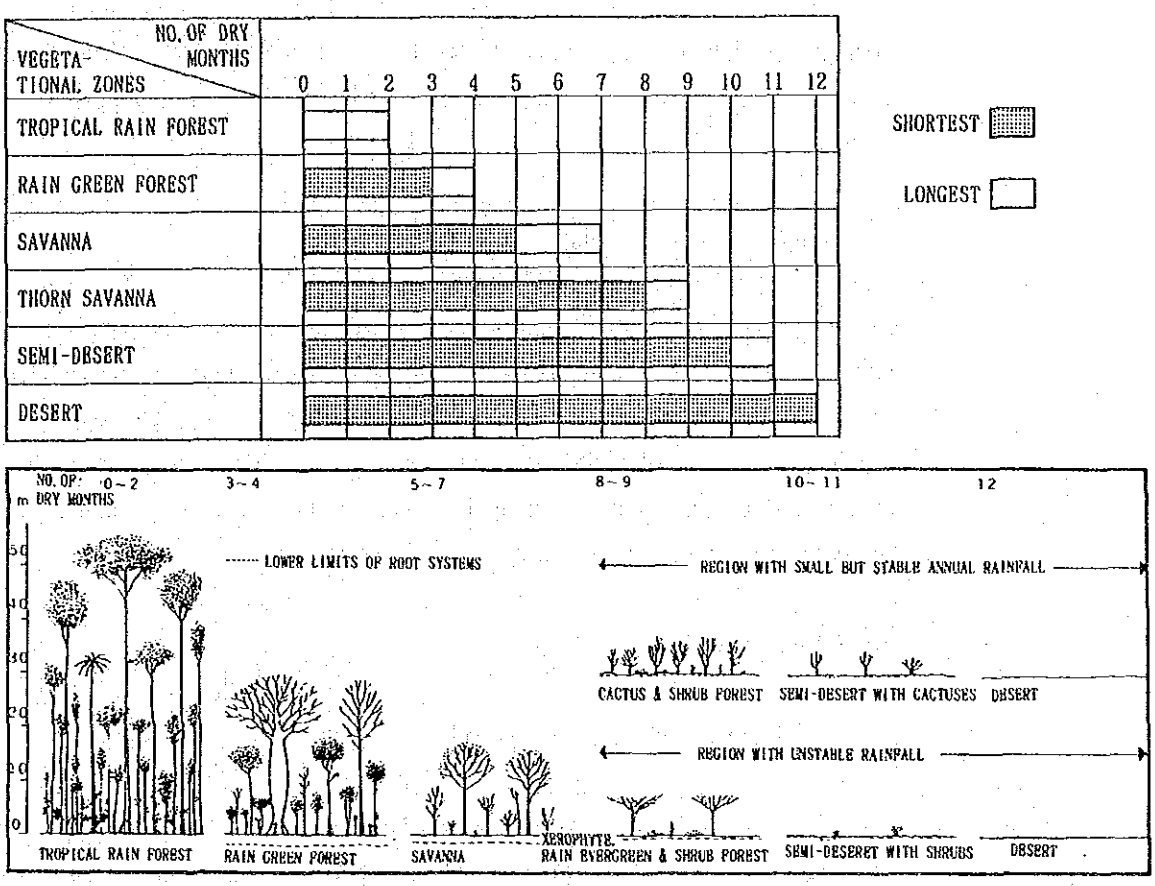
12.2.5 Vegetation

(1) Tropical Vegetation

The classification of tropical vegetation based on the length of the regional dry season is as shown in the following figure:



The vegetation in the vicinity of the planned power station site belongs to the rain green forest zone, and consists of forests, savannas and derivative savannas resulting from the slash-and-burn method of agriculture.

A rain green forest is also called a "seasonal rain forest", and it is a forest mixed with deciduous trees in a region with a lot of annually-one-sided

rainfall and its dry season longer than three to four months. As the dry season is longer, the area tends to turn from a rain forest into a savanna.

Trees in the rain green forest are generally shorter than those in the tropical rain forest. The high tree stratum is 20 m to 30 m in height, and dominant species are clearly recognized. The forest is mostly divided into two strata such as the high tree stratum cast leaves in the dry season while the low tree stratum consists of evergreen trees.

A savanna is the vegetational state which is grassland equally studded with trees in the rain green forest zone. The dry season at a wet savanna lasts 2.5 to 5 months. Most savannas in Africa have resulted from the slash-and-burn method of agriculture which burns rain green forests to create burned/cultivated fields in the dry season. They are called derivative savannas.

(2) Vegetation Survey

i) Outline of Vegetation

The outline of vegetation in the vicinity of the planned power station site based on the on-site survey and aerial photographs is as follows:

The topography of the basin of Kihansi River in the vicinity of the upper dam reservoir is gently sloping, and almost has no forest due to the slash-and-burn method of agriculture and its climate, but burned/cultivated fields and derivative savannas. Vegetation mixed with ferns is seen partly along a tributary of Kihansi River.

There are burned/cultivated fields and derivative savannas on the right side of Ruaha River similar to the basin of Kihansi River, and the Uzungwa Scarp Forest Reserve on the left side.

The vegetation of the section from the upper dam to the Kihansi Falls about 1 km downstream from the lower dam mainly consists of burned/cultivated fields and derivative savannas on both sides of Kihansi River.

The area from the Kihansi Falls to the lower power station outlet is so steep and difficult to use that the untouched forest vegetation spreads similar to a forest reserve.

The area downstream from the outlet of the lower power station is a savanna which turns into a swamp in the rainy season, and mainly has true grasses about 2 m in height dotted with acacias, etc.

ii) On-Site-Survey of Vegetation

With the help of Iringa Region's forest officers, the representative areas of vegetation were chosen and the location of vegetation survey line as shown in Fig. 12-10 was determined for conducting the on-site survey of vegetation in the planned impoundment area of the forest reserve or its vicinity. The survey of vegetation with checks on each tree was conducted by establishing each rectangular section (20 m x 10 m) above and below the border of the planned reservoir's surface located on the survey line (Fig. 12-11, 12).

The survey of vegetation about the names of main tree species, stratus structure, plant coverage ratio, height of trees, diameter of trees at breast height, cross sections of soil, etc., was conducted.

According to the results of the survey, the vegetation of the surveyed area shows multiple strata such as the high tree stratum, sub-high tree stratum, low tree stratum, grass and shrub stratum, and each plant coverage ratio is 40%, 30%, 50% and 50% respectively.

The high tree stratum consisting of *Parinari curatellifolia*, *Makaranga kirimanjarika*, etc., is about 20 m in height, the sub-high tree stratum consisting of *Albizia vorsicolor*, etc., is about 12 m in height, the sub-low tree stratum consisting of MPIRIPIRI, etc., is about 5 m in height, and the high tree stratum is partly mixed with deciduous trees (Table 12-2).

Arboreal usneaceas and moss are seen in the forest, and the area's environment seems humid.

The estimated volume of trees at the surveyed area was about 100 tons/ha, according to the dry trunk weight determined on the basis of the Shidei and Kira method which measures the volume of trees in consideration of the diameter of trees at breast height, and the height of trees. This volume is much smaller than the volume of trees 400 tons or above/ha in the average tropical rain forest and 300 tons/ha in the tropical rain green forest.

According to the soil survey conducted at the same time as the vegetation survey, surface

soil consists of three layers such as the upper layer covered with a thin layer of fallen leaves and brunches, the middle layer of black humus soil 30 cm top 50 cm in thickness, and the lowest layer of lateritic soil in yellow through red (Fig. 12-13).

According to the on-site survey or the hearing survey, there is no precious plant around the project site.

Fig. 12-10 Vegetation Map

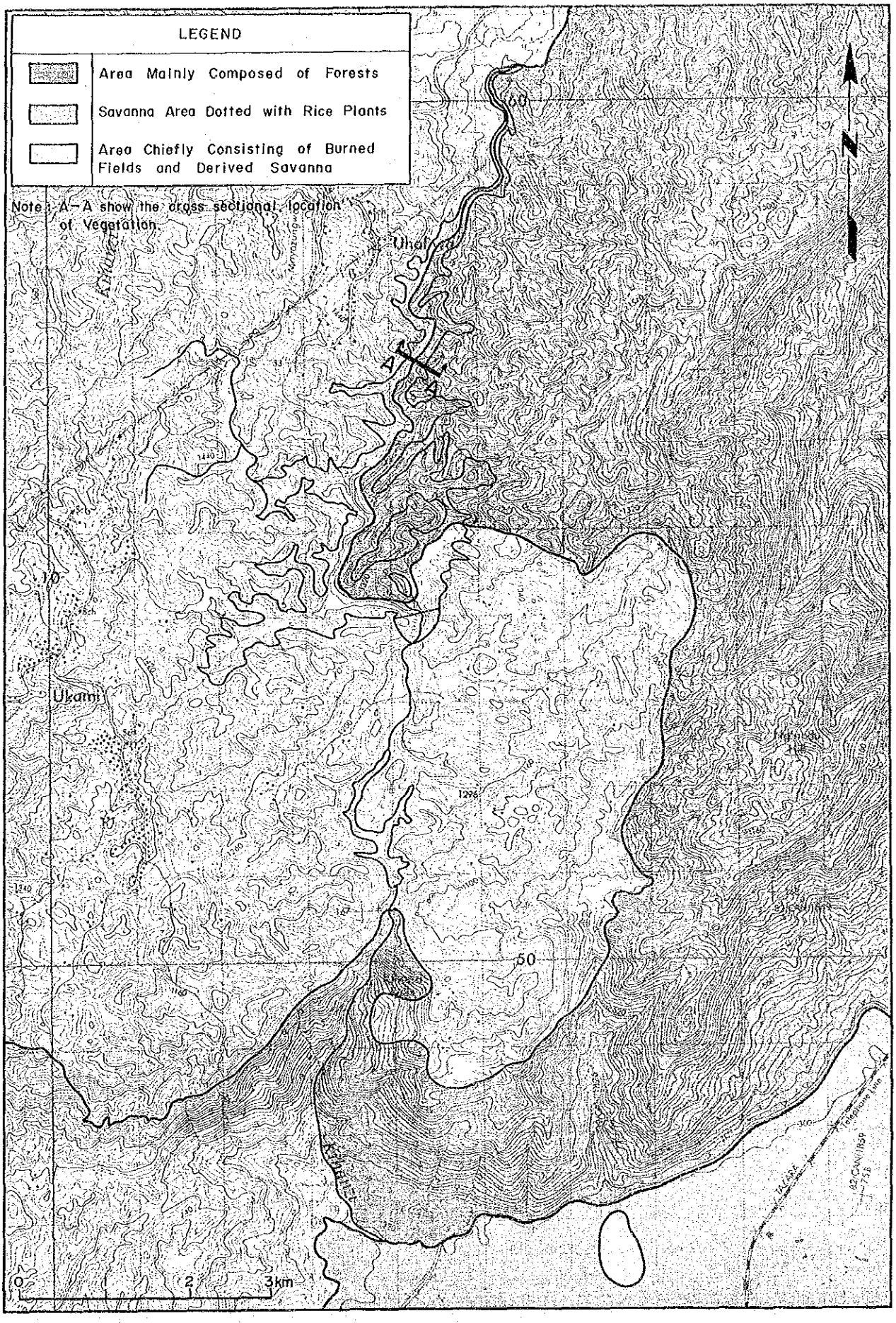


Table 12-2 Main Constituent Species of Each Stratum

Classification	Plane Coverage Ratio(%)	Height (m)	Main Consituent Species
Tree Layer	40%	20	*Makaranga kilimanjarika*, *Boscia mossambicensis Parinari curatellifolia*, *Phylanthus sp.*, *Cardium sp.*, *Schrebera elata*, *Pterocarpus tinctorius*, *Camipuora ugogensis*, *Catunaregam spinosa*, MPETA, MWISA, MYAKATITU
Lower Tree Layer	30%	12	*Albizia versicolor*, *Parinari curatellifolia*, LIPUMU, MOHOMERO, LUKONGO, MUTANGA, MPETA
Shrub Layer	50%	5	MPIRIPIRI, LUKONGO, LIPUMU
Herb Layer	50%	0.5	LITWEVE

Note: The capitalized words show the names of species in their language.

