the impact of the project on your income? (Will it increase, diversify or decrease)
4. Do you see a situation whereby the project can deny you access to the resources you need to undertake for your activities?
5. Do you envisage any benefits from the proposed project?
6. Were there any serious effects of floods downstream before the construction of the existing upstream dams?
7. How do the downstream communities adjust to the flooding during the heavy rains in the upper catchments of the Tana River?
8. Do you remember specific years of flood occurrences in the last thirty (30) years?
9. How do floods affect
    a) Fisheries?
    b) Forests?
    c) Pastures?
    d) Farmland?
10. Is there any relationship between floods and famines with regard to resource utilisation?

Some of the above questions are similar because they were intended for cross-checking the accuracy of the opinions of the public. Since the opinions of the riparian communities downstream were found to be similar, they have not been categorised according to the three zones outlined earlier.

The downstream environment consists of trust land which is used communally by different communities. However, the local people insist that the land has been inherited from their ancestors. Since 1900, it is said that each clan owned farms divided among the village households. These farms are divided into two categories:

- Those farms located on the river banks where flood recession agriculture is practised
- Those farms dependent on rainfed agriculture where floods are uncommon.

The above farms are used interchangeably depending on the prevailing climatic conditions in the region. Furthermore, the arrangement is intended to minimise the risk of climatic and flooding hazards. The farms are organised to avoid any conflicts between clans but any dispute is normally settled by the elders from different clans.

Droughts and floods are commonplace in the downstream environment. Before the construction of the upstream dams, floods used to occur annually but since the initiation of the dams, the flood frequency has changed to five years. This kind of observation by the local people requires further verification from the statistical records of the hydrological regime and climatic data[1]. What is clear is that during heavy floods, the local communities depend on rainfed agriculture by planting annual crops, particularly maize, cowpeas, green grams, pumpkins, melons, millets, etc. However, when the floods recede, the river banks are planted with perennial crops: bananas, mangoes, pawpaw, sugarcane, coconuts and citrus fruits. Under normal circumstances, there is biannual flooding during the long rains (March to May) and the short rains (October to December).

In response to the questions, the local people said that the existing dams upstream have reduced flooding and siltation. Consequently, there has been decline in agricultural production, fishing and the areas prone to flooding. Some of the lakes and swamps have dried up, thus minimising the fish breeding grounds in the wetlands. Even the forests have been affected. Famines have become more common.

The above opinions indicate that any additional dam upstream would make the situation worse by further reducing the productivity of the downstream environment and biodiversity. Because of this difficulty, subsistence cultivation, fishing and pastoralism would be affected considerably. Moreover, lack of flooding does not only reduce the breeding and feeding grounds of fish and birds but also affects the forests and pastures. Recent investigations show that lack of flooding reduces the feeding

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[1] It should be noted here that the hydrological records from the gauging station at Garsen are poor and do not provide the necessary records for the Tana Delta. Similarly, discharge data are mostly lacking from the majority of the other gauging stations on the lower Tana with the exception of Garissa.

grounds of the water birds, while the livestock carrying capacity of the range areas has declined considerably due to reduced flooding. Moreover, the pastures in areas not flooded for long periods are heavily infested with weeds like Fue, Mbalambala and *Indigofera* spp are substituting for grasses, making for unfavourable botanical changes in the range. Of course the persistent decline in milk yield in the recent years in the downstream environment is linked to both deteriorating pastures and livestock diseases.

According to the Ormas and Wardei pastoralists, both manyatta and urene livestock have suffered from lack of flooding and long spells of drought. Desiccation of *Cyperus rigidfolia* is associated with lack of flooding. However, there is a fallacy about the effects of the existing upstream dams on the flooding of the downstream environment. The communities downstream have apparently received wrong signals about the proposed dam. While the dam could help in regulating the river flow, the message conveyed through secondary sources show that the dam is intended to control flooding. Therefore, the hostility of the downstream communities is due to wrong messages or misinterpretation of the effects of the existing dams upstream. This implies that participation of the local people during the initiation of the project is a necessary prerequisite in order to explain clearly the potential benefits of the project. Effective communication with the different communities would facilitate the planning, implementation and management of such a project.

When asked to comment on the effect of the project on their incomes, the local communities indicated that the project is likely to reduce farmland, pasture land, fuelwood, forests and fisheries from which they earn a living. They insist that the project would reduce the diversification of their social and economic activities which depend on flooding. However, previous studies reveal that the dams may have effect on small floods but not big floods. Of course, reduced agricultural, fishing and livestock production activities would lead to serious repercussions on the downstream environment and heavy dependence on external food supplies.

Because of the uncertainties of the regulation of flooding, the downstream communities feel that the proposed project would deny them access to some resources, especially farm land, pastures, fisheries, fuelwood and other forest products. However, the people believe that the control of flooding would facilitate transport and communications as well as marketing of the farm produce. They also believe that the project would facilitate rural electrification in the downstream environment. Without the provision of such facilities, the downstream communities do not envisage the direct benefits accruing from the proposed project. Even the urban centres downstream lack electricity!

During the heavy rains and floods, the downstream communities have to change by migrating to the urban centres or to drier areas. Nevertheless the local people cannot remember exact years of flood occurrences in the last 30 years. But the most commonly remembered years are 1961, 1964, 1966, 1968, 1969, 1971, 1974, 1979, 1988, 1989 and 1994. There is confusion about the dates of flooding because the local people depend on their memories. Despite this difficulty, it was clear that 1961 was the time of the worst flood in the region. During this year, the river changed its course, people migrated to relatively drier areas and the people were provided with relief food. Consequently, most properties were damaged. Furthermore, many villages shifted from their original places to the present sites, e.g. Hewani village. Hewani is a local name for a village which was surrounded by water.

In a nutshell, biannual flooding helps in increasing the productivity of the delta through the deposition of the silt. This implies that any additional dams may reduce siltation and lead to decline in the biodiversity, livestock and agricultural production systems. Consequently, this is perceived to lead to the chronic famines and diseases in the region. What the downstream communities want is a project which 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 which 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 Project. Such changes have precipitated conflicts in resource utilisation downstream.

It is emphasised that unnecessary rumours that the project is intended to control floods is 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. The wildlife and the various ecosystems downstream depend on the Tana River but some of these opinions require scientific observations and verifications. Of course, severe floods lead to population migrations, loss of property and life. Ultimately, we should not ignore the local people's perception of their environment and the upstream dams.

18.5 INSTITUTIONS AND ORGANISATIONS

18.5.1 Government Institutions

Most of the government institutions recognise the important role of biannual flooding of the downstream environment (NES 1985, Republic of Kenya 1979, 1993, 1994). However, the records do not show systematically the temporal variations of the floods before or after the construction of the first upstream dam in 1968. Instead one publication has concentrated only on the 1961 famine and floods which were quite unique (Colony and Protectorate of Kenya 1961). Equally, NES (1985) has attempted to show the occurrence of drought and famine chronologically downstream since the 1850 to 1984 without specific mention of the years of flood occurrence.

Despite the above shortcomings, NES believes that the construction of more dams upstream will result in a more regulated river flow but will simultaneously deny the flood plain of the annual deposition of alluvium soil which would improve the flood plain ecosystem.

Since 1970's development plans have highlighted the impact of floods on the downstream environment, which usually interfere with the spatial organisation of the production systems. These impacts are outlined below:

- Most of the land lying below 45 m a.s.l. are prone to floods during the heavy rains in the upstream catchments. This disrupts communications and adversely affects fisheries, agricultural production and marketing systems.
- Lack of biannual flooding is associated with lack of silt and nutrient supply to replenish the flood plain and the delta. Similarly, lack of flooding would increase the salinity of the ground water sources.

It is generally thought that the Tana River Basin has "unlimited potential"[1] for irrigated agriculture because of the fertile alluvial soils and the frequent flooding of the river itself. But the river, which is a source of livelihood for agriculture, has at the same time often been the cause of catastrophe during high floods. Under such devastating conditions, the crops are damaged while the people are subjected to famine relief food through the Government (Republic of Kenya 1980). The heavy downpours of rainfall in 1961 and 1989 caused extensive floods downstream which damaged roads, farms, fisheries and resulted in loss of human life and properties. Because of the poor precipitation and the low water holding capacity of the soils, crop

[1] This commonly held belief may be incorrect and a continued reliance on an "unlimited potential" for irrigated agriculture in the Tana Basin may in the long-term lead to inappropriate and potentially destructive land use and development policies. Clearly, the irrigation potential in the Tana River basin is limited by several important factors, including (1) the availability of suitable soils for irrigation, (2) the volumes of water available on at least an 80% probability of occurrence, as well as other important constraints such as topography. In addition, irrigation is a relatively high cost form of agriculture with significant annual maintenance costs and, as a direct consequence of this, requires returns from cash crops so that the systems are not uneconomic. Cash crops require reasonable access to markets. The potential for irrigation within the Tana River Basin as a whole has been estimated at about 91,000 hectares, of which approximately 20,000 are developed (although Bura and Hola are currently in need of rehabilitation). A significant proportion of this potential lies in the upper parts of the Tana Basin.

production is almost entirely confined to the flood plain of the Tana River and depends on the biannual floods.

One of the peculiar characteristics of the Pokomo which is well-documented is their voluntary and traditional villagization, which is due to the topography of the River whose inundations bring them their livelihood as agriculturalists (Rowlands 1955, Republic of Kenya 1959). But during the floods, only pockets of dry sites remain and on these hills a few centimetres above the flood the population naturally congregates.

It is reported by the administration that Pokomo have worked out by experience of the peculiar conditions on the River a convenient form of land tenure whereby every Pokomo has a right to the river bank and the flood for an indefinite distance away so that low, medium or high flood can ensure some successful food crop production.

Potentially, the Pokomo live a semi-nomadic agricultural life style in search of suitable sites for their crops and they follow the river in its vagaries and cuts to keep their fishing close and their fields under observation. Indeed the Pokomo use artificial furrows to take the flood to the low lying fields.

While the Pokomo and Malakota are subsistence riverine farmers, the Orma and Wardei are pastoral communities practising transhumance, a seasonal movement in search of water and grass. Normally, the pastoralists use the rangelands situated in the hinterlands of the delta during the wet season, but during the dry seasons, they migrate to utilise the pasture and water resources of the delta. This implies that during dry periods, there are land use conflicts between the agriculturalists, pastoralists and wildlife.