Fig. 12-11 Cross Sectional Drawing of Vegetation

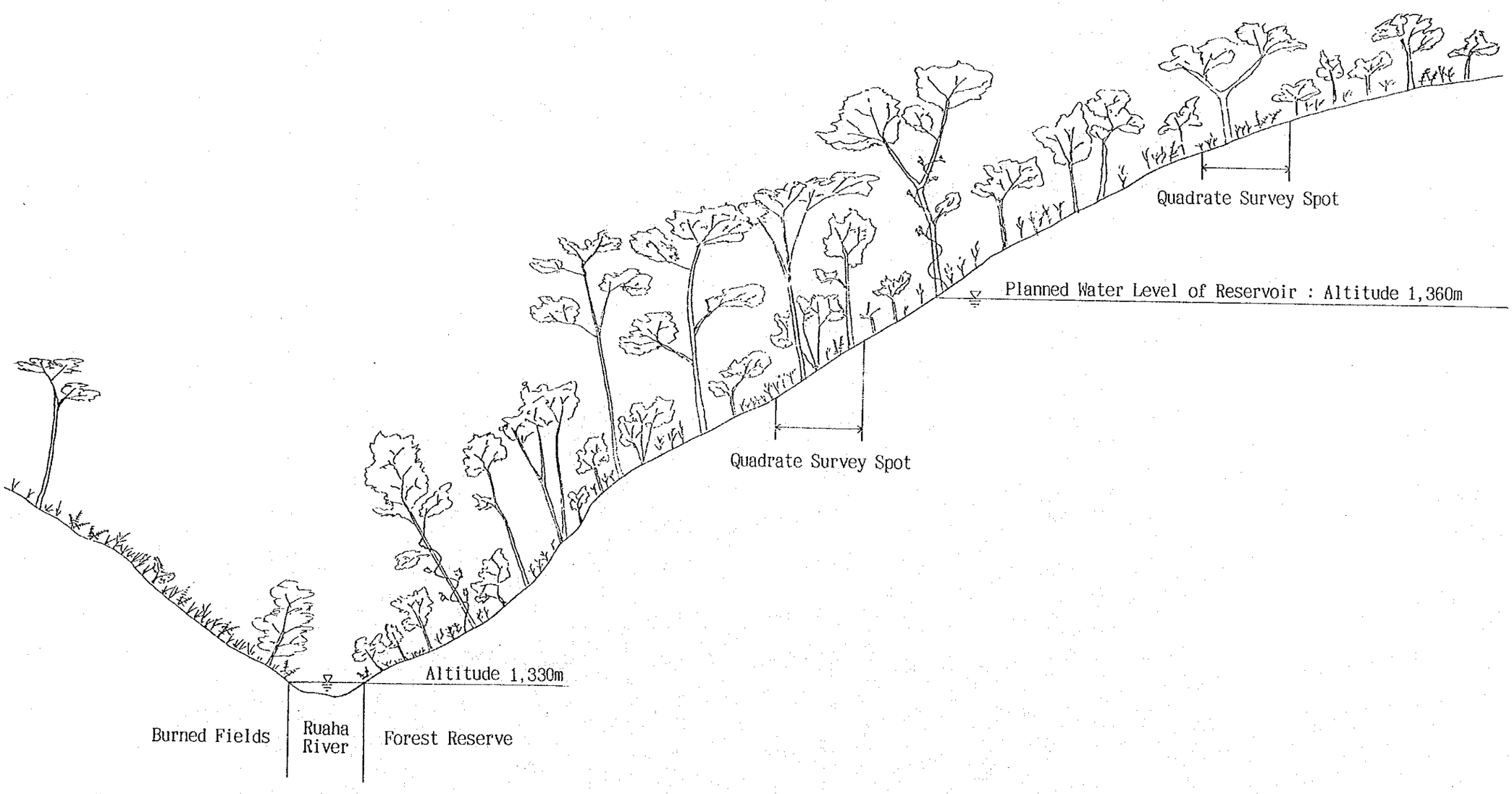
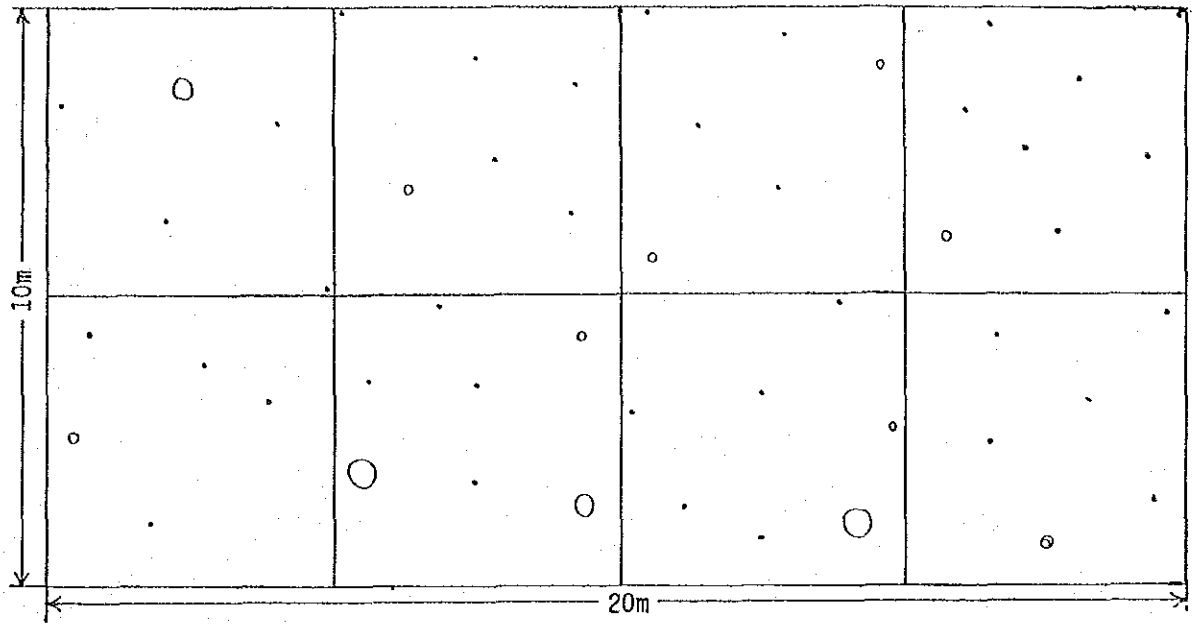
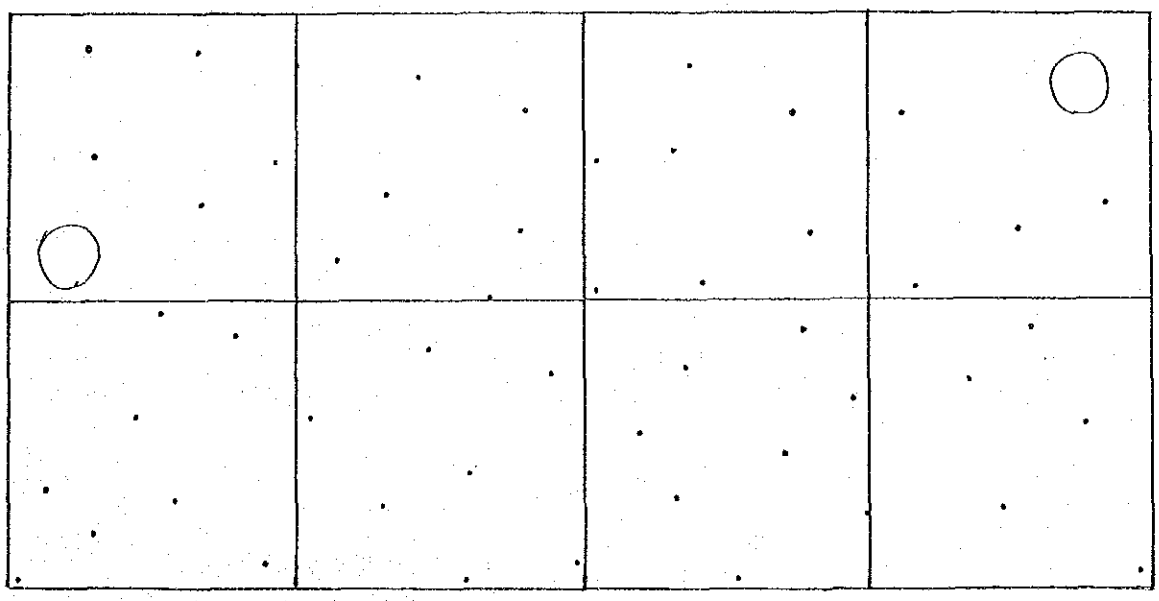


Fig. 12-12 Vegetation of Surveyed Quadrate Section

(Below the Planned Reservoir's Surface-EL. 1,350 m)



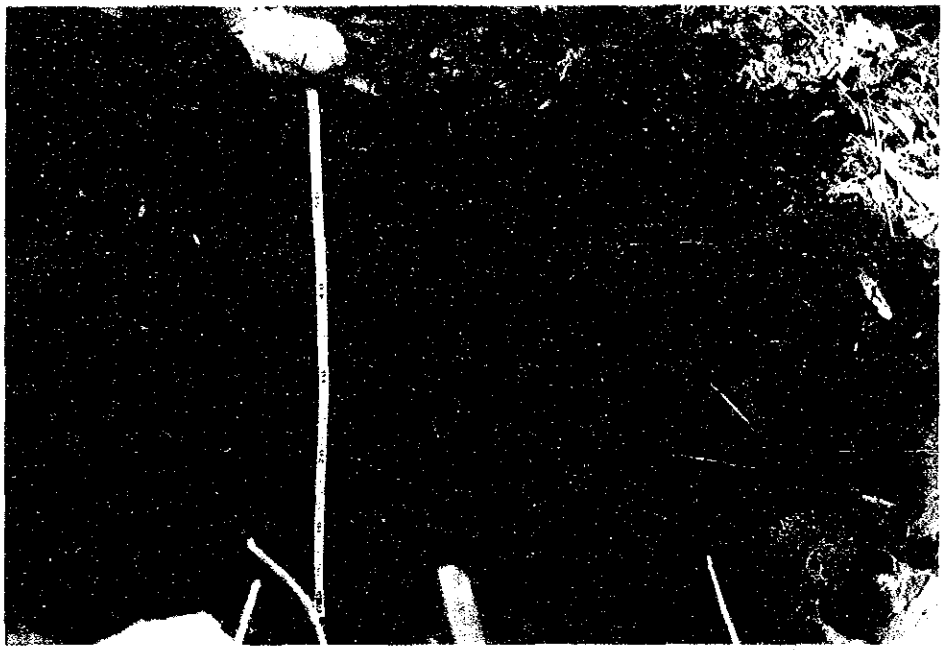
(Above the Planned Reservoir's Surface-EL. 1,390 m)



Note: · and ○ respectively show the location of trees 3 to 10cm, and 10cm or above in diameter at breast height.

Fig. 12-13 Cross Section of Soil

(Below the Planned Reservoir's Surface)



(Above the Planned Reservoir's Surface)

12.2.6 Animals

The survey aimed at grasping the general situation of animals on the basis of existing data, partially supplemented by hearing and on-site surveys. The hearing survey of animals in the vicinity of the planned power station site was conducted with the help of Dar Es Salaam University's department of zoology (Prof. Dr. Kim M. Howel), Iringa Region's game officers, people in Uhafiwa Village and Ukami Village.

According to the survey of mammals, there live one of deer species named Funo in their language, Tree Hylax, wild pigs, buffaloes, giant flying squirrels, monkeys in the Uzungwa Scarp Forest Reserve near the planned power station site. Hippopotamuses also inhabit in swamp areas. And large-sized animals do not live in burned/cultivated fields and derivative savanna areas.

As for birds, the inhabitation of crows (*Vorvus* sp.), eagles (*Tetathopius* sp.), hawks (*Lophaetus* sp.), heroins (*Srdea* sp.), etc., is known.

As for reptiles, there live vipers 50 cm in length named Kifitu in their language, pythons, and geckos.

As for batrachians, the existence of frogs (Rana sp.) has been recognized by the on-site survey.

A national park is planned to be established on the eastern edge of the Uzungwa Mountains which includes the planned power station site on its western edge, and there inhabit various species of mammals (Data 2). The project site is more than 100 km away from the planned park site, but these animals are possible to inhabit or move to the planned power station site since the Uzungwa Mountains are undeveloped and topographically and vegetationally continue. As a precious species of animals inhabiting in the Uzungwa Mountains, Iringa or

Uhehe Red Colobus monkeys are mentioned in the documents (Rogers & Homewood, 1982).

12.2.7 Aquatic Animals

Aquatic animals were acquired by basket nets, gill nets, and fishing in Kihansi River and Ruaha River near the planned power station site for observation in addition to the hearing survey.

(1) Observation by Basket Nets

Four basket nets (50 I cm x 25 E cm x 25 W cm) named "Mondori" were set at each one of three places such as (a) the planned upper reservoir, (b) the planned upper dam, and (c) the planned lower power station outlet, and pulled up 24 hours later. As a result, the inhabitation of the following aquatic animals was confirmed.

Class	Species	Number	Length	Point
Crustacea	BRACHYURA	4	5 cm	a, b
Amphibia	*Rana* sp.	3	5 cm	a
Pisces	(NGOGO)	3	2 cm	c
	Pollimynus sp. (NDIPI)	1	3 cm	

Note: Names in native language are indicated in ( ).

(2) Observation by Gill Nets

Gill nets (three-piece nets 20 m in length) were set at a place 2 km downstream from the outlet of the lower power station, and pulled up next morning. As a result, the inhabitation of the following aquatic animals was confirmed.

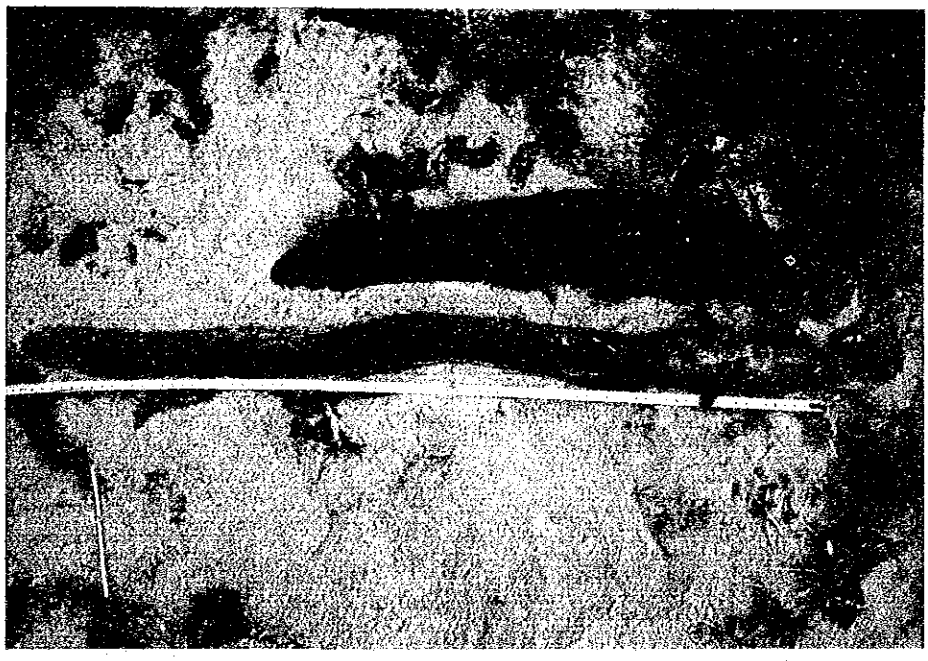
Class	Species	Number	Length
Pisces	Characiformes (NJEGE)	8	12 cm
	Garra sp. (MTUKU)	1	8 cm
	Cypriniformes (BENASONGO)	110	10 cm
	Cypriniformes (BURA)	22	6 cm

Note: Names in native language are indicated in ( ).

(3) Observation by Fishing

Aquatic animals were acquired by fishing at the lower reaches of the outlet of the lower power station for observation. As a result, one of catfish species (about 50 cm in length) and one of eel species (about 80 cm in length) were caught (Fig. 12-14).

Fig. 12-14 Acquired Fish at Lower Reaches of Outlet



(4) Hearing Survey

The hearing survey was conducted in Uhafiwa Village near the planned power station site. According to people in the village, only small fish inhabit in Kihansi River and Ruaha River upstream from the outlet of the lower power station.

Catfish, eels, etc., inhabit in Kihansi River downstream from the outlet of the lower power station, and are acquired for food.

12.2.8 Water Quality

(1) General State of Water Systems

Kihansi River is a tributary of Kilombero River in the Rufiji River System, and its source originates in the Ihing Ana Forest Reserve about 2,000 m above sea level located about 30 km north-northwest of the upper dam site. Kihansi River flows southwards through hilly land consisting of derivative savannas which results from the slash-and-burn method of agriculture, and joins its tributary named Ruaha River just above the planned upper dam site about 1,400 m above sea level. Kihansi River reduces its altitude with continuous falls from the upper dam to the outlet of the lower power station, flows into Kibasira Swamp about 300 m above sea level, and joins Kilombero River nearly in the middle of this swamp. Ruaha River joined by Kilombero River flows into the Indian Ocean at a place about 140 km south of Dar Es Salaam, the capital city of the country (Fig. 12-15 (1), (2)).

The catchment area of Kihansi River upstream from the planned lower station site is about 600 km^2 in area. The average gradient of Kihansi River is about 1/90 from its source to the upper dam, about 1/30 from the upper dam to the lower dam, and about 1/5 from the lower dam to the outlet of the lower power station.

There is a forest area on the left side of Ruaha River as the Uzungwa Scarp Forest Reserve. There are burned/cultivated fields and their derivative savanna areas on both sides of Kihansi River except on the right side of Ruaha River and in the vicinity of the lower power station.

In burned/cultivated fields and their derivative savanna areas, thick lateritic soil in red brown below surface soil is exposed by the flow of surface soil due to deforestation, and it is washed away into rivers by rain together with surface soil in the rainy season.

The water quality of rivers seems to be kept clean due to no facilities to cause water pollution, such as mines, factories, etc., no living waste water flowing directly into rivers, and no still-water areas such as lakes, ponds, etc., as well.

According to the records from 1974 to 1986, the amount of flowing water in Kihansi River at the stream-flow gauging station (1KB28) 1 km downstream from the outlet of the lower power station is a maximum rate of 50 m^3/sec and a minimum rate of 7.5 m^3/sec.

(2) Present State of Water Quality

i) Water Quality Measurement

Five water quality surveys were conducted during the dry season from June to September. Research materials acquired in August were analyzed later in the laboratory. The two measuring places were a point about 500 m downstream from the junction of Kihansi River and Ruaha River, and another point about 1 km downstream from the outlet of the lower power station.

Water temperature, electrical conductivity, turbidity, dissolved oxygen, and pH among the items of on-site measurement were measured by portable measuring devices. Chemical oxygen demand (COD), (NH_4^+-N), (NO_2-N) and (PO_4^{3-}-P)

were measured by test kits based on the calorimetric method. The transparency of water was measured by a transparence measuring instrument, that is, a measuring cylinder 30 cm in depth used for recognizing cross-shaped lines at the bottom. The odor and color of water were qualitatively measured by human senses. The water quality analysis was made in the water quality laboratory of Dar Es Salaam University. Research materials were acquired at the upper dam site early in the morning, and transferred with cold reserving boxes to the university next morning.

ii) Results of Water Quality Analysis

The location of water quality examinations, the results of water quality measurement, and the results of water quality analysis in the laboratory are as shown in Fig. 12-15 (3), Table 12-3, and Table 12-4 respectively.

The physical characteristics of water quality are as follows:

* The average electrical conductivity is low, standing at 17.3 μS/cm, and the amount of dissolved inorganic substances existing as ions is very small. This amount is close to the quality of rainwater.

* The amount of total suspended solids (SS) and the amount of total residues are standing at 120 mg/ℓ and 150 mg/ℓ respectively, but the turbidimeter shows nearly 0 in value. This is because suspended solids seem to consist of relatively big grains of rocks and stones such as mica, etc. In fact, stone grains in

the water of rivers are seen to glitter. The largest stone grain is about 0.5 mm in size.

* The transparency of water measured through the transparent measurement is more than 30 cm, and the transparency measured by eye sight is also more than 1 m. All suspended substances in the transparence measuring instrument are deposited on the bottom in 30 minutes.

* The water of rivers almost has no odor.

* The amount of dissolved oxygen (DO) often stands at relatively-high values since those rivers have a lot of falls and are very steep.

The chemical characteristics of water quality are as follows:

* The average hydrogen-ion concentration exponent (pH) is 4.9, showing relatively strong acidity.

* The concentration exponent of nitrogen and phosphorus causing eutrophication as eutrophic salt is very low.

As for electrical conductivity and eutrophic salt, the results of water quality analysis of water in Little Ruaha River, that is, a tributary of Great Ruaha River flowing on the other side of its watershed show the same trends.

Frequent-shifting land application through the slash-and-burn method of agriculture which is popular in the vicinity of the planned project

site, is well-known for turning soil into infertile soil with strong acidity.