As the population increases and land becomes more scarce downstream, it becomes mandatory to intensify agricultural productivity through irrigation technology. Therefore, those institutions, particularly TARDA and the Ministry of Agriculture, Livestock and Marketing believe that the proposed dam must have the capacity to cater for the future irrigation demands besides considering the needs of water for domestic purposes.

18.5.2 Specific Institutions and Organisations

There are mixed opinions by communities, institutions and organisations on the proposed Mutonga and Grand Falls Dams. Over 90% of the population recently surveyed would like to continue their current lifestyles of small-scale farming and husbandry (Anon 1995). This study predicted that due to the land use system in the area (75% customary, communal ownership) the local people might challenge the Government on the issue of infringement on their rights of access to natural resources, such as land, water, fisheries and vegetation.

Recently the local communities living downstream protested on the introduction of Tana Delta Irrigation Project (TDIP) which they feel limits their utilisation of the natural resources, including grazing, in that area (Nippon Koei. 1993, Horta 1994). This implies that initiation of any new dam upstream should be in the interest of the various interested parties downstream in order to foster the co-operation needed to protect the ecological and production systems. Even more important is the significance of involving the communities, institutions and organisations in the planning, management, monitoring and evaluation of the project.

Implementation of environmentally sensitive projects in developing countries continues to be difficult because of a lack of technical and administrative capacity and the absence of an environmental component (Horta 1994a). On this basis, Horta criticises World Bank funded projects, especially those along the Tana River, e.g. Bura,, which have led to undesirable ecological and social changes. Experts opinions indicate that the forest ecosystem that shelters two rare primate species: the Tana River Red Colobus and the Crested Mangabey are already threatened by the existing upstream dams. However, the Mutonga/Grand Falls Hydropower Project shows government and donor commitment to environmental impact assessment which, if implemented through monitoring and evaluation, would alleviate the anticipated ecological and social consequences.

According to TARDA, half of Kenya s irrigation potential is within the Tana and Athi Rivers Basins (24,000 ha) and that the construction of such a dam will enhance agricultural production. TARDA insists that the dam must be designed to cater for irrigation and other users downstream through the release of sufficient water at the demand periods. This is because dam construction and consequently irrigation developments in the downstream environment are a major concern of TARDA and are designed to overcome part of Kenya s land hunger problem, with plans for the settlement of 40,000 people (Rowntree 1990).

During the workshop, it was expressed that the extent to which the artificial floodwater will affect the change of flora and fauna of the downstream environment must be determined before the implementation of the project. However, this would require a parallel study covering a relatively longer period of at least two flood seasons.

18.5.2.1 Tana Delta Management Committee

Because of the importance of the downstream environment, the Tana Delta Management Committee was set up after pressure from the international community and conservationists and a directive from the President that no new activities should be initiated in the Tana Delta until a proper management plan is prepared under TARDA (EAWLS and IUCN 1994). The management committee is composed of potential interested parties drawn from:

- Tana and Athi River Development Authority (TARDA).
- National Environment Secretariat (NES) of the Ministry of Environment and Natural Resources.
- East African Wildlife Society (EAWLS).
- Coastal Development Authority (CDA).

- Permanent Presidential Commission on Soil Conservation and Afforestation (PPCSCA).
- National Museums of Kenya (NMK).
- Kenya Association of Tour Operators (KATO).
- Tana River County Council (TRCC).
- Tana River District Commissioner (Chairman of DDC).
- Four Local Representatives from Tana Delta.
- World Conservation Union (IUCN) co-opted.

The Terms of Reference for the steering committee are:

- To formulate an immediate action plan specifying the activities to be carried out and draw out work programmes within the broad guidelines of protecting the environment and the Tana River Delta Wetlands, and within the framework of a broad environmental assessment and management plan. The overall effect of such plans would be to create the effect of the wise use of the environment.
- To prepare a document with which funds for various activities can be sought, obtained and utilised.
- To document, contact and maintain the support of various interested groups.

Following the formation of the steering committee an expert was commissioned to carry out a study with a view to compiling an annotated bibliography of the literature pertaining to the Tana River Delta. The study was funded by IUCN. Consequently, a workshop was held to consider the results of the study and other issues. As an outcome of the discussions, it was resolved that an awareness task force be established to campaign and sensitise the delta communities about the development and benefits of the delta. Currently, a liaison officer has been deployed to sensitise the delta communities. After successful sensitisation of the local people, an environmental impact assessment study would be carried out but this is dependent on availability of funds. However, the current study of the impact of the Mutonga and Grand Falls dams on the delta should be seen as complementary to the above study.

18.5.2.2 TARDA

As a parastatal, TARDA has assumed more or less absolute authority over the allocation of water resources in the Tana River Basin, and was considered as a strongly centralised organisation, controlled by top-down planning, and the interests of political elites and foreign agencies (Rowntree 1990). This criticism no longer holds water as TARDA now involves interested parties in the delta embracing local communities, institutions and professional organisations.

A stronger criticism is that TARDA has acted to marginalise the significance of EIA on its development projects, reducing the influence of donors and outside agencies on decision-making on the one hand, while not consulting with the National Environment Secretariat on the other (Hirji et al. 1991). Furthermore, these authors argue that TARDA failed to consult local government in planning its activities, despite provision for its representation on the District Development. The above criticisms have little to do with flooding of the downstream environment and there are at present arrangements for linkage or consultation with downstream users and local people, so as to achieve a better integrated approach to the management of the Tana River Basins.

Communication with TARDA management revealed a number of important issues:

- TARDA was created through an Act of Parliament in 1974 and given the mandate to manage water and land resources in the Tana and Athi River Basins. Since then the Authority has drawn up long range development plans and initiated a number of studies and surveys which are a necessary prerequisite for assessment of alternative demands on available water and land resources.
- The organisation is concerned with optimum utilisation of the waters of the Tana River in order to accelerate development. Hydropower generation has been identified as one of the components of any viable development along the river and five major projects have already been constructed at Kiambere, Kindaruma, Gitaru, Kamburu and Masinga.
- The proposed Mutonga and Grand Falls dams are expected to improve irrigation, public water supplies, fisheries and tourism development, as well as provide hydropower.

18.5.2.3 IUCN

During communication and discussions with IUCN the following points have emerged and they merit serious attention:

- The construction of the dam will have major effects on the downstream environment.
- It is a major concern of IUCN that the fluctuations in the flow of the river thereby simulating the natural situation, be maintained. If this is done, through controlled release of flood waters, then it is their opinion that the proposed dams could have positive effects on the environment. IUCN is not advocating large, uncontrolled floods every year, but a means of releasing sufficient volumes of water at the correct times in order to create floods on the lower flood plain and Tana Delta that will assist in the maintenance of these environments both ecologically, socially and economically.
- The organisation prefers having a clear policy on downstream floods before the commissioning of the dams and to have a regular monitoring of the

operating rules during the operational period of the dam. IUCN stresses the need for monitoring of water release, to ascertain to what extent the release of water will result in the necessary recharge of the flood plain and Tana Delta.

- IUCN maintains that suspended sediments and organic matter originating probably from the slope of Mount Kenya are important to the flood plain and the delta alike. Theoretically, sediments generated below the proposed dam would not have the capacity to rejuvenate the flood plain and the delta.
- Information from other delta ecosystems show that mangroves play an important role in providing a large number of direct benefits to the local people as well as providing breeding grounds for a number of sea fish species. But mangroves require a certain amount of fresh water, and floods are essential for the development of mangrove forests. The question, therefore, is how frequently the mangrove stands in the delta will be flooded after the construction of the proposed dam. Any decline in mangroves may adversely affect the offshore fishing industry.

18.5.2.4 East African Wildlife Society (EAWLS)

The mission of the EAWLS is to promote conservation and wise use of wildlife and the environment. The society plays important role in public lobbying and advocacy. The most recent and perhaps most vigorous lobbying campaign was directed to the largest ecosystem in Kenya, the Tana River Delta Wetlands. This was meant to guard the delta from commercial exploitation and environmental degradation. This culminated in a Presidential Decree towards the formulation of a management plan for the area that will ensure both conservation and wise use of the delta s resources.

- EAWLS has had a long history of involvement in conservation issues in the Lower Tana Basin. It has funded several research and monitoring projects in and around the Tana River National Primate Reserve (TRNPR) with a view to enhancing conservation of the riverine forests which are the habitat of two endangered and endemic primate species : the Tana River Red Colobus and the Tana River Crested Mangabey. Therefore, EAWLS is concerned about development activities in the Upper Tana River Catchment areas that might have adverse environmental impacts on the ecosystems downstream.
- EAWLS commends TARDA and JICA for studying the proposed dam effects on downstream communities and ecosystems, and particularly for embracing innovative option of artificial annual floods and silt release to restore downstream ecosystems.
- Because of lack of flooding data, EAWLS recommends thorough field data collection on flooding, maps illustrating flood patterns. Methods of predicting flooding and changes in flooding are considered equally important.
- EAWLS supports IUCN on the role of silt generated from the upper catchments of the Tana River in maintaining the soil fertility and downstream ecosystems.

18.5.2.5 The Kenya Wildlife Service (KWS)

KWS recognises the importance of co-ordination on land use both at national and local levels and sets the task for promoting the development of improved co-ordination mechanisms. For both ecological and economic reasons, it is imperative that biodiversity of the downstream environment should not be adversely affected by human activities upstream.

- It is the view of KWS that the impounding of the Tana River is expected to affect the river flooding and sedimentation patterns and regimes. Consequently, this will certainly have serious repercussions on the biodiversity and socio-economic activities of the local communities in the flood plain and the delta.
- The construction of the proposed dam may affect one of the most delicate ecosystems in Kenya, TRNPR which is the habitat for the endangered and endemic primate species : the Tana River Red Colobus and the Tana River Crested Mangabey.
- KWS notes that by impounding the river at Grand Falls, it will take many months for the dam to fill and during the same period, the project will only release 30% of the average flow. This means that downstream ecosystems will be adversely affected due to lack of flooding and siltation. Consequently, this would also adversely affect the socio-economic status of the local communities downstream. It is again emphasised that flooding and sedimentation are crucial for the sustenance of the Lower Tana River ecosystem. There is no adequate data to facilitate the understanding of the behaviour of the Tana River and its subsequent effects on the hydrology of the flood plains and the delta.
- KWS maintains that all interested parties in this project should be involved and consulted on various aspects of the EIA study.