Fig. 12-15 (1) Water System Map of Rufiji River

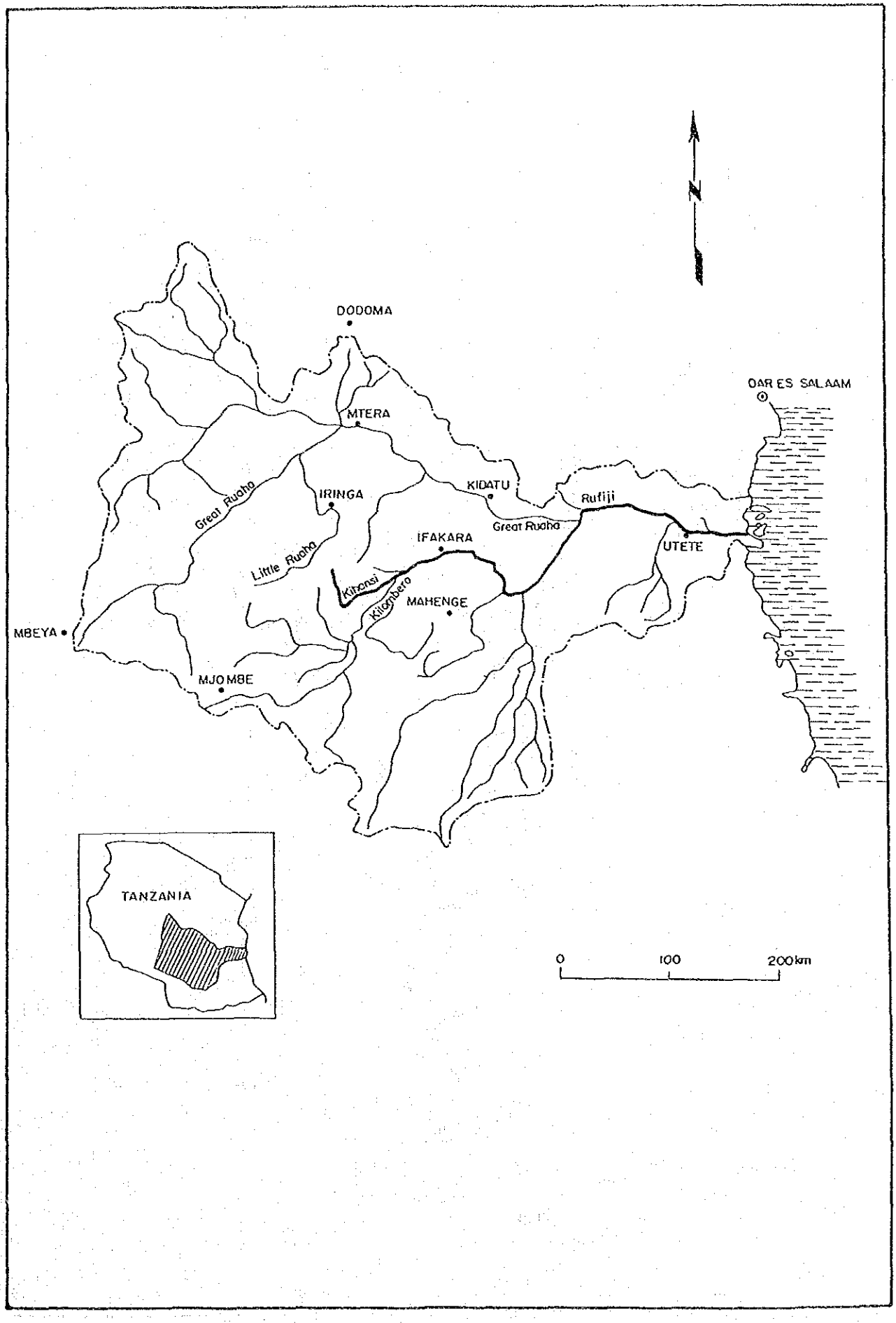


Fig. 12-15 (2) Water System Map of Kihansi River and Ruaha River

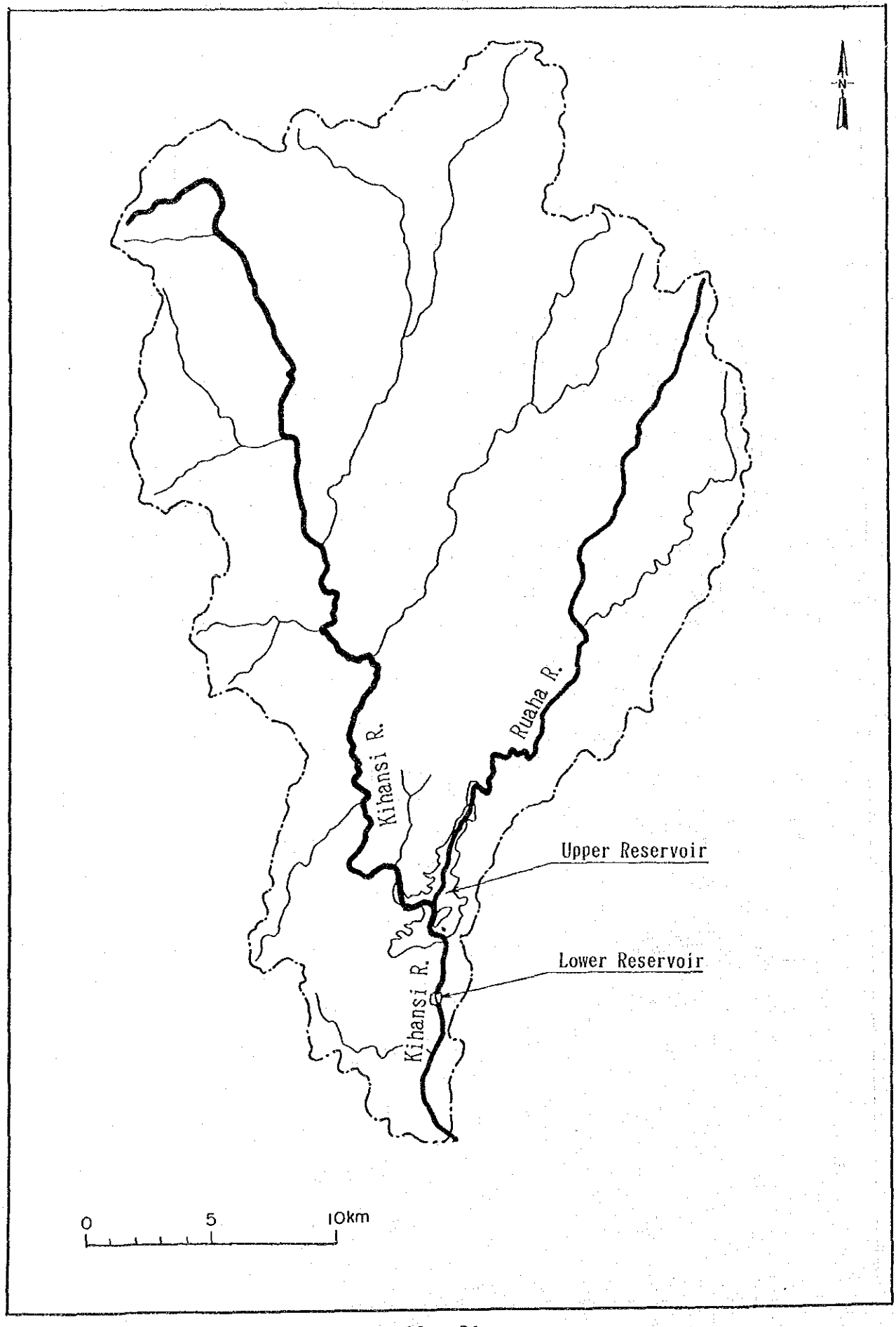


Fig. 12-15 (3) Location of Water Quality Examination

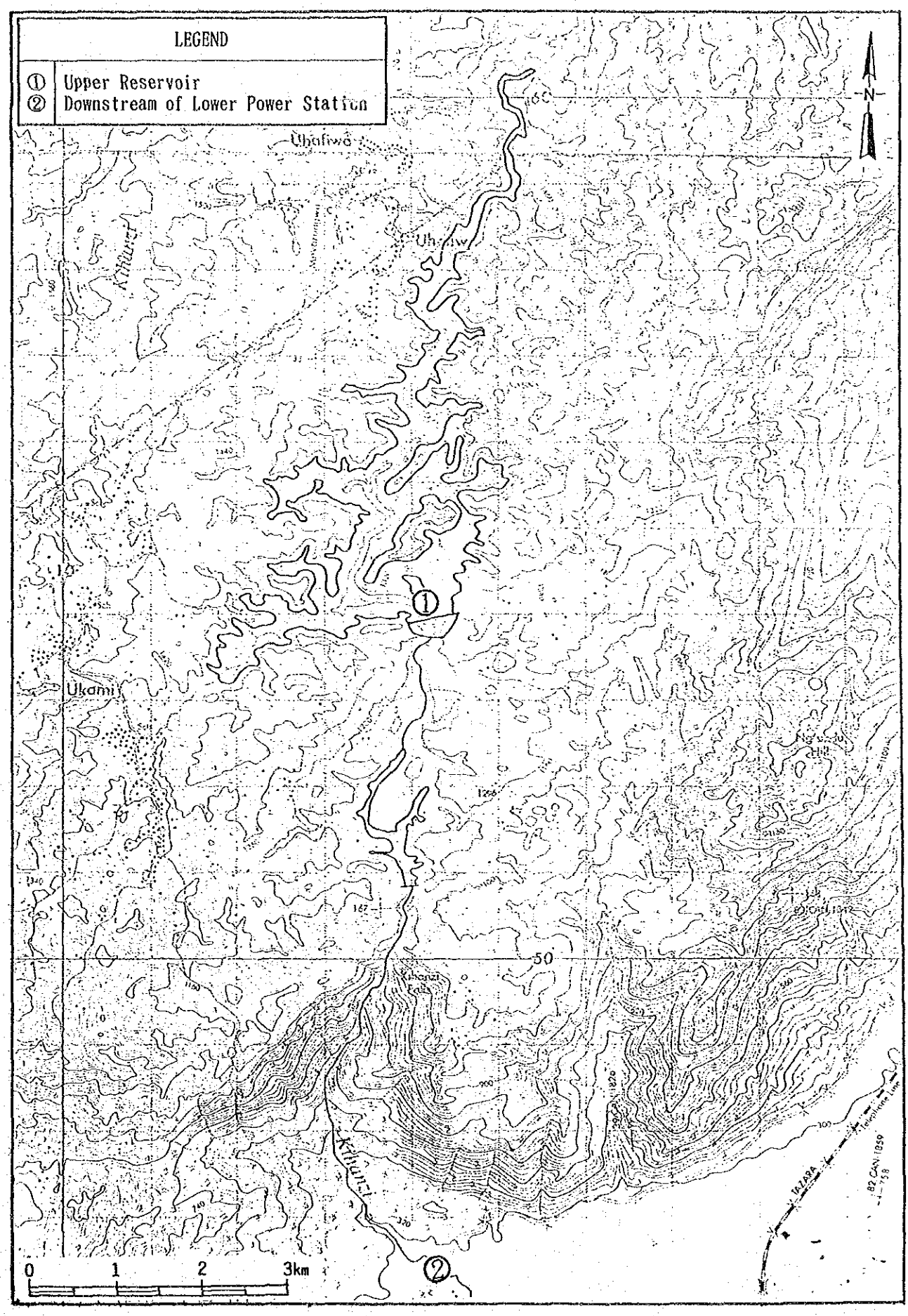


Table 12-3 Results of Water Quality Measurement

Item	Unit	Measuring Point (1)					Measuring Point (2)	
Date of Measurement		June 11 9:00	August 8 16:00	August 13 7:00	August 29 8:00	September 17 17:00	June 16 8:00	August 10 16:00
Water Temperature	°C	15.4	17.2	15.5	14.9	17.8	16.7	19.5
Transparency	cm	30 <	30 <	30 <	30 <	30 <	30 <	30 <
Electric Conductivity	μs/cm	16.3	16.2	18.0	17.9	18.2	16.7	17.8
Turbidity	Degree	0	0	0	0	0	0	0
Odor	-	Nothing	Nothing	Nothing	Nothing	Nothing	Nothing	Nothing
Water Color	-	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown
Dissolved Oxygen	mg/ℓ	9.9	7.4	9.4	8.1	6.2	7.8	6.4
pH	-	5.5	4.9	5.0	4.8	4.5	5.2	5.0
Chemical Oxygen Demand	ppm	< 2	< 2	< 2	< 2	< 2	< 2	< 2
NH_4 -H	ppm	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	<0.5
NO_2 -N	ppm	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	<0.02
PO_4 -P	ppm	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2