18.6 CONCLUSIONS AND RECOMMENDATIONS

1. There are mixed opinions by communities, institutions and organisations on the impact of flooding on production systems. Heavy floods are deleterious to arable agriculture, and fisheries, while normal floods enhance flood recession agriculture, pastures and fisheries. It has been shown both by Phase 2 hydrological studies, and by the Hydrological studies carried out by this study, that none of the proposed dams will be capable of regulating any of the larger, damaging floods. These large floods will therefore continue to occur with the a similar frequency as in the past. At the same time, construction of the proposed dams will have a serious negative effect on the frequency of the "normal" floods that bring major benefits, unless controlled flood release mechanisms are incorporated at the design stage and subsequently managed for the benefit of downstream communities and ecosystems.

2. Community participation and consultations with institutions and organisations have become very important in river basin development involving the construction of large dams. This is so because community participation and local knowledge in managing natural resources and production systems of the downstream environment are fundamental.

3. No relevant information exists on research done by government organisations, international organisations, international an local NGO's on the effect of natural floods on the downstream production systems because of the lack of capacity to monitor floods.

4. The downstream communities and other interested parties are not sure how artificial flooding mechanisms would work and what remedies are required to alleviate any shortcomings. It is recommended that any additional dams should not have adverse effects on the downstream ecosystems and production systems which would trigger changes in the communities social and institutional set up.

5. An important consideration is also that a well managed controlled flood release mechanism will assist in enhancing the political stability of the Lower Tana and Tana Delta.

6. There is a wealth of literature on the various aspects of river basin development and water resources management but literature pertaining to issues of community participation in river basin planning and management in Kenya (and elsewhere) is scarce. Despite the importance of river basin development, there is limited evidence of experience of community participation in the planning process, whether directly or indirectly through the active involvement of institutions and organisations articulating the views and needs of the local population.

7. Collaboration between interested parties in the downstream environment would strengthen the capacity for monitoring and evaluating the changes which are likely to occur, greatly assist in identifying and mitigating adverse impacts, as well as enhancing beneficial impacts. This calls for the participation of local communities, institutions and organisations in project planning and management from an early stage. It is evident that professional organisations have tremendous capacity for monitoring and evaluation. The participation of the different parties would facilitate co-ordination of land use in the downstream environment. However, the government will have to provide a directive on who will have the mandate and responsibility for management of the water and sediment release systems and ensure effective monitoring and evaluation of project performance.

Chapter 19

DOWNSTREAM ECOLOGICAL SYSTEMS

19. DOWNSTREAM ECOLOGICAL SYSTEMS

19.1 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 upstream dam construction. 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 serve to 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, but perhaps the most impressive aspect of floodplain grasslands under normal conditions is the close integration of the physical and biological components within the system. It is this closely integrated system that results in the high carrying capacities generally associated with floodplain ecosystems. However, the traditional integration of human, physical and biological activities which make up the ecology of the floodplain can only work if there is a community of micro-organisms, plants and animals which are adapted to the particular frequency of the environmental events which are fluctuating. In the case of the Tana River floodplain the important driving variable is the bi-annual flooding regime.

If flooding is reduced below a critical frequency, the particular 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 greater carrying capacities.

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 are an important economic and cultural component of many of the downstream systems, such impacts are likely to be significant and far reaching.

19.2 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 and these riverine forests owe their existence to the proximity of ground water resulting from the presence of the Tana in this otherwise arid region. The riverine forests, which can grow up to 30 m, are dominated by evergreens with some semi-deciduous species and have a spatial extent determined by the proximity of ground water to the surface. The surrounding vegetation is classified as dry woodland and wooded grassland (savannah).

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[1]. Forest regeneration is dependent on overbank flooding and its growth and phenology are closely related to the rise and fall of the river level[2]. Natural forest regeneration depends entirely on overbank flooding, which usually occurs at flows above 500 m^3/sec measured at Garissa (i.e. 500 m^3/sec is the threshold above which flooding normally occurs).

19.2.1 Conservation Status

Tana Riverine forests are of National, Regional and Global importance in that they serve as the only habitat for the endangered Tana River Red colobus (*Colobus badius rufomitratus)* and Tana River Crested mangabey (*Cercocebus galeritus galeritus*). In an effort to conserve the unique biodiversity of Tana riverine forests the TRPNR, with a total area of 169 km^2 was established in 1976.

Other primates in these forests include and the sykes monkey (*Cercopithecus mitis albotorguatus*), Zanzibar galago (*Galago zanzibaricus*) Vervet monkey (*Cercopithecus althiops pygerythrus*) Yellow baboon (*Papio cynocephalus cynocephelus*) Garnett's galago (*Otolemur garnettii*) and the Senegal galago (*Galago sengalensis*).

It must be noted that these endangered primate species depend on a number of specific forest tree species found in these riverine forests, both for food and for maintenance of

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[1] The importance of flooding regimes to the Tana River floodplain and delta forests is considered in detail by Hughes, F.M.R. (1990). The influence of flooding regimes on forest distribution and composition in the Tana River floodplain, Kenya. *Journal of Applied Ecology*. 27:475-491.

[2] Additional work on the hydrological requirements of the Tana River floodplain forests is proposed for inclusion in the "Parallel Study" following recommendations made by the Public Workshop held at the end of phase 2 of this study.

the structure of their specialised habitat. Maintenance of these forest tree species is therefore equally important as the primates themselves.

In addition at least five plant species have so far been identified as rare and a further three species are classified as endangered.

Factors that reduce or degrade flood plain forest, coupled with the small size of the protected area, jeopardise the long-term preservation of these forests. Protection of the primates is dependent on maintenance of a high-quality habitat, a closed tree canopy greater than 10 m in height, and a variety of food resources. The Red colobus show greater relationships to, and dependency on, the structural characteristics of the forest with preference for a higher stature forest with a closed canopy (they do not come to the ground). These forests are dominated by *Ficus sycomorus*, *Pachystela msolo*, *Sorindeia madagascariensis*, *Diospyros mespiliformis*, *Garcinia livingstonei*, *Mimusops fruticosa* and *Acacia robusta*. High mangabey densities are also associated with a similar forest structure, suggesting that protection of forests satisfactory to the colobus will also promote conservation of mangabey populations. All the primates prefer interior forest patches and are highly susceptible to any disturbances that reduce forest area.

Table 19-1 Some Rare and Endangered Plant Species in the Riverine Forests

Rare[3]	**Endangered**	**Disjunct Distribution**
Acalypha echinis	*Coffea sessiliflora. sessiliflora*[4]	*Diospyros kabuyeana*
Alafia microstylis	*Cynometra lukei*	*Pachystela msolo*
Anisocycla blepharosepala. tanzaniensis	*Pavetta sphaerobotrys. tanaica*	*Populus ilicifolia*
Oxystigma msoo		
Uncaria africana africana		

Upstream from the reserve, there is a loss of important primate food resources and a general decline in forest structure. These changes may be explained by an increase in distance from the species-rich coastal flora, coupled with a more arid environment. Forests in this area have a lower species diversity and degraded structure relative to the forests within the reserve. Therefore, the loss of one forest area can not necessarily be compensated for by the conservation of another area.

[3] **Rare** - Found only in a few localities, not necessarily widely separated geographically; **Endangered** - Low population, which is under some threat which may make the population unviable; **Disjunct** - Populations widely separated geographically.

[4] An indigenous wild Coffee, found in these riverine forests, with potentially very large economic benefits through plant breeding (disease resistance etc.).

19.2.2 Loss of Forest Habitat

Environmental gradients and human activities greatly influence the distribution and ecology of the Tana riverine forests.

Major forest loss has resulted from clearance for agriculture. Between 1960 and 1985, it has been estimated that 56% of the forest areas were lost within the present reserve, largely as a result of forest clearance by farmers.[5] Regeneration and colonisation of potential forest areas are also limited by the cultivation of young flood plain sites which would otherwise be suitable for pioneer forest. The pastoral Orma burn plains vegetation to improve and extend grazing, resulting in grassland encroachment on forest margins.

Additional impacts on forest composition and structure result from the use of forest products, but do not necessarily result in a loss of forest cover. Extraction of plant resources for firewood and medicinal uses does not generally make a noticeable impact on forests, unless extraction is at an unsustainable level. Charcoal is not produced by the Pokomo in this area and most firewood is taken from surrounding scrub woodland. Medicinal plant uses require only a small amount of the plant and are infrequently collected. The most conspicuous extraction activities are harvesting of mature trees for canoes and beehives, pole removal for building purposes and palm frond cutting for mats and roofing.

The development of the Bura and Hola Irrigation Schemes through the settlement of large populations, many from outside the district, dramatically increased local population pressure both directly and through increasing pressure on traditional pastoral and farming activities. result was a marked increase in fuelwood/charcoal demand. Downstream forests in the Wema-Hewani region are now threatened by the development of the Tana Delta Irrigation Project (TDIP)[6], which is likely to result in the complete loss of major forest blocks in Polder 1.

19.2.3 Riverine Forest, River Discharge and Groundwater

The primary sources of energy in this ecosystem are waterflow, flooding frequency and duration (hydroperiod), and the accompanying sediment gains and losses. These forests rely more or less entirely on flooding and groundwater (itself recharged partly or entirely through flooding). Indeed, their presence being limited to the floodplain reflects this requirement. Rainfall over a region from near Hola to Garsen, covering much of the lower Tana forests, is recorded at an annual average of less than 550 mm annually (Figure 19-1). It is clear that rainfall alone is not sufficient to sustain these forests.

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[5] Figures for loss of forest cover can be misleading. Researchers use different names for the same forest patch, or use different criteria in determining what should be classified as a forest. The definition of forest cover is largely related to the scale of the analysis. An area defined as closed canopy forest at a reconnaissance level will contain a matrix of forest and non forest vegetation cover which can be identified in a detailed ground survey.

[6] It must also be noted that TDIP, whilst possibly providing employment for about 1,000 workers is displacing between 5,000 - 10,000 people who either lived on or otherwise depended on the land taken up by the Polders.

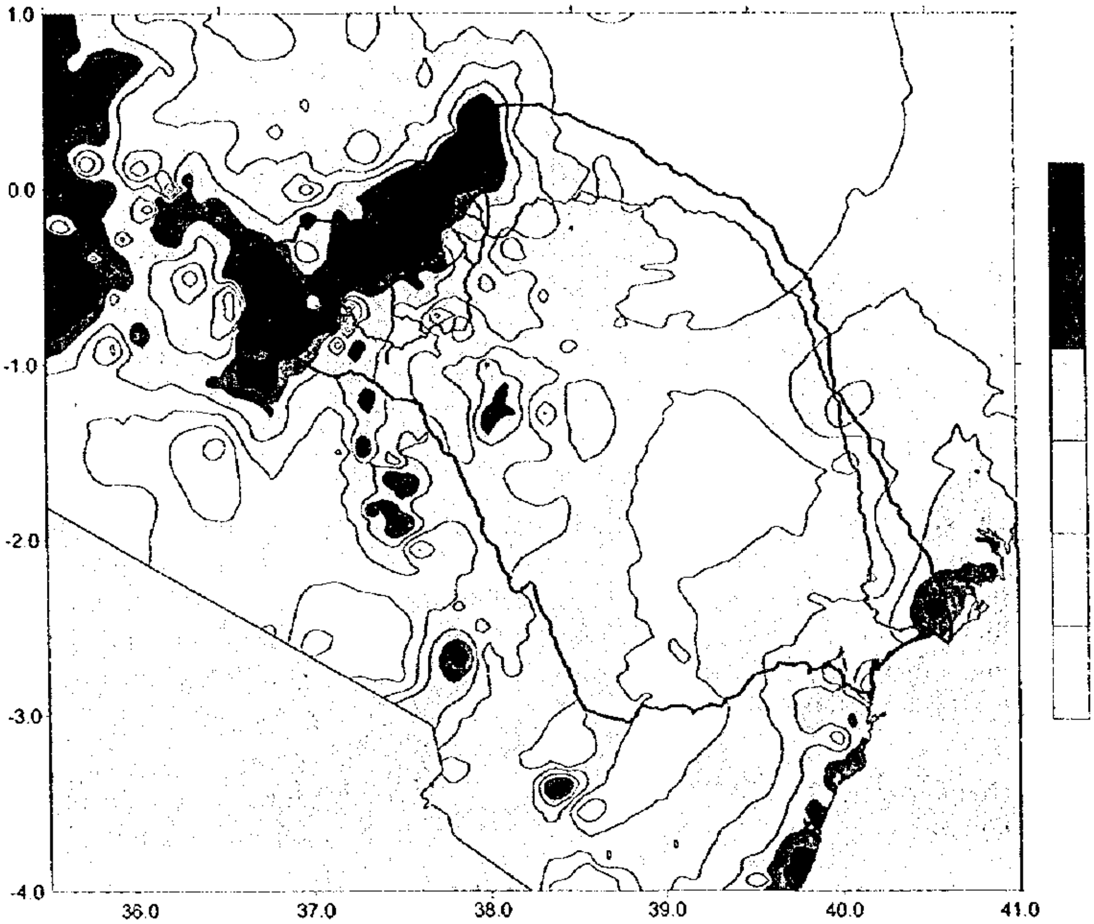
Annual high flows on the Tana occur principally during the months of April to early June and November to December (see Figure 4-6). The topography of the Tana flood plain is diverse, resulting from the processes of channel erosion and sediment deposition. It is characterised by meander scrolls, ridges and swells, created by abandoned point bar deposits as the river channel has migrated laterally; and by oxbow lakes, which are relict meander bends that have been cut off.

When floodwaters overflow the riverbank, there is a sudden reduction in water velocity, resulting in deposition of the suspended sediment load. The coarse grained material is deposited close to the riverbank, and will vertically accrue with successive floods to form levees. It is on these levees, which are made up of relatively coarse, well-drained deposits, that riverine forests develop. During infrequent very high floods, the coarse deposits allow rapid drainage when the water level drops. Away from the levee towards the flood plain interior finer sediments are deposited. The resulting soils tend to be poorly drained and may be subjected to long periods of inundation, forming backwater swamps. These may be very important for fisheries.

Under natural river flow conditions, flood intensity and frequency of inundation tend to be inversely proportional within the flood plain. There is a continuum from high intensity, low frequency floods that affect most of the flood plain, to the low intensity, high frequency floods that only affect the lower elevations within the flood plain. The vital importance of the larger floods (above "normal" flooding) is summarised below:

High intensity, low frequency floods	Determine patterns of large features persisting for hundreds of years, such as oxbow lakes and relict levees. The 1961 floods, with a flow rate >3,500 m^3/sec, formed Congolani oxbow lake. The 1969 floods (flow >2,000 m^3/sec) formed Baomo ox-bow lake. Within the last few years, relatively large floods have resulted in the draining and virtual abandonment of Baomo lake by the main river.
Medium intensity, medium frequency flows	Determine patterns of ecosystem structure such as zonation of species associations, which have lifespans of tens to hundreds of years. These floods are also of major importance to flood recession agriculture since much of the topography that this form of agriculture depends on is at least partly determined by these floods.
Low intensity, high frequency floods ("Normal Floods")	Determine short-term patterns such as seed germination and seedling survival.

Figure 19-1 Average annual rainfall (mm) over Tana River basin and adjacent areas[7] with average monthly data from Lower Tana stations



ID	NAME	ANNUAL	J	F	M	A	M	J	J	A	S	O	N	D
9039000	GARISSA	319.5	10.9	5.5	34.7	68.2	17.1	5.1	2.4	6.4	6.6	25.0	77.8	59.8
9139000	BURA	1476.4	12.8	9.5	46.1	819.9	303.2	11.4	10.9	10.1	81.9	25.3	84.6	60.7
9140005	GALOLE	423.1	16.1	15.3	35.5	64.3	40.2	25.1	18.6	17.1	30.2	31.2	79.7	49.8
9140006	TANA EXPERIMENTAL STATION	422.8	14.3	15.1	28.7	59.4	60.3	34.7	17.9	18.7	18.4	35.7	62.2	57.4
9140007	MASALANI	550.0	14.9	51.5	44.2	67.8	70.1	25.7	25.1	22.7	15.4	39.9	100.4	72.3
9140009	HANDAMPIA	323.9	30.2	20.9	23.8	38.3	59.7	.0	15.0	29.3	11.9	36.8	58.0	.0
9140012	TANA RIVER FOREST STATION	406.6	17.3	11.4	34.8	40.9	78.9	31.6	12.3	13.3	17.0	22.7	53.1	73.3
9240000	KIPINI	1120.7	29.2	8.9	53.9	159.1	343.2	155.6	77.6	40.7	49.4	52.1	67.9	83.1
9240010	GARSEN.	547.4	13.4	7.6	41.8	82.9	92.3	43.0	38.5	31.6	21.0	43.2	76.6	55.5
9240016	REUBEN MWEWE	302.6	4.4	46.9	54.5	50.4	.0	92.8	.0	.0	53.6	.0	.0	.0
9240026	SERA CHIEF'S OFFICE	523.8	1.4	.0	86.5	41.3	128.7	29.7	7.6	21.5	45.6	70.2	49.4	41.9

[7] This rainfall map was produced from a database of 1,203 point data sources (rainfall recording stations) representing average annual rainfall from available rainfall stations in Kenya, using Kriging techniques to generate the rainfall isohyets.

Plant species composition within the flood plain tends to follow a gradient of flooding frequency and duration, which is a reflection of the species response to flooding and factors associated with soil aeration. Seedlings of many flood-adapted plant species show sub-optimal growth rates either under extremely saturated conditions, or under the low water potential conditions which result in water stress.

Table 19-2 Forest Dependence on River Flow

Forest Dependence	Hydrological Requirements
Germination	Low Intensity, High Frequency Floods - providing adequate soil moisture; medium floods will tend to drown emerging seedlings; high floods will remove topsoil profile.
Seedling Establishment	High Groundwater during the dry season - but still not preceded by an excessive flood for germination.
Primary Productivity	Sediment Deposition - high biomass production as a result of seasonal deposition of nutrient rich sediments.
Creation of New Riverine Environments	High Intensity, Low Frequency Floods - or medium intensity medium frequency - lead to the creation of new oxbows and new river channels with associated point bar structures.

Under the arid conditions of the Tana floodplain, available information suggests that germination of riverine forest species is dependent on the low intensity, high frequency floods, while establishment of saplings is dependent on soilwater availability during the dry season (when water stress due to low river discharge is likely to be most severe).

Although no study has specifically focused on the primary production of the Tana riverine forests, similar ecosystems tend to have very high rates of primary production and normally support a high amount of biomass. This is in part due to the seasonal deposition of nutrient-rich sediments derived from upstream. Even where the upland soils are relatively poor in nutrients, the periodic input and concentration in a relatively small flood plain significantly augments the nutrient capital of the riverine ecosystem.

On an entire ecosystem basis, the functioning of the lower Tana riverine forests is highly dependent on an input of allochthonous materials (water, nutrients, sediments). Information from similar ecosystems indicates that impacts that affect any of these inputs rapidly affects the whole ecosystem, because they reduce primary production. Rapid ecosystem deterioration follows. This will be irreversible until natural water flows and geomorphology are reconstituted.

19.2.4 Recent Vegetation Changes

The last flooding of forest areas in the TRNPR, prior to the second rains of 1994, took place in 1990. Prior to this there had been no effective flooding for eight flood periods. This series of low flood or no-flood seasons can be taken as representative, although probably less severe than the long term impact of upstream dam construction.

It is recognised that herb and shrub species respond more quickly to changes in the environment than do canopy trees. If herb and shrub species associated with particular canopy species are known, then it should be possible to determine successional trends on the basis of short-time data. For the present study, vegetation data was collected from 55 permanent sampling plots that were established in 1989 along 4 transects within forest patches of the TRPNR. This data has been analysed in conjunction with earlier data sets from the same sampling plots.[8]

One particular site, the Baomo transect, is of special interest. This set of sample plots runs from an oxbow lake which has not received river water since a flood event in January 1990. This oxbow has gradually lost water over the last four years; it's water-level was estimated to be 0.75 m. lower than that of the river during November 1994. Floristic changes in the riverine forest bordering this oxbow lake over the last four years can be attributed to a reduction in water availability and lack of sediment deposition.

Methodology

Vegetation data collected from a single permanent sampling plot over several time intervals can be treated as separate plot-time observations, which can then be ordinated. A succession pattern can be discerned by examining the resulting time trajectory for that sampling plot, which is traced through the floristic space defined by the ordination. All plant species occurring within the sampling plots (trees, shrubs, herbs, herbaceous vines and woody vines) were identified, providing presence/absence data. For each species occurring within each sampling plot, data on cover/abundance using the modified Braun-Blanquet method was also collected during November 1994. Similar data was collected over the periods February-March 1989, September-October 1989, and July 1990.