Table 12-4 Results of Water Quality Analysis

Name	Unit	Results of Analysis
Full flow filter residues	mg/ℓ	150.0
All suspended substances	mg/ℓ	120.0
Electric conductivity	μm/cm	22.0
All nitrogen	mg/ℓ	0.002
Phosphate	ppm	Nil
Sulfate	ppm	Nil

12.2.9 Noise

There is no artificial noise source near the planned power station site.

12.2.10 Vibration

There is no artificial vibration source near the planned power station site.

12.2.11 Local Community

(1) Location

The planned power station site is located in the southwest part of Morogoro Region near the borderline of Iringa Region. The upper dam is located about 80 km south of Iringa City in the central and south part of the United Republic of Tanzania, the lower dam is about 3 km south of the upper dam, and the lower powerhouse is another 4 km south of the lower dam. Both administration and people in this area are still confused at their own autonomous bodies since the area in the vicinity of the planned power station site used to belong to Iringa Region before (Fig. 12-16).

The project site is located in part of a mountainous area named Uzungwa Mountains. These mountains are characteristic of their unique topography with a continuous precipice about 200 km in length about 1,500 m above sea level. The mountainous district is covered with forests, and designated as a forest reserve. There is Kibasira Swamp about 300 m above sea level under the precipice, and the Tazara Railway and local roads run at the foot of mountains (Fig. 12-17).

(2) Population

The average population growth rate of the United Republic of Tanzania is very high standing at 3.4% a year (1973 to 1984), and the life expectancy at birth is only 52 years (1984).

There are Uhafiwa Village and Ukami Village near the planned power station site, having a population of 1,200 and 2,200 respectively. The composition of population in Uhafiwa consists of about 40% for 12 and less years of age, about 50% for 13 to 50 years of age, and about 10% for more than 50 years of age. The composition of population in Ukami consists of about 64% for 17 and less years of age, about 35% for 18 to 55 years of age, and about 1% for more than 50 years of age. The number of households in Uhafiwa and Ukami is about 200 and 340 respectively. The number of households increased rapidly after the village consolidation policy (Operation Vijiji) based on socialism starting in 1971, but has hardly increased in recent years.

(3) Industries

People in Uhafiwa and Ukami make a self-sufficient living mainly by agriculture. They cultivate mountainous slopes except the forest reserve, and grow beans for staple food, corn, and sweet potatoes on burned fields. Tobacco, sugar canes, and onions little in quantity are gown as well. Burned fields are cultivated at intervals of 2 to 3 years, and can be cultivated all the year round since it rains even in the dry season due to the topographic characteristics. Cereals are used for self-efficiency and domestic animals' baits. Only little cereals are soled in neighbor towns such as Chita, etc., once in a while for purchasing daily

necessities such as clothes, etc. Bananas and bamboos are grown as permanent farm products, and alcohol drinks are produced from bamboos. As for domestic animals, goats, pigs, rabbits, and dogs are raised. Cattle and sheep are also raised in Ukami Village. The villages are surrounded with forests, but no forestry exists since the area is designated as a forest reserve. People use firewood for cooking and heating, but they do not sell firewood and charcoal for a livelihood in the same as those in towns near big cities.

There is no fishery since only small fish exist in neighbor rivers. Fishery seems to be conducted in rivers near Chita since villagers purchase smoked fish and dried fish made of catfish, etc., in towns like Chita. No nomads such as the Masai use the project area.

12.2.12 Transportation and Public Facilities

(1) Traffic

i) Ground Traffic

The ground traffic map of the project area is as shown in Fig. 12-17. It takes about 8 hours to get to Iringa from the capital city, Dar Es Salaam through A7, a paved main road on the way to the upper dam. From Iringa, an unpaved local road is used passing by in front of Kilolo, and from there to Uhafiwa a connected road runs southwards through hill land which is a derivative savanna resulting from the slash-and-burn method of agriculture. It takes about 3 hours from Iringa to Uhafiwa in the dry season since the conditions of the roads are bad, and it takes even more than 3

hours sometimes in the rainy season. The road especially near Uhafiwa is passable by only small jeep. It takes about 1.5 hours on foot along a mountain road from Uhafiwa to the upper dam site. Bus service for Kilolo is available from Iringa. It takes about 2 hours along B127, an unpaved but local trunk road from Mikumi located also along A7 to Ifakara on the way to the lower power station. A local road runs almost in parallel with the Tazara Railway in Kibasira Swamp for about 100 km between Ifakara and Chita. This section is gradually repaired, but there are tentative bridges for makeshift use in place of some of permanent bridges which were washed away.

The road 20 km in length from Chita to the lower power station was partly blocked off by a river flood, and is impossible to use in the rainy season. It takes about 3 hours in the dry season to get to the lower powerhouse from Ifakara. It takes about 2 hours and about 6 hours on foot from the upper dam site to the lower dam site and from the lower dam site to the lower powerhouse respectively.

The Tazara Railway passes by near the lower power station, and the nearest station is Chita. Bus service for Dar Es Salaam is available from Ifakara.

ii) Water-Borne Traffic

Kihansi River, Ruaha River, and Kilombero River near the project site are not used for water-borne traffic.

(2) Public Facilities

There are one elementary school in Uhafiwa and two elementary schools in Ukami. Children of 7 to 15 years old go to those elementary schools.

There is a dispensary with a permanently-stationed medical assistant and nurse in Uhafiwa in charge of three villages such as Uhafiwa, Ukami, and Ihimbo. There is a mission hospital in Usokami Village lying nearly midway between Uhafiwa and Iringa. The hospital is equipped with enough facilities for hospitalization and operations, and several doctors and nurses are working there.

There are two churches in Uhafiwa, and three churches in Ukami. These churches are Roman Catholic, Russian Orthodox, Protestant, etc.

12.2.13 Land Utilization

The area near the power station site can be broadly divided into the Uzungwa Scarp Forest Reserve, and derivative savanna and savanna swamp areas mainly comprising burned/cultivated fields and unused fields.

The forest reserve is designated from the left bank of Ruaha River to Kibasira Swamp. In burned/cultivated fields (Fig. 12-4), cereals such as beans, corn, etc., are grown. And unused fields are covered with weeds and shrubs.

Kibasira Swamp lying down from the outlet of the lower power station is designated as the kilombero Game Controlled Area. The area is hardly used since it is overgrown with true grasses and partly submerged in the rainy season.

All the land in the United Republic of Tanzania is public land, and the methods of land possession and utilization are determined according to the rules concerning the application of the Land Act.

There is no plan to designate new areas for special purposes near the planned power station site.

12.2.14 Water System Utilization

There is no fishery within Kihansi and Ruaha Rivers near the planned power station site, nor are fishery rights created. No irrigation facilities such as dams, weirs, etc., exist. Residents use spring and valley water as drinking water, but not water in both rivers. Rivers in Kibasira Swamp near the outlet of the lower power station are not used at all.

Fig. 12-16 Administration District Map of the United Republic of Tanzania

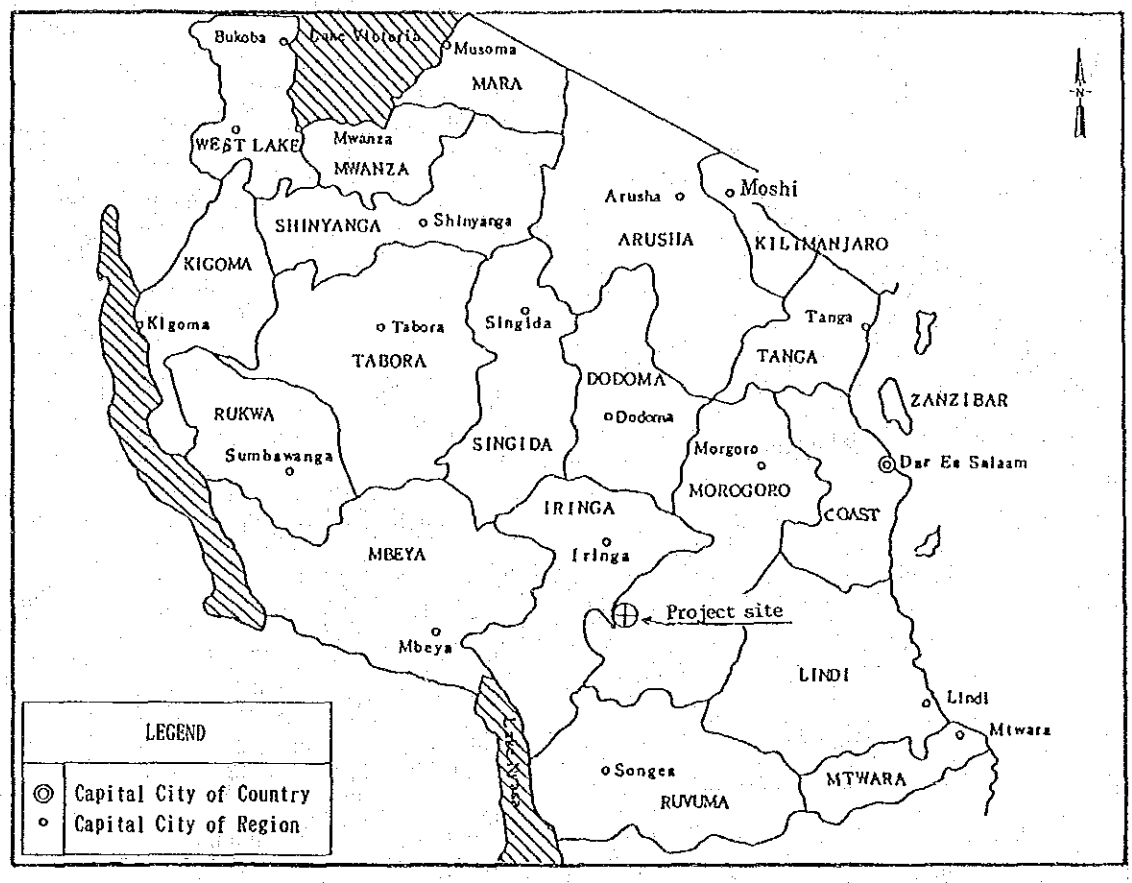
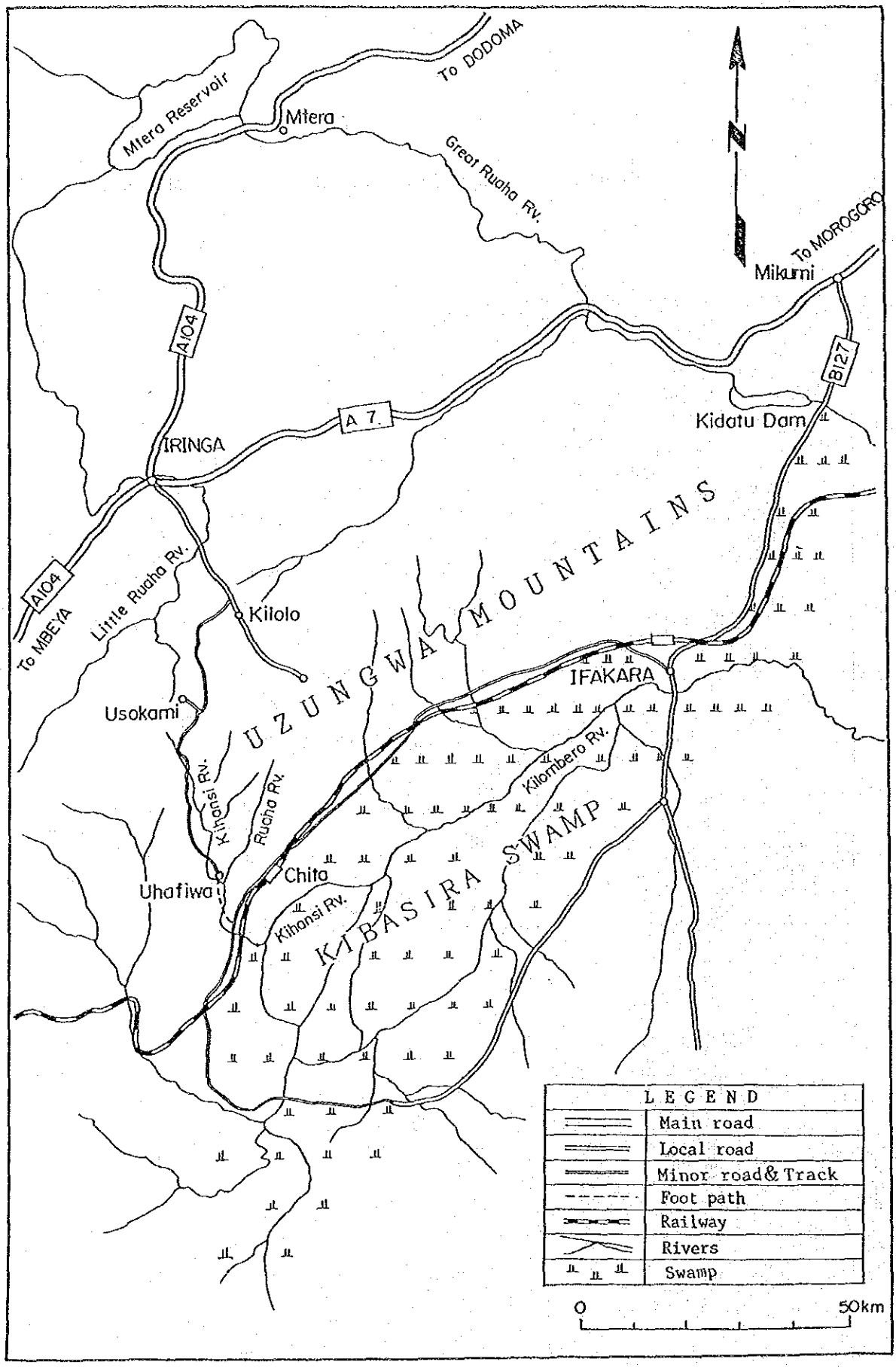


Fig. 12-17 Traffic Route Map



12.2.15 Public Sanitation

The infant mortality rates in the United Republic of Tanzania have been 10 times as high as those in advanced countries in recent years, and the average life span of the Tanzanian is only about 50 years of age. And the conditions of sanitation, medical service, and nutrition affecting the Tanzanian can be easily regarded as bad.

Of the diseases and causes of death in the United Republic of Tanzania, malaria, onchocerciasis, bilharziasis cannot be ignored.

Based on the records of the dispensary in Uhafiwa Village near the planned power station site, the number of patients for each disease is as shown in Table 12-5. The diseases of the respiratory organs rank high since Uhafiwa Village is located in a plateau almost 2,000 m above sea level, and it is considerably cold at night during the dry season. There are almost no mosquitoes which carry malaria near Uhafiwa Village, but residents seem to contract it when they go to lower swamp areas in Chita, etc. Residents often suffer from intestinal helminthiasis and diarrhea since they use valley and spring water as drinking water without water supply facilities.

The dispensary in Uhafiwa Village also provides diagnosis and treatment for two other neighbor villages. The number of patients is about 8,000 a year, and about 40% of the patients go to the dispensary for 2 or more days. The number of serious cases who had to be sent to different hospitals in 1988 was 40. About 40 babies are born in Uhafiwa Village every year. Helminthiasis such as malaria, etc. should be seriously considered since the area near the lower power station is a swamp. In the Uzungwa Scarp Forest

Reserve, the inhabitation of harbor black flies which cause onchocerciasis has been recorded.

12.2.16 Cultural Assets and Recreation

According to the hearing survey, no cultural assets regarded as archaeologically and historically important have been confirmed in the planned power station area or its vicinity.

Table 12-5 Main Diseases and Number of Patients in Uhafiwa Village's Dispensary

(No. of patients)

Ranking	Name of each Disease	1986	1987	1988
1	Upper respiratory infections	1,970	2,000	2,400
2	Pneumonias	1,540	800	2,300
3	Malaria	1,900	2,600	3,400
4	Diarrhleal Desease	440	400	500
5	Helminthiasis	320	400	500

12.3 Measures Planned for Environmental Conservation and Evaluation of their Effects on Environment

Measures planned for reducing the effects of the establishment of the power station on the environment were studied and their effects on the environment were evaluated at the same time.

The secondary benefits which would be given as a result of the establishment of the power station and its environmental measures are also mentioned.

12.3.1 Matters following Completion of Power Station

(1) Protection of Nature

Part of the planned power station site is designated as the Uzungwa Scarp Forest Reserve. Kibasira Swamp downstream from the outlet of the lower power station is designated as the Kilombero Game Controlled Area. The purposes of these designated areas are not opposed to the development plan of the power station at all, but the power station plan should be carefully carried out in consideration of the protection of nature since the protection of nature is an important issue for both the United Republic of Tanzania and the World.

(2) Vegetation

The effects of the establishment of the power station on the neighbor forest vegetation are expected to be small since land surface will be altered in burned/cultivated fields and their unused fields. Part of a road and transmission line passing through the forest area will be newly constructed over about 1 km, and measures against the soil erosion, etc., in this section will be

taken by minimizing deforestation, land surface alteration, and excavation in addition to the execution on stable slopes and banking on the sites of land surface alteration.

Part of the forest reserve which will be submerged by the impoundment of the upper reservoir, should be cleared for preventing the future undesirable effects of trees inside the reservoir on the environment, that is, floating trees as an obstacle to the gate passage, water quality deterioration due to decaying trees, an obstacle to water-borne traffic, an obstacle to casting nets, and scenic deterioration due to dead trees. Floating plants inside the reservoir and plants along its bank should be removed as required since they sometimes become homes for vermin and aquatic animals.

The flow of water downstream from the upper dam is to be changed, but the distance of its section is short, the annual rainfall of the area in the vicinity of the planned power station site is relatively high, and there are a lot of tributaries and spring water in the lower reaches of the river. Therefore, the vegetation of this area seems to be largely dependent on rain water and underground water, and the effects of changes in the flow of water in rivers on the vegetation of this area can be regarded as small.

The transmission line is planned to be connected with Iringa by way of the lower power station and the upper power station, but it is to pass through burned/cultivated fields except some parts of the line as mentioned above, and the vegetation of this area is expected to be scarcely affected.

(3) Animals

Part of the Uzungwa Scarp Forest Reserve along Ruaha River will be submerged by the impoundment of the upper reservoir with an area of 2.3 km^2, covering only less than 1% of the entire forest reserve. The reservoir will provide the water side which is suitable for the inhabitation of animals all the year round, that is, newly-created inhabitable circumstances in place of partly getting rid of the inhabitable foundation of land animals. The waterside will become a suitable habitat, especially for waterfowls which inhabit in still-water areas overgrown with grass. Larger animals eating these birds might be possible to inhabit there.

Paths for animal movement are expected to be rarely blocked off since the pressure pipe-line route is to be laid underground and deforestation under the transmission line will be minimized. Animals are expected to rarely cross this section since part of the section is highly developed as burned/ cultivated fields on the right side of Ruaha River although the forest reserve exists on the left side of the river which is designated as the reservoir.

It is desirable to prevent people related to the power station from capturing wild animals completely for the sake of the positive protection of animals in this area since the forest reserve and the Kilombero Game Controlled Area are located next to the planned power station site.

(4) Aquatic Animals

According to the on-site and hearing surveys, the number of both aquatic animal species and aquatic animals themselves inhabiting in Kihansi and Ruaha Rivers is very small.

It is difficult for aquatic animals to inhabit in these rivers since water in the rivers shows relatively-strong acidity as well as infertility, no adhesive algae are seen, and falls exist so continuously that the rivers are very steep with exposed rocks at the riverbed. Since the upper reservoir will create a still-water area of 3.9 km^2, aquatic animals suitable for still-water areas are expected to increase in number in this area in place of aquatic animals suitable for torrents do decrease in number. If the water level of the reservoir is changed quickly in a short period of time by the operation of the power station, vegetation along the lake bank is supposed to become so unstable that aquatic animals which deposit eggs in this section as their habitat are not suitable, but the circumstances are expected to be scarcely affected since the water level of the reservoir is changed slightly in height in a short period time.

The inhabitable circumstances of aquatic animals in the lower reaches of the upper dam are expected to be scarcely affected since water is expected to flow into this area from their tributaries to a certain extent. The inhabitable circumstances of aquatic animals in the lower reaches of the outlet of the lower power station is to become better on the contrary since a certain amount of water is expected to flow into this area all the year round.

(5) Water Quality

A still-water area of 3.9 km^2, that is, the impoundment of the upper dam reservoir over Kihansi River and its tributary named Ruaha River, a differently-water-flowing section about 1 km in length downstream from the upper dam, and another section about 5 km in length downstream from the lower dam over Kihansi River, will be created by the establishment of the upper and lower power stations respectively. A certain amount of water is to, all the year round, flow into the lower reaches of the outlet of the lower power station without changes in the flow of water in the rainy and dry seasons in the same way as before.

According to the results of the survey of water quality, the water of rivers is kept clean due to no facilities to cause water pollution, such as mines, factories, etc., no living waste water flowing directly into rivers, no agricultural chemicals and fertilizers in use, and no still-water areas such as lakes, ponds, etc., in this basin.