Ordination of vegetation data from the 55 permanent sampling plots, collected over four time intervals between February-March 1989 and November 1994, was by Detrended Correspondence Analysis DCA, a multivariate indirect gradient analysis technique that searches for major gradients in the species data irrespective of any environmental variables. Sampling plots are arranged within a reduced co-ordinate system based on their similarities (or dissimilarities) in species composition. The sampling plots ordination co-ordinates are averages of the species ordination co-

[8] Full details of the survey are given in a separate report available from the JICA Study Team, jointly produced by Kamau Wakanene, Center for Biodiversity Studies - National Museums of Kenya and Alexander Njue, Department of Botany - Kenyatta University.

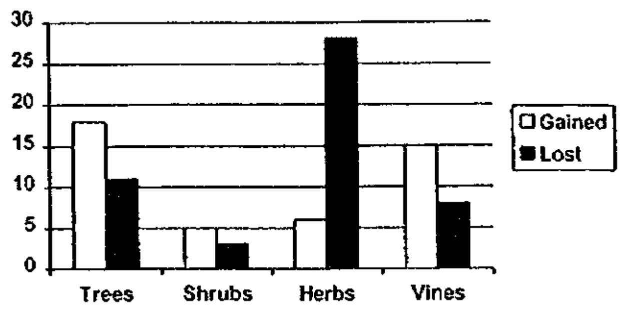
ordinates. This procedure was carried out using all plant species occurring within the 55 sampling plots, and repeated using herb species only.

Results and Conclusions

For most sampling plots, relatively little movement through the floristic space defined by the ordination axes is apparent over the period February-March 1989 to November 1994. This indicates little floristic change (succession) has taken place in these sampling plots over this time interval, when one takes into consideration all plant species (trees, shrubs, herbs, herbaceous vines, woody vines) occurring in these plots. However, a pattern of movement can be seen in plots 8, 9, and 10 (outer plots along the Guru North transect, bordering open grassland; and also in plots 51 through 55 (outer plots along the Baomo Transect, which starts at an oxbow lake).

When the above procedure is repeated using herb species only the movement in plots 51 to 55 is much more pronounced than in plots 8, 9, and 10. It has already been noted that herb species respond more quickly to changes in the environment than do canopy trees. The longer trajectories for plots 51 to 55 indicates a greater change in floristic composition. From the original vegetation data, it becomes apparent that this forest (Baomo) contained fewer herb and shrub species in November 1994. This is in contrast to conditions in 1990, when ordination of species data from the same sampling plots indicated as successional a trend leading to a more closed canopy forests.

Figure 19-2 Summary of Recent Vegetation Changes in Baomo Forest Transects resulting from Dry Conditions: 1090 - 1994



For further details and a listing of the individual species, see Progress Report 1, produced at the end of Phase 2 of the feasibility study (Nippon Koei 1995).

From analysis of the vegetation data, it is appears that the Baomo forest is experiencing general senescence. This effect is more pronounced the further one moves away from the source of groundwater (Baomo oxbow lake). It is postulated that this is a result of a gradual reduction in soil water availability. It was estimated that in November 1994, this oxbow lake contained less than half the amount of water it contained in January 1990.

It is surprising to note the relatively short period of time it has taken (4 years) for this forest vegetation to go into senescence. Indications are that the successional trend for Baomo forest is towards the drier (Savannah) type of vegetation typical of the surrounding areas.

It is known that the depth of the water table increases as one moves away from the active river channel. The above results indicate that a sustained reduction in river discharge would lead to a general senescence of all Tana riverine forests. The effect would first become apparent at the outer edges.

19.3 MANGROVES

19.3.1 Species Composition

Mangrove ecosystems (both vegetation and fauna) occur within the intertidal zone between the mean neap tide and exceptional spring tide levels. Most mangrove tree species tolerate and are adapted to saline and to tidal flooding conditions.

Most mangrove species do not tolerate permanent flooding of the root systems, either by seawater or freshwater. Although highly adapted to tidal flooding and waterlogged conditions, periods of flooding of more than 48 hours will usually kill the trees. True mangroves therefore occur at the seaward fringes of shores or in estuarine conditions, where the floodwaters of the rivers are freely drained. Where water, either saline, or sweet, stays for a period of a few days to months (seasonal flooding), swamps, either marshy grasslands (brackish conditions) or riverine (backswamp) forest develop.

Mangrove forest usually develops in relatively calm water, protected from direct ocean waves or scouring effects of rivers. The rate of sedimentation in mangroves must be in balance with the growth of the roots system of the tree species. If the rate of sedimentation is very high, the root systems may be covered and the forest will die back. Similarly if the rate of erosion is high (e.g. in the creeks) the seedlings will not be able to establish themselves and mature trees may be undermined.

Mangrove vegetation consists mainly of a number of tree halophytes. Other vegetation in the form of lichens, palms and ferns may also occur. Closely associated are a number of salt marsh grasses and salt tolerant shrubs. In Kenya eight mangrove tree species occur: *Sonneratia alba, Avicennia marina, Rhizophora mucronata, Ceriops tagal, Bruguiera gymnorrhiza, Xylocarpus granatum, Lumnitzera racemosa* and *Heritiera litoralis*.

Mangrove tree species have adapted to salinity through a variety of mechanisms. Some species (*Avicennia sp., Sonneratia sp.*) excrete salt (saltglands), others have developed xeromorphic characteristics. The problem of flooding and unconsolidated, anaerobic soils have been solved by the development of aerial root systems, which protrude above the topsoil. Different species have developed different root systems (some in the form of 'pencils', others in the form of 'knees', etc., some roots may even show secondary (elongated) growth). The root systems of colonising tree species provide them with the stability needed to stay upright in spite of the strength of the waves or river flows. (typically *Sonneratia sp. and Avicennia sp.).*

Though these adaptations to the adverse environment make mangrove tree species highly suitable for growth in the intertidal zone, they are quickly outcompeted by other species when the anaerobic conditions of the soil due to frequent flooding cease to exist or when the water and soil salinity approaches lower levels. Terrestrial plants often associated with high salinity are for example *Sueda monoica*, frequently found at the inland side of the salt flats, or grasses such as *Sporobulus spicatus*. Here aerobic conditions predominate, although the salt content of the soil is still high. In areas which are permanently flooded (sweet water swamps or marshes), mangrove species are outcompeted because if the roots are completely covered by water for a period longer than approximately 48 hours, the plants asphyxiate.

19.3.2 Tana Delta Mangrove Habitats

In the Tana River Delta three different areas occur where the above conditions are fulfilled: at the present outlet of the river at Kipini; and the former outlets at Mto Tana and at Mto Kilifi (see Figure 7-4).

Kipini

The present outlet of the Tana at Kipini is characterised by an estuarine mangrove vegetation caused by the interaction of the permanent river flow, flooding of the river causing pointbars, levee and backswamp system, and the tidal movements with the intruding salt water influence. This outlet became the main outlet of the river in the 1860's when the Belazoni channel was dug connecting the former Ozi creek with the Tana River. Evidence of former more saline conditions can still be found in the remnant vegetation further inland on both sides of the present river and the existence of the highly saline bare areas bordering a zone towards Witu-Kipini road.

The Kipini outlet contains a mangrove vegetation and associated swamp vegetation which is unique in Kenya in its floristic composition and structure. Due to the geomorphological setting of this outlet a mangrove forest has developed on the levees which is intermixing with a sweet water backswamp forest. At the same time it is the only area in Kenya where the appropriate conditions for the growth of *Heritiera litoralis* occurs over a large area.

Table 19-3 Inundation Zones and Mangrove Species

Tidal Zone	Flooding period	Species	Height Above Sea Level (m)
Land flooded at all high tides	Flooded 1-2 times daily, 20 days minimum per month	Sonneratia alba Avicennia marina	1.7 - 2.0
Flooded by medium high tides	Flooded 10-19 days per month	Rhizophora sp.	2.0 - 2.2
Flooded by normal high tides	Flooded 9 days per month	Bruguiera sp. Ceriops tagal	2.2 - 2.7 2.5 - 3.0
	Flooded 9 days per month (Landward fringe)	Xylocarpus granatum Avicennia marina	2.2 - 3.0 2.7 - 3.2
Flooded by spring tides only	Flooded only a few days per month	Lumnitzera racemosa	3.7 - 4.5
	Fresh to brackish water; salinity 0 -1%	Heritiera littoralis	>4.5

The mangrove forest is well developed, with mature trees. (generally reaching a height of 20 m. or larger). Until recently it was almost undisturbed as *Rhizophora mucronata* and *Ceriops tagal* which are the preferred species for poles (the main use of the mangroves in Kenya) are not present in this area. Large *Xylocarpus granatum* and *Bruguiera gymnorrhiza* which are extensively cut elsewhere for industrial firewood purposes, are rarely harvested here because of the distance to markets. Only the *fito's* and smaller size trees are harvested for house construction. As a result, this area is the only relatively undisturbed area for these species.

Mto Tana

This outlet is well protected from direct wave action by a dune formation. The mangrove area is characterised by the dominant influence of the tides. No significant formation of levees and backswamps is noticeable and the tidal movement is slowly forming creeks further inland, intruding into the salt grass marshes; trees are colonising the newly formed creek sides.

The creek banks are eroded by the intruding tidal movements, after which *Avicennia marina* colonises these sides, often enclosing extensive flood plain marsh grasslands. These grasslands are not easily invaded by the mangrove tree species and are maintained by river floods which leaches excessive salts and maintains high ground levels through sedimentation. Just behind the coastal dune, a more continuous mangrove forest has developed. The species composition of this forest differs considerably from that of the forest at Kipini. Here the *Rhizophora mucronata*, *Ceriops tagal* and *Avicennia marina* are dominant.

This area is also unique in Kenya, in that the mangroves are unconfined on the inland side, resulting in the undisturbed interaction of the mangrove area with the flood plain and extensive marshlands (either of sweet and salt water character).