The quality of water is characteristic of having little dissolved inorganic substances existing as ions. The water quality of rivers is close to rainwater. Eutrophic salt is very little in quantity as well. The water quality of rivers tends to have relatively strong acidity, standing at 5 in pH value. The suspended solids are characteristically consist of small stone grains.

The characteristics of water quality are owing to the land surface in this basin chiefly consisting of burned/cultivated fields and their unused fields, that is, infertile soil which has been

exceedingly cultivated as well as the surface layer in these areas comprising lateritic soil.

i) Upper Reservoir

Since the frequency of annual water replacement (the ratio of the amount of water inside the reservoir: the amount of water annually flowing into the reservoir) in the upper reservoir as the index to the change of water quality is low, and the reservoir is relatively deep, methane and hydrogen sulfide are possible to occur together with the decrease of dissolved oxygen at the deepest area of the reservoir by the decomposition of trees and organic matter. It is known that iron and manganese liquefy out of anaerobic soil at the bottom of the reservoir.

These environmentally undesirable consequences are expected to be considerably avoided by the deforestation of trees inside the impoundment of the reservoir. The moderate eutrophy of water provided with eutrophic salt by the decomposition of organic matter at the bottom and trees inside the reservoir can give nutrition to plankton, and contribute to the cultivation of fish in the reservoir.

ii) Lower Reaches of Upper Dam

The water quality of the lower reaches of the upper dam is expected to be scarcely affected due to no sources of water pollution in the vicinity of this area.

(6) Noise

Turbines, generators, etc., can be regarded as possible noise sources, but they are designed to be installed inside the buildings. The surrounding environments are expected to be scarcely affected.

(7) Vibration

Turbines, generators, etc., can be regarded as possible vibration sources, but they are to be installed on the solid foundation. The surrounding environments are expected to be scarcely affected.

(8) Industrial Activities

Of all trees in part of the forest reserve with an area of 2.3 km^2, belonging to the impoundment of the upper reservoir, those suitable for use as wood can be applied to the power station as its construction materials by the deforestation of those trees before its submergence. Other miscellaneous trees should be used as charcoal materials, etc., as well.

In the case of the existing power stations of Mtera and Kidatu, the disordered deforestation of trees for firewood conducted by residents in the vicinity of the power stations causes the destruction of forests and their ecology since good access to the forests was given by the completion of neighbor roads. The utilization of forest resources should be continuously observed for avoiding spreading the unruly development of neighbor areas by limiting the application area to the vicinity of the power station.

A certain amount of water is to, all the year round, flow into the lower reaches of the outlet of the lower power station, following the operation of the power station, and water will be able to be applied to various purposes such as irrigation water for cultivated fields, etc. Since Kihansi River flows into Kibasira Swamp about 1 km downstream from the outlet of the power station, joining several other rivers there, the effects of changes in the flow of Kihansi River itself on the entire swamp are expected to be small.

Kibasira Swamp downstream from the outlet of the lower power station is not used now for agriculture and any other purposes. At present, there is no plan to use the area for agriculture through irrigation in the future. If it takes place from now on, a certain amount of water annually flowing out of the power station will be able to be effectively applied to irrigation agriculture.

(9) Transportation and Public Facilities

The conditions of roads with access to villages in the vicinity of the power station are very poor, and some of them are impossible to pass through especially in the rainy season. There is no auto road to directly go to the nearest towns of Chita, Ifakara, etc., located in swamp areas from these villages.

The road conditions of this area are expected to be improved by building a road used for the construction of the power station as well as a road used for the maintenance of the power station following its operation.

The structure, etc., of those newly-built roads used for the construction and maintenance of the

power station should be carefully planned for avoiding soil erosion due to this rainy area.

The upper reservoir will become a lake with an area of 3.9 km^2, and give mutual access to both neighbor villages of Uhafiwa and Ukami through water-borne traffic on the surface of the lake. Up to present, there has been a terribly-steep mountain path 20 km in length as the only means of transportation, but the future relationship between both villages will be promoted since they will be able to visit each other through water-borne traffic over a distance of about 6 km. It will become possible to easily go to the dispensary in Uhafiwa as well.

(10) Land Utilization

Land used for the construction of the power station can be broadly divided into two sections, that is, one section used for the permanent facilities of dams, power stations, switchyards, pressure-pipe line routes, etc., and the other submerged by the impoundment of the dam.

An area of 3.9 km^2 will be submerged by the impoundment of the upper reservoir. Of this area, an area of 2.3 km^2 will belong to the forest reserve, and the rest of the area (1.6 km^2) will belong to burned/cultivated fields and their unused fields. A very-small area of 0.3 km^2 will be submerged by the lower adjusting reservoir.

Residents in this area are making a self-sufficient living by the shifting cultivation method of agriculture. The shifting cultivation method of agriculture needs to avoid using fields for a certain period of time for preventing land from becoming infertile and having a stable harvest in the long run. As a result of cultivated fields

smaller in area, this period of time will be shortened. Land on mild slopes suitable for the slash-and-burn method of agriculture is limited and most cultivated fields are along the banks of rivers since this area is mountainous. Therefore, it is not necessarily easy to find substitute fields for cultivated fields which will be submerged. The slash-and-burn method of agriculture is said to have its own limitations in the number of people to be fed a certain area of land and the frequency of land utilization. Beyond the limitations, it is said that soil starts losing nourishment and the rapid flow of surface soil takes place.

Appropriate substitute land is preferable to be prepared for preventing the submergence of cultivated fields from damaging normal agriculture in this region. This is the way that the unruly development of the forest reserve by residents is expected to be avoided.

(11) Water System Utilization

No fishery is conducted in the planned power station area. Since the upper reservoir will have a still-water area of 3.9 km^2, and its water is expected to become eutrophic to some extent. It will be possible to engage in fishery from now on by stocking the lake with terapia, etc.

Since the facilities of fishery for coping with changes in the water level of the lake are required in the case of conducting fishery in the reservoir, and a lot of firewood is used for smoking fish as their general preservation method in this region, it should be considered that these things will be the new consumption sources of forest resources.

Clean water provided by water supply facilities is well-known for rapidly decreasing chronic diseases due to inferiority in water quality, epidemic diseases in digestive organs through water as a medium, etc. The construction of waterworks based on the reservoir is expected to contribute to a remarkable improvement in the living and sanitary conditions of residents in villages near the power station. However, the application of this system should be carefully planned since there are problems with the use of water in the reservoir, such as the breeding of plankton especially in a still-water area, iron and manganese liquefying out of anaerobic soil at the bottom, and helminthiasis thorough as a medium. The effects of the construction of the upper dam and the lower dam on the environment by the conversion of the riverbed of Kihansi River are expected to be small since Kihansi River in the section which has the planned power station site is very steep, consisting of continuous falls with exposed rocks at the riverbed. The effects of Kihansi River itself on the environment are expected to be small since Kihansi River joints a lot of rivers in the lower reaches of the outlet of the lower power station.

(12) Public Sanitation

In the villages of Uhafiwa, Ukami, etc., near the planned power station, helminthiasis and diarrhea are main diseases next to respiratory infections, and malaria, schistosomiasis, etc., carried by intermediate hosts which live still-water areas have not been recorded. The contraction of helminthiasis and diarrhea seems to be mostly owing to drinking valley water, etc. The existence of a lot of malaria patients and the inhabitation of harbour black flies which carry onchocerciasis in

swamp areas downstream from the outlet of the lower power station have been reported.

A still-water area of 3.9 km^2 will be submerged by the impoundment of the upper reservoir. If floating plants such as water cabbages, hornworts, water hyacinths, etc., and lakeside plants such as true grasses, especially reeds, etc., increase inside the reservoir, these plants are expected to not only become homes of snails which are intermediate hosts for haematozoa such as bilharzias but also promote the breeding of mosquitoes which carry malaria and filariasis.

If floating plants, lakeside plants, and sudds appear inside the reservoir which affect the breeding of snails and mosquitoes, it is desirable to remove and mow them as required. Harbour black flies are possible to inhabit in the waterways of the power station, and they should be properly exterminated for the sake of employees themselves.

The appearance of the reservoir will make it easier for residents to use its water than river water, and the proper educational activities on the application of water seem necessary to be conducted. The power station is expected to be operated without any problem by carrying out these measures.

(13) Cultural Assets and Recreation

No cultural assets regarded as archaeologically and historically important have been confirmed in the planned power station area or its vicinity.

The tourist sources of the project site area and its vicinity are regarded as poor at present, and not expected to be developed in the future either,

since the project site is far from major cities, has no good roads, and has almost no attractive wild animals inhabiting.

12.3.2 Matters Concerning Period of Construction Work

The natural environment can be avoided being altered regardless of size in the process of construction work, and there are two kinds of alteration consisting of permanent ones such as topographical and vegetational alteration, and temporary ones only in the period of construction work, such as noise and vibration. In the case of the former, the most fundamental measure is to minimize the gross area of converted land, and various protective measures should be rapidly taken without leaving the area unrestored. In the case of the latter, the best construction work methods and the best construction machines should be applied. These measures should be properly chosen on the basis of the object affected by the alteration of the natural environment. Even if the alteration of the natural environment is permanent, measures should be taken for turning its effects on the natural environment into temporary ones.

It is not ready to determine the detailed contents of construction work since the upper power station and lower power station are in the processes of the pre-feasibility study and the feasibility study respectively. Therefore, in the case of evaluating and the effects of the establishment of the power station on the environment and studying their measures, the fundamental policies of environmental protection measures will be shown on the basis of our experiences of constructing the existing power stations in the past in addition to the evaluations of only peculiar problems with this power station.

(1) Protection of Nature

There are designated areas relating to the protection of nature, such as the Uzungwa Scarp Forest Reserve and the Kilombero Game Controlled

Area. The purposes of both designated areas are not opposed to the construction of the power station, but people concerned should be informed of the objects of establishing the designated areas, the contents of their rules, and their borders.

Land such as the sites of temporary facilities, quarries, soil dumping grounds, etc., used for the construction work of the power station should be concentrated as much as possible at the irreducible minimum of necessities. The acquirement of concrete aggregates and dam construction materials from quarries can be reduced as much as possible by using riverbed deposits and excavation materials. Measures planned for the reinforcement and afforestation of slopes should be taken for avoiding flow of earth and sand while the arrangement of earth and sand behind the back of the dam and its application to public land facilities as construction materials should be considered.

(2) Vegetation

Trees in part of the forest reserve which will be submerged can be used as construction materials with the permission of the forestry department, but deforestation should be continuously superintended for avoiding the unruly development of this area by identifying the submerged area in advance. The supply of fuel to workers who engage in the construction work for preventing them from acquiring firewood in the forest is also expected to become one of the effective measures of environmental preservation in a certain sense.

(3) Animals

Since the temporary evacuation of regional animals due to the construction work of the power station is imagined, its artificial effects on the inhabitable environment of animals should be minimized during the period of the construction work and removed in the long run after the completion of the power station. Concrete measures are as follows:

i) The noise, vibration, lighting at night, etc., during the construction work should be carefully planned for avoiding the bad effects on the inhabitable conditions of animals.

ii) The unnecessary acquirement of animals should be prohibited by giving information on the protection of animals to workers related to the construction work and by preventing them from bringing in hunting tools such as hooks, etc.

iii) The inhabitable conditions of animals should be preserved by arranging and cleaning up inside the construction work area, removing construction materials and waste products after the completion of the construction work, and conserving rivers. Food should not be discarded carelessly.