Mto Kilifi

The mangroves at Mto Kilifi are set in yet another geomorphological environment. Here dune ridges alternating with the lower tidal influence swamps occur more or less parallel to the sea shore dunes. As in the Kipini area and the Mto Tana area the mangrove ecosystem is protected from the ocean by a dune system. The main difference is that here, particularly towards Ras Ngomeni the extent of the mangrove vegetation is limited by the inland plateau; the only free association between the mangrove ecosystem and the delta is limited to the northern part of this area. As a result of this two separate mangrove formations occur, one in the north which still belongs to the actual delta and one near Ras Ngomeni which is dependent on the Tana river sediments for its protection (dune formation).

The vegetation in this area is characterised by a larger variety of species, due to the sweet water influence of the sandy beach ridges and the former river influence, which has undergone significant changes after the Kipini site became the main outlet of the river. This is shown by the presence of old *Avicennia sp.* trees which are taller then expected, given the present salinity levels.

At present the vegetation is again changing due to the influence of commercial salt production, where part of the mangrove vegetation has been removed for the construction of salt pans, others have been constructed in the salt flat areas directly behind the active mangrove vegetation. Increasing salinity has led to the die-back of a large number of mature trees near to some of the ponds. The former vegetation characterised by the abundance of *Bruguiera gymnorrhiza* and *Xylocarpus granatum*, with the more salt tolerant and commoner species such as *Ceriops tagal*.

19.3.3 Associated Fauna

The fauna associated with mangrove habitats in the Tana river delta is also unique in Kenya, and possibly to the East African region. It can be divided into three categories, the larger wildlife, birds and fish.

Larger Wildlife

The mangrove and riverine vegetation in the Tana river near Kipini are associated with a population of large crocodiles and a number of hippopotamus. Buffalo are present in an area south of the river behind the frequently flooded mangroves. Although crocodile, hippopotamus and the buffalo are not dependent on the mangrove habitat as such, the association of the mangrove forest with these species is unique for Kenya, and therefore the area contributes to ecosystem diversity. Other large wildlife associated with the southern flood plain are the Topi and Waterbuck, who migrate into the flood plain in the non-flood season.

Turtles are known to lays their eggs on the beaches in front of the mangroves of the Mto Tana outlet. Changes in the sediment load of the river may trigger changes in the coastal configuration, including the possible erosion of such habitats.

Birds

Arguably the birds are the most important wildlife component in the delta. Part of the delta is proposed for protection under the Ramsar convention and part of the southern flood plain is a proposed nature reserve.

The water birds of the delta were recorded to provide inventory data for the proposed Tana River Delta National Reserve. The aim of the inventory was to provide a basic understanding of the Tana Delta wetland ecosystem. The water birds were used as indicators of the health of wetlands.

A total of 40 water bird species were observed in the mangroves during the dry season (June to November, 1992) and 23 during the wet season (December to February, 1993). The mud flats between the mangroves edges and the creeks or river were the critical foraging habitats for waders. The creeks were also a feeding ground for the Pink-backed Pelicans, Long-tailed Cormorants and the African Darter. A total of 275 bird species (including terrestrial birds) were recorded in the entire study area. Out of these, 79 species were observed in the mangroves.

The mangroves also provide roosting sites for other waterbirds which include the African Darter, Woolly-necked Storks, White-faced Whistling Ducks, Herons, Storks and Ibises. The other species not directly associated with water but observed in the Mangroves include large flocks of Carmine Bee-eaters, Madagascar Bee-eaters, Golden Palm Weavers, White-throated Bee-eaters and Black-breasted Glossy Starlings. The mangrove edges along the Shekiko creeks were also lined with colonial nests of the Golden Palm Weavers. An African Fish Eagle was also observed incubating a nest in the mangroves. Ospreys were observed perching and hovering over the mangroves

The overall picture indicated by this study imply that all wetland habitats types in the Tana Delta including the mangroves are important and play a complementary role in supporting the delta's biological diversity.

Fisheries

In the Tana delta a distinction can be made between the area influenced by sweet water inundation (flood plain) and brackish and salt water inundation (mangroves). Both are important for fisheries due to their role as nursery grounds.

Mangroves support important coastal and nearshore fisheries and good correlation has been found between prawn and fish yields and the area of mangroves adjacent to the fishing ground. Studies in other mangrove areas (Gazi Bay and Tudor creek) have indicated the following:

- Mangroves provide the major nursery grounds for the young fish that support the artisanal fishery in Kenya;
- And for the lesser species which do not feature in the fisheries but are of great importance in the food webs in the shallow nearshore waters;,
- Mangroves provide the spawning grounds for some resident and shore line species.

Studies elsewhere have shown that fish and prawns generally occur in greater numbers and biomass than in other nearshore habitats. The abundance of a variety of food and the turbid waters appear to be main contributing factors.

The main fish groups found in mangrove creeks include the following species of major commercial importance: scavengers (*Lethrinidae*), rabbitfishes (*Scaridae*), snappers (*Lutjanidae*), kingfishes (*Carangidae*), goatfishes (*Mullidae*) and barracuda (*Spyraenidae*), Surgeon and Unicorn fishes (*Acanthuridae*), and grunts (*Heamulidae*). In addition six species of prawn have been found in the mangrove creeks, including the commercially important species such as *Paneaus monodon*.

Pond Cultures

Within the Tana delta some mangrove area has been converted to pond cultures either for salt or shrimp production. Fishermen's Choice prawn farm is located at the Tana River/Kilifi Districts boundary (near Mto Kilifi). The project has a series of ponds into which water is pumped from the creeks for rearing prawns. The larvae are collected from the nearby mangrove creeks and introduced into the ponds. Harvesting of prawns for marketing is done after 2 months. Additional plans exist to convert more areas to pond culture.

19.3.4 Primary Functions of the Mangrove Ecosystems

Important functions of the mangrove systems include:

- Coastal protection and protection of other ecosystems;
- Production and maintenance of primary resources such as trees, benthic organisms, etc. which in turn are the source of wood, litter, medicine, tannins;
- Production and maintenance for secondary and tertiary resources, such as the fisheries resources, honey, larger mammals and birds, through production of food and provision of habitats;
- Maintenance of biodiversity;
- Production of oxygen, sink for carbon.

Coastal Protection

This function of the mangrove resource is frequently overlooked. Mangroves have a very important function in stabilising the shoreline, through trapping sediment, acting as wind breaks, and through absorption of nutrients. Mangrove systems can only occur in balanced situations. If the rate of sedimentation or erosion is too high the mangrove system will suffer or disappear. This dynamic equilibrium is easily disturbed and major impacts, be it naturally or human induced can have major impacts on the distribution and survival of the mangrove ecosystem.

The mangrove ecosystem and coral reef ecosystem are closely interlinked, the mangroves trap sediment and nutrients, originating from the hinterland or in suspension in the sea water, which if they spread towards the coral reefs would destroy them. (living coral reef thrives best in nutrient poor and clear water). The coral reefs in turn protect the mangrove ecosystem from strong wave impact.

Production and Maintenance of Primary Resources

The mangrove ecosystem provides for the growth of primary resources such as plants which in turn produce products which can be used such as wood for poles and timber, medicine, floats for fishnets, and tannins. It also produces litter which is an important input for the reworking by the animals dependent on the mangrove systems, and forms an important aspect of the food web.

Production and Maintenance of Secondary and Tertiary Resources

The mangrove ecosystem traps sediment and nutrient from flood and tidal water and produces litter. This is reworked by crustacea, benthic organisms and becomes largely available for consumption as detritus. A large number of organisms feed on the detritus after which fish, prawns, crustacea and other secondary animals will consume directly or indirectly part of the mangrove resources. Only an intact healthy mangrove ecosystem is able to support the animal population.

Maintenance of Biodiversity

Biodiversity of the mangrove ecosystems is maintained through the production of primary, secondary and higher organisms and its interrelationships with other ecosystems. The link with the coral reef systems and the protection of inland resources as well as the provision of gradients and habitats give the mangroves resources a particular value.

Production of Oxygen, Sink for Carbon

As with all other forests the mangrove forest produce oxygen. Mangrove forests functioning in the same way as other forests, sequester carbon, contributing to the halt of air pollution and global warming.

19.3.5 Secondary Functions of the Mangrove Ecosystems

Direct Source of Employment - Forestry and Tourism

Since the mangrove produce wood for timber, poles and a variety of other products as well as honey and medicine, mangroves are usually (heavily) exploited. The exploitation of mangrove in Kenya is both for local and commercial purposes. This creates a large number of jobs, at the site of harvest, in the transport sector and in the administrative sector.

The mangrove resource can be a direct source of employment for the tourism sector. Tourists can be led by boat through the mangroves creeks to observe wildlife and birds. It would also possible to develop paths through the mangroves.

Indirect Source of Employment - Fisheries and Tourism

Fishing can occur within the creeks of the mangroves, usually it occurs in adjacent areas. As mentioned before a large part of the commercial fish and prawns as well as oysters and crabs depend directly or indirectly on the mangrove ecosystem. The result is that the fishing industry, artisanal or semi-industrial is also dependent on the mangrove resource.

Tourism is at times indirectly dependent on the mangrove resource. In Mida creek boat trips are organised, visiting the creek. The existence of the creek with its exceptional fish and bird resource is in itself dependent on the functioning of the mangroves. Tourism in coral reef areas is also indirectly dependent on the mangrove ecosystem.

19.3.6 Use of Mangrove Resources

Many of the local and commercial uses of the mangroves have already been mentioned in previous sections. Table 7-8 gives the main uses of the direct products of the mangroves.

Largely as a result of distance from the main urban centres, commercial exploitation has so far been limited in the Tana river delta.

Wood and Wood Resources

Mangrove forests are highly endangered everywhere in the world and Kenya is no exception. All tree species contain valuable heartwood and therefore all species are good for some use. This in contrast to most terrestrial indigenous forests where usually only a small percentage of species are commercially valuable. The main products are poles and fuelwood. Wood products are harvested for house construction, e.g. of *Xylocarpus granatum, Bruguiera gymnorrhiza* and for boat masts, *Heritiera littoralis.*

Table 19-4 Traditional Uses of Mangrove Products

Species	Products	Uses
Avicennia marina	Wood	Timber and firewood
	Roots	Relieving minor fish stings
Bruguiera gymnorrhiza	Fruits	Medicine for sore eyes
	Wood	Poles, timber and firewood
Ceriops tagal	Bark dye	Preserving fish nets and mat making
	Bark infusion	Treatment of heamorhagic conditions
	Wood	Poles, timber and firewood
Heritiera littoralis	Wood	Poles, timber, firewood and boat building
Lumnitzera racemosa	Wood	Firewood and fencing
Rhizophora mucronata	Bark dye	Mat making
	Wood	Poles, timber and firewood
	Bark of prop	Mosquito repellent
Sonneratia alba	Wood	Firewood and timber
	Bowed wood	Ribs for boats
	Pneumathophore	Fishing floats
Xylocarpus granatum	Wood	Poles, timber, firewood and carving
	Bark	Cure diarrhoea, seed ointment, insect bites

Fish, Crustacea and Prawns

It has been estimated that the Ungwana Bay shallow waters contain an approx. 25 tons/km^2 of marine products, mainly fish and prawns, although not all species are necessarily dependent on the mangrove resource. The commercial catch from Mto Kilifi and Ngomeni is supposed to be registered at Malindi, although as much is landed directly at Mombasa. There is no clear indication of the amount derived from the delta system.

The most directly quantifiable fisheries associated with the mangroves is the prawn farming operations. Production levels have reached 200 kg/ha and can produce harvests every two months.. The main constraint is the seed for stocking the ponds which has to come from the wild.

Salt Pans.

The salt production from Ngomeni to Kurarwa is associated with the delta and its direct surroundings, due to the fact that the ponds are build partly in and partly behind the mangrove forest. The present area occupied by the salt farms is 7.9 ha, only part of which is used for salt production. The total volume of raw salt produced is an estimated 70,000 tons/year.

The salt industry is indirectly dependent on the stabilising influence of the mangrove forest in the minimising of wind blown sediments.

Wildlife and Tourism

This mangrove zone is included in the area proposed as a wetlands reserve. The area contains a rich birdlife and unique vegetation types and gradients. Large wildlife uses the resources in the non flood periods. The sand barriers in front of this mangrove outlet are known to contain a large number of turtles who lay their eggs in this part of the beaches.

Tourism is not developed at present. It could be developed if the security situation were improved.

19.4 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 will be described briefly below, although the level of ecological detail available for each site varies considerably, as does the likelihood of significant impact from proposed dam development.

19.4.1 Meru National Park

Meru NP is the first protected area which the Tana River flows past below the proposed Grand Falls dam site. Protected status for the area now occupied by Meru National Park was first established in 1966 when the area was declared the Meru County Council Game Reserve. The present day Meru National Park was formally gazetted one year later in 1967, and covers an area of 870 km^2 lying between 0°20'S - 0°10'S and 38°E - 38°25'E, approximately 370 km NE of Nairobi in Meru District.

Meru NP forms an almost triangular shape. From its broadest NW boundary, the Park gradually tapers to its narrowest point. To the south, the Park boundaries are formed by first the Ura and then the Tana River; to the NE, the boundary is formed by the Rojewero River. An altitudinal gradient runs across the park, dropping from the 800m contour of the foothills of the Nyambeni Range, whose peaks lie 15 km to the NW, to around 300m in the SE corner of the park. A total of 15 permanent streams drain the foothills of the Nyambeni Range in the western section of the NP. These converge into the Rojewero, Kioulu or Ura rivers which flow south-east across the park, or along its boundaries, before finally draining into the main Tana river. All three of these rivers may cease to flow along some of their length during the long dry season from April-October.

The vegetation of Meru NP was described by Ament (1975). All of the rivers within Meru NP have fringing riverine vegetation, consisting mostly of doum palm (*Hyphaene compressa*), Raffia palm (*Raphia farinifera*), and *Acacia elatior*. This evergreen vegetation contrasts strongly with the surrounding deciduous dry thorn bush and woodland of the surrounding plains, dominated by *Combretum* spp. and *Commiphora* spp..

The river water and fringing evergreen vegetation provide an important resource for the animals of the Park. Few animals are known to be entirely dependent upon the riverine habitat for their survival, but several show limited distributions around these areas, notably the East Africa red squirrel, Pel's fishing owl, the African finfoot, brown-banded woodpecker, smaller black-bellied sunbird, violet wood hoopoe and scaly babbler. The overall contribution of the streams/rivers running from the Nyambeni Hills within the NP to the survival of animals in the dry season is greater than that of the main Tana River channel; any change to the riverine vegetation of the Tana river channel alone would have a minimal impact on the ecology of the park area.

Adjacent to Meru NP, to the east of the Rojewero River, lies the Bisanadi National Reserve, an area of 1,956 km^2 extending eastwards to the Bisanadi River. Bisanadi NR was gazetted in order to improve the protection provided to the Meru elephant and buffalo populations which disperse into these areas during the wet season.

The Tana itself forms only 15.5 km of the southern Park boundary. At this point the river runs mostly over solid basement rock (e.g. at Adamson's Falls) and little or no flooding occurs along this length. The thin fringe of riverine vegetation is more dependent upon persistent groundwater seepage than flooding for watertable replenishment and is unlikely to change much as the result of the proposed dam project.

Although additional dams on the Tana upstream of Meru NP will alter the flow characteristics of the Tana river past the park, it is unlikely that this will have any significant impact upon the rest of the Park. The majority of the water resources of the park derive from the Nyambeni catchment area; these tributaries of the Tana will be unaffected by further dam development on the Tana. The forest of the Nyambeni Hills is already being extensively degraded by illegal timber extraction and encroachment for subsistence agriculture. This will lead to increased total water runoff into the Meru river system, but the distribution of runoff will be altered. Dry season flows will be reduced, whilst wet season flows will be larger, increasing the size of peak floods, and increasing soil erosion and sediment flow into the Tana.

19.4.2 Bisanadi National Reserve

Bisanadi NR covers an area of 1,956 km^2 immediately adjacent to Meru NP between the Rojewero and Bisanadi Rivers. The Reserve was established to provide additional protection to the wet season dispersal areas of animals, notably elephant and buffalo, from Meru NP. Bisanadi NR has been loosely managed by the Meru NP HQ and has never been fully described in terms of vegetation and ecology. There is little reason to expect that the comments made for Meru NP above would not apply to Bisanadi NR.

19.4.3 Kora National Park

The area know known as Kora NP was initially established as a conservation area by George Adamson, who paid a private rent to the local Council to use the land for rehabilitation of captive-reared lion, and later leopards. In November 1974, after a period of extensive poaching of rhino and elephant, an area of 1,570 km^2 was formally gazetted as Kora National Reserve in order to increase the level of protection which could be provided by the Wildlife Conservation and Management Department (WCMD). In 1976 a further strip of land north of the Tana River was added to the Reserve, bringing the total area to the present day 1,700 km^2. In 1983, an ecological inventory of the Kora NP was completed by a combined team Kenyan and overseas scientists (Coe and Collins 1986). Much of the detail below is derived from this report. In February 1989, management of Kora passed to the newly formed Kenya wildlife Service (KWS) as the are was upgrade to National Park status.

The northern boundary of the main body of the NP is formed by 65 km of the Tana River. The western boundary of Kora is adjacent to the North Kitui NR, whilst the eastern boundary is formed by the seasonal, meandering Mitamisyi River.

The land slopes gently (0.5 - 0.7 m/km) from a maximum altitude of around 560m in the SW at Kaithango Hill, to about 210m in the NE corner of the park. A number of seasonal "sand rivers", notably the Munone, Mthonai, Mburu and Chanyigi, flow in a generally northwards direction across the Park. The seasonal Mitamisyi River flows around the main basement land mass of the park to join the Tana at Hameye Swamp.

The seasonal laghas of Kora NP, and indeed the entire catchment area between Grand Falls and Garissa (downstream from Kora) make little contribution to the Tana river flows. Average monthly flow decreases considerably between Grand Falls and Garissa (from 247 cumecs to 177 cumecs; 1985 figures). The maximum discharge ever recorded at Grand Falls is 6,218 cumecs, on 17th April 1964, whilst the maximum at Garissa is only 3,562 cumecs, on 21st November 1961. Similarly, the lowest flows recorded for Grand Falls and Garissa are 15.0 cumecs and 7.7 cumecs respectively.

The loss of volume from the Tana between these two points is due to evaporation and seepage, mostly from the extensive Hameye Swamp on the eastern margin of the Park.

Sediment flows at Garissa range from a maximum of 6,000 ppm, equivalent to 150,000 tonnes per day, to a minimum of 400 ppm during low flow periods. Additional dams will undoubtedly trap more sediment in their reservoirs, reducing the sediment load of the river immediately downstream. The Tana River will become more erosive in this region; although this will have little immediate effect on those sections of the Kora riverfront which comprise basement rock, it will increase removal of material from the alluvial sediments at the west and east extremes of the Park. These areas of grassland are an important grazing resource for wild plains game and for pastoralist livestock. The Hameye swamp also plays an important role in absorbing the excess water and energy of extreme flood events. Erosion of a direct channel through this region will significantly change the flow characteristics of the Tana River downstream.

The smaller V-shaped laghas show little variation from the surrounding plains vegetation except for a slight increase in density of *Acacia tortilis* and *Terminalia spinosa*.

The seasonal laghas are broad, shallow, sandy washes, filled with coarse material derived from the surrounding regolith mantles of the plains. Some laghas show brown silty/sandy terraces about 1.5m above the present channel and rock and organic debris from previous flows may be deposited up to 2m above the beds. Flow in the laghas is, however, rather erratic and some may not flow more than once a decade.

The sandy beds of the larger seasonal laghas are kept free of vegetation by the erosive effect of the water flows when they occur, but along the sides and on raised islands, *Hyphaene compressa* palms and *Acacia elatior* may be found The surrounding banks tend to be dominated by a mixture of *Acacia-Commiphora* bush, interspersed with *Terminalia spinosa*, *Boswellia neglecta*, *Salvadora persica*, *Euphorbia cuneata*, *Boscia coriacea*, *Cadaba glandulosa* and *Asepalum eriantherum*.

The south bank of the main river channel has only narrow deposits of alluvial material along most of its length with the Park. In some areas the basement rock extends right up to the river-edge, forming cliffs of varying height.

The riverine vegetation of Kora is confined to a narrow strip along the Tana River and does not compare in extent with the broader riverine forest found on the alluvial floodplain which starts to the east of the park. Most of the river within the Reserve supports only a single broken line of trees along the bank, even when the alluvial deposits are up to 100m wide, indicating watertable near the surface does not extent far beyond the immediate river boundaries in this section of the river.

River bank vegetation is dominated by doum palms (*Hyphaene compressa*), *Acacia elatior* sp. *elatior*, and *Acacia tortilis* spa *spirocarpa*. These are accompanied by the shrubs *Premna velutina*, *Flueggea virosa*, *Cordia sinensis*, *Lawsonia inermis* and

Salvadora persica. The herb layer is in general sparse and dominated by the sedges, *Cyperus articulatus* and *C. undulatus*, the composites *Blainvillea gayana* and *Acanthospermum hispidum*, and the grasses *Echinochloa haploclada* and *Brachiaria deflexa*. Amongst the other trees found less frequently are *Populus ilicifolia*, *Tamarindus indica* and *Ficus* spp..

The confluences with the seasonal watercourses are characterised by narrow fringes of doum palm, sometimes accompanied by the low shrub, *Maerua subcordata*. Areas of alkaline soil and saline springs are colonised by dense stands of *Salvadora persica* and *Suaeda monoica* respectively; the latter is found between the mouths of the Mbubu and Kyanyiga rivers and about 6-8km from Kora Rock.

There are two main exceptions to the general trend of a thin riverine fringe. The first is a region in the far NW corner of the Park where alluvial deposits stretch up to 2 km in from the river. This region is flooded in most years and is covered in a fine, greyish-brown silty-sand, which supports quite dense vegetation, including *Acacia tortilis*, *Acacia seyal*, *Hyphaene compressa*, *Salvadora persica*, *Cordia* spp., *Combretum hereroense* and grasses. Regions like this provide important dry-season grazing and browse, especially from *Acacia tortilis* pods (Haro and Oba 1993).

The other main exception is the Hameye swamp region in the far NE of the park. This area is the first true section of alluvial floodplain along the Tana River and was known to be covered in forest in 1963. In 1970, the Tana river opened a new channel to the south of the forest. By 1975 the Hameye area was covered by more open shrubby vegetation, which has returned subsequently to full canopy forest. It is not known if the composition of the forest has changed markedly during this change, nor exactly what caused this cycle of vegetation change.

The terrestrial fauna of Kora NP is unlikely to be affected by the proposed changes in the Tana River flow resulting from further dam development upstream of the park. The main use which terrestrial animals make of the river is for drinking water; reduced flows will not affect availability of water for drinking.

There are significant populations of hippo and crocodile along the river within Kora NP. Hippo are common at the eastern and western margins where surrounding plains support enough grassland to support the requirements of a healthy population. The availability of grazing, not river water for drinking or bathing, is the limiting factor on hippo in ASAL areas. The Kora hippo population was affected badly by drought in 1982/3, with significant mortality through starvation. Loss or reduction of flooding in the alluvial plains in the west and east corners of the Park will increase the vulnerability of hippo populations to future droughts. Hippo are becoming increasingly rare outside of protected areas in Kenya, so any potential loss of viable breeding populations must be assessed very carefully.

Crocodile are common along the entire length of the river within the Park, and there are clear signs of local breeding (i.e. many juveniles). Little detail about their breeding sites is available, but it is unlikely that the proposed changes to the flow regime through the park would have a significant impact upon the crocodile population.

The fish within the Tana River at Kora were surveyed by Campbell, Coe and Saunders (1986). A total of 21 species were recorded, 10 of which were considered to be common. Little is known of the detailed distribution and ecology of these species within the Tana River, but it is unlikely that the proposed changes in flow regime will lead to the local extinction of any of these species in this stretch of the river although changes in sediment load and water clarity might adversely affect particular species through modification of the substrate or greater exposure to predation from kingfishers and herons.

19.4.4 North Kitui And Rahole National Reserves

North Kitui NR plays a similar role for Kora NP as Bisanadi NR plays to Meru NP. In a similar manner, the Reserve has never had its own administration, has been only weakly managed, and is poorly studied in terms of ecology. Recently, the original gazetted area of 63 500 ha was reduced by 11 000 ha. The long-term future of this area as an important site for conservation is poor. Any impacts arising from dam development are predicted to be similar to those outlined above for Kora NP.

Rahole National Reserve covers an area of 1,270 km^2 and was created to demonstrate the possibility of co-existence of wildlife and pastoralists. The Reserve is situated north of the Tana River in an area which has been subject to outbreaks of banditry and poaching throughout the 1980s, and little is known of the current conservation status of the area. Management and ecological inventory work are negligible and nothing can be said with any confidence about the likely impact of flow changes in the Tana River.

19.4.5 Arawale National Reserve

Arawale NR covers an area of 1,165 km^2, 77 km south of Garissa on the eastern bank of the Tana River. The reserve has a boundary of 48 km along its western border parallel, but not right up to, the Tana river, and was set up specifically to conserve the Kenyan populations of Hunter's hartebeest (*Damaliscus hunteri*). This antelope is restricted to the arid scrubland areas north/east of the Tana River. No reliable census data exist for this shy, sparsely-distributed antelope; both ground and aerial survey techniques produce estimates with extremely large standard errors. Most of the estimated 3,000 remaining animals move widely across the region, often leaving the relative security of Arawale NR and entering areas with widespread banditry and animal poaching.

The Reserve boundaries do not stretch right to the edge of the Tana River, so no direct impacts from a change in river flow can be expected. Although riverine forest is not directly essential to the continued survival of Hunter's hartebeest, which traditionally would range across the dry bushland characteristic of this region of Kenya, any forest are provides improved cover in which poaching risk is reduced. Loss of riverine forest cover in this region, a likely consequence of development of the High Grand Falls dam (see below) could therefore further contribute to the likely extinction of this species in Kenya.

19.4.6 Tana River National Primate Reserve (TRNPR)

TRNPR was gazetted in 1976 in response to a marked reduction in the riverine forest habitat along this stretch of the river, from around 100 km^2 during the 1960s, to 59 km^2 in 1975, 17 km^2 in the 1980s, and just 9.5 km^2 today. The riverine gallery forest is not continuous, but consists of 25-30 separate patches, each in a different stages of formation, maturity and degeneration. Historically, this patchwork of forest successional stages was the result of changes in the hydrology of the river, shifting its path across the floodplain. Over the past 30 years, forest clearance for cultivation has matched the natural rate of forest decay, dramatically reducing the area of mature forest between 1960-80. Since 1980, loss of mature forest has slowed, but increased cultivation on newly-exposed sediment has eliminated almost all natural succession to mature forest which would normally occur on non-forest patches. Recent surveys indicate that the area categorised as forest within TRNPR has increased during the 1980s, with almost three times as much forest forming as was lost (244 ha versus 74 ha respectively). But these figures ignore the loss of land upon which new forest would be formed; thus, although there have been recent gains in forest area, the total area of regenerating forest is now seriously depleted and the long-term future of the forest is not assured.

The remaining forest still represents one of the most biologically diverse sites in Kenya, containing over 650 plant species (including 10 rare species, 5 species endemic to the region, 3 of which are restricted to Tana River alone). There are 262 recorded bird species (including 3 regional endemics), plus 57 mammal species, including the rare Hunter's hartebeest and three primate species endemic to Kenya, Syke's monkey (*Circopithicus mitis alboquatus*), the Tana River red colobus (*Colobus badius rufomitratus*) and the crested mangabey (*Cercocebus galeritus galeritus*). The latter two endemic sub-species are restricted to the riverine forest in and around the Reserve. Both species have undergone rapid population declines in the 10 years from 1976-1985 (down by 80% to 250-300, and down by 25% to 700, respectively), and now are considered to be "critically endangered" and "endangered", respectively. The Tana River red colobus is ranked as the most threatened of Africa's primate species. Without active intervention and management, the Tana River red colobus has a 90% probability of extinction within the next 200 years.

After gazettement in 1976, TRNPR passed though a period of relatively good management, but was virtually abandoned by Wildlife Conservation and Management Department (WCMD) in the 1980s. During this period, a research project run by the National Museums of Kenya (NMK) continued to study primate biology from the Mchelelo Research Camp. Following the 1989 transformation of the old WCMD into the parastatal Kenya Wildlife Service (KWS), some management has been re-introduced to the Reserve. But increasing human population pressure is threatening to over-exploit the natural resources of the entire ecosystem, and the long term viability of the riverine forest will be dependent upon an integrated development package focusing upon both human and ecological needs. Negotiations over a GEF project proposal aiming to achieve this goal which had been stalled by political tension and legal technicalities over land ownership has recently reopened.

19.4.7 Tana Delta National Wetlands Reserve (Proposed)

The first formal proposal for a protected area in the delta region of the Tana River was made by the Kenya coastal forest Survey in 1988. A more detailed recommendation, proposing exact boundaries, was prepared by Robertson and Luke as part of their final Coastal Forest Survey Report (Robertson and Luke 1993). Support for the proposal has been widespread and the proposal has been presented to the Tana River District Development Council. The proposed Reserve would include around 300 km^2 of wetland habitat; the boundaries would run north from a point just to the east of Mto Tana, then due east to meet the Tana at Milimani, running north of the Tana until crossing again at Ribarama and then following the east bank of the present Tana to near its outlet at Kipini.

The reserve would protect a variety of wetland habitat types, including floodplain grassland, woodland and bushland, mangrove forest and sand dunes. A provisional plant survey identified over 300 plant species (including 18 rare or endangered taxa) in the delta region. In addition, the delta contains abundant wildlife, and provides important dry seasonal grazing for Orma pastoralist livestock herds.

The present status of the protected area is not clear as the result of a number of overlapping claims on the land (Kondertu Ranching Co. 20 000 ha; Intersystems Ltd. 2 000 ha). Kondertu Ranching Company subsequently leased part of their concession to Coastal Aquaculture Ltd. for prawn farming. Coastal Aquaculture Ltd. now holds around 8 000 ha of the delta wetlands. Further development within the delta region has been suspended by Presidential decree, at least temporarily, but direct development threats to the delta grasslands and mangrove threatens to undermine the livelihoods of many local inhabitants. Equally serious changes to the wetland ecology will result from the changes in river flow and drainage induced by the headworks at Sialoni, the dikes of the Tana Delta Irrigation Project (TDIP), the new road from Garsen-Lamu and the damming of Kalota Brook by local Pokomo farmers. The delta region is critical need of a co-ordinated management plan which meets the requirements of local inhabitants whilst at the same time conserving as much of the natural ecology, and unquantified economic benefits of the wetland ecosystem. Changes in flooding regime resulting from further dam development would need to be carefully integrated into such a management plan and should not be allowed to proceed in isolation.