Since part of the forest reserve is possible to remain as a shoal in the middle of the upper reservoir, it should be made sure of whether remaining animals exist or not before the submergence of the area.

(4) Aquatic Animals

Waste water from the construction site should be properly managed since deterioration in water quality tends to affect aquatic animals badly as a main cause during the period of the construction work.

(5) Water Quality

The occurrence of muddy water due to the excavation of earth and sand, etc., treated waste water from concrete plants, and living waste water from on-site offices, can be regarded as the causes of changes in water quality during the period of the construction work.

When underground water and rain water mixed with earth and sand coming from its excavation, transport, and dumping work during the period of dam, tunnel, and road construction work, flow into rivers the water gets muddy.

In the case of dam construction work, the large-scale occurrence of muddy water can be avoided by changing the direction of river water and discharging its clean water directly into the lower reaches of the dam through a by-pass tunnel for preventing it from flowing directly into the construction work area before the dam construction work starts. It is desirable to treat water which gets muddy by underground water and rain water from the construction work area in temporary-constructed sedimentation ponds, and to discharge its supernatant water into the rivers. After muddy water from tunnel construction work and aggregate plants, waste water from concrete plants, and wash water used for concrete mixer trucks are treated in the sedimentation ponds in the same way, it is also

desirable to discharge treated water into the rivers.

After living waste water from workers related to the construction work is treated in the sedimentation and filtration tanks, it should be discharged into the rivers. It is desirable to treat human waste in sewage disposal facilities, but if impossible, it is necessary to prevent this waste from flowing into the rivers by letting it percolate through soil.

(6) Noise

Machines such as aggregate plants, concrete plants, and construction machines are regarded as noise sources during the period of the construction work, but the construction work area is far from houses. It is expected that residents can avoid being affected almost completely. As for blasting, dynamite should be set in a time zone, exclusive of early morning and night.

Animals might temporarily evacuate from the construction work area, but it can be thought that there will be almost no effects on them in the long run.

(7) Vibration

Blasting is regarded as a vibration source during the period of the construction work, but it can be imagined that there will be almost no effects on both residents and animals in the long run and in the same way as noise.

(8) Transportation and Public Facilities

i) Transportation

After the construction work of the power station starts, traffic is expected to rapidly increase by the frequent transport of people and construction materials. Since the roads from Iringa and the power station are in a bad condition, traffic safety measures such as the complete execution of safety speed limits, etc., should be taken. Since residents along the roads have no traffic with access to towns, a lot of them probably want to use vehicles for the construction work. It is desirable to discuss the limitations on the application of these vehicles with the representatives of residents in advance in consideration of traffic safety.

ii) Public Facilities

Since a lot of people will engage in the construction work in a short period of time and the planned power station is located at a remote place deep in the mountain, public facilities such as a hospital, a school, a meeting place, etc., seem necessary to be prepared for construction workers and people who will go in and out of this area for the construction work.

These facilities which will be open to residents in this region are expected to contribute to improvement in their living conditions.

(9) Water System Utilization

Since rivers in the planned power station site and its vicinity are not used for fishery, agriculture, water-borne traffic, etc., there will be no effects of the construction work on them at all.

(10) Public Sanitation

During the period of the construction work, the maintenance, inspection, and management of construction machines, and the education of construction workers on safety should be promoted while a person in charge of each kind of dangerous construction work such as blasting, etc., should be appointed.

The satisfactory education on fires should be given to construction workers while measures against fires, such as the installation of equipment for fire-extinguishing purposes, and controls should be taken for preventing mountain areas from catching on fire.

The education on the concepts of sanitation should be given to construction workers in addition to facilities for sanitating the conditions of drinking water, food, clothes, houses, etc. The occurrence of diseases as a group should be prevented by the extermination of vermin carrying diseases, and the elimination of puddles suitable for homes of malaria mosquitoes.

12.4 Monitoring

The establishment of the power station is expected to scarcely affect the environment provoking a serious issue according to the present state of the environment and the evaluation of the effects on the environment. As a result of appropriate measures, some of the effects on the environment can be properly controlled for the protection of nature, and each one of the measures should be environmentally monitored for making sure of its results. The environmental monitoring should be conducted after the operational start of the power station and in the period of the construction work as well.

12.4.1 Matters following Completion of Power Station

(1) Animals

Since the finny tribe (fish species, No. of inhabitants, etc.) in the reservoir can be used effectively as an index to changes in water quality, and plants (floating plants and waterside plants) become homes for vermin, the occurring conditions of each one of them should be properly surveyed.

(2) Water Quality

The conditions of floating water in rivers will be changed by the construction of the power station. A huge still-water area will be created by the reservoir while some sections of rivers with increased or decreased floating water in the lower reaches of the power station will appear as well. The water quality of these sections should be properly surveyed for making sure whether or not deterioration in water quality occurs.

The survey of water temperature, transparency, pH, electrical conductivity, dissolved oxygen, and eutrophic salts is expected to be effective in determining water quality.

12.4.2 Matters Concerning Period of Construction Work

(1) Water Quality

Transparency, pH, etc., should be surveyed at the outlets of temporary-constructed sedimentation ponds and living-waste-water filtration tanks for the protection of water quality. The quality of waste water should be managed based on a certain determined density of each item.

(2) Noise and Vibration

It is desirable to properly confirm the situations of noise and vibration at chosen measuring points in neighbor villages.

12.5 Compensation

12.5.1 Legal Compensation in the United Republic of Tanzania

(1) Land Tenure in Tanzania

Under the provisions of the Land Act of Tanzania, the total land area in the Republic is PUBLIC LAND. Therefore, land may not be dealt as a direct object of purchase.

Land is controlled and managed by respective boards/councils appointed by the Ministry of Lands and Surveys, the sole custodian of Public Land. Subject to the provisions in this act, the powers vested in the appointed authorities enable them to have rights to administer, dispose of, and alienate any piece of land as may be deemed, for the interest of the public.

However, the majority of the PUBLIC LAND is held in two major categories of tenancy:-

i) Land held under LEASE HOLD GRANT

Land held under LEASE HOLD GRANT means Land surrounded with boundary stakes in the case where the survey of its location, area, and configuration is precisely made and the application for its tenure is granted to the applicant by the Country. The tenant can acquire holding rights as his property for borrowing money from a bank on the security of this property, etc., but he must pay rent to the Country. This is applicable mainly to Urban areas. This is sometimes applicable to the outskirts of Urban areas as well as in the case where the borders of farms and ranches are necessary to be confirmed as their property for

borrowing money from a bank. The contract for Land held under LEASE HOLD GRANT, extending over a long period of time such as several decades, is generally made. The tenure may be renewed. This is applicable to any person including foreigners.

ii) Land held by CUSTOMARY TENURE

This is applicable to the indigenous and mainly in Rural areas, and the customary tenure differs from tribe/District to tribe/District. Subject to the provisions in the act, it is equally lawful for persons holding land by customary tenure to occupy it without grant, lease, or license from a controlling authority.

Land is mutually confirmed by regional "witnesses" among residents. The borders of land are recorded (memorized) based on topographic characteristics such as certain trees, stones, etc. This tenure is determined based on the mutual fiduciary relation among residents, and not applicable to foreigners. Since there are no documents for proving the tenure of land, this tenure cannot be used for borrowing money on the security of real estate, but they are not obliged to pay rent to the Country. The tenure may be inherited.

Of the total area of the planned power station site in the Kihansi Hydroelectric Power Station Project, most land is estimated to be held by CUSTOMARY TENURE.

(2) Land held by Hydroelectric Power Station

Land required for the hydroelectric station is broadly divided into the DAM, POWER STATION FACILITIES, RESERVOIR, WATERWAY and TRANSMISSION LINE and ROAD. A certain area around the dam and power station facilities will be held under LEASE HOLD GRANT from the viewpoint of their maintenance and financial values. A zone called "Right of Way" or "Way Leave" will be established around the reservoir in the shape of a belt. The zone will not be subjected to the tenure of anybody, leading to the maintenance of the reservoir after all. "Right of Way" or "Way Leave" including the administrative road is about 100 m in width. "Right of Way" or "Way Leave" will not restrict the rights of the reservoir itself. The rights of aquatic utilization of the dam lake will belong to the Fisheries Department at the Ministry of Resources, and the utilization of the reservoir by fishermen with its fishery right will not be restricted.

A certain width of "Right of Way" or "Way Leave" will be also established on the ground for underground structures such as the water-conveyance and pressure-pipe line route. "Right of Way" or "Way Leave" which is about 60 m in total width or 30 m in width on the right and left sides will be established for the transmission line route in the same way.

(3) Land Acquirement Methods

The application for land acquirement should be made to the village assembly, District Council, Regional Council and Ministry of Land by turns for acquiring land held under LEASE HOLD GRANT. The tenure of

land will be finally granted to the applicant by the Ministry of Land.

In the case where land intended for application is overlapped by another person's land held under CUSTOMARY TENURE, this part is not approved by the village assembly, but it is possible to purchase the tenure. If land held by another person as vested rights belongs to land held under LEASE HOLD GRANT, all the formalities should be performed again with the approval of the person and require a great deal of labor and time.

(4) Compensation by Hydroelectric Power Station

In the case where a national project like the hydroelectric power station is carried out in an area whose land is held by CUSTOMARY TENURE, the processes of compensation are as follows:

i) An electric power company will be obliged to notify the Regional and District Authorities of the execution of the project and to apply for the acquirement of land.

ii) In the case where the effects of the project execution, such as house moving, etc., the electric power company will inform residents of this matter in advance.

iii) The rightful person having land held by CUSTOMARY TENURE will be informed of the acquirement of land.

iv) The person holding land will be compensated for his property belonging to its land.

v) In the case of house moving, the person concerned should leave the applicable land within three months.

(5) Estimation of Compensation Money

The organizations which are responsible for estimating the amount of compensation money are as follows:

i) Government Valuer (Regional)

ii) Land Officer (District)

iii) Representatives of the electric power company (Survey and Way Leave Dept.)

iv) Local CCM Official (Chama Cha Mupindose, Village Chairman)

v) Owner of the affected property, and other witnesses

The processes of compensation money estimation are as follows:

i) The above-mentioned organizations will conduct the on-site survey and record items worth paying.

ii) The Government valuer will estimate the amount of money for those items based on the standards of the Country.

iii) The catalogue of compensation items will be prepared based on the catalogue of estimated properties.

iv) The catalogue of compensation items will be sent to the committee of the Regional and District Authorities and approved by the members.

v) The approved catalogue of compensation items will be sent to the electric power company for payment.

vi) The electric power company will pay compensation money to the Regional and District Authorities in the case of having no objection to the results of the catalogue after confirming the coincidences between both contents of the catalogue and its own survey.

vii) The Regional and District offices will pay compensation money to the persons concerned.

(6) Objects intended for Compensation

In the case of individuals, objects intended for compensation mainly consist of houses and agricultural products. The amount of money required for house moving is estimated instead of the sale prices of houses. In the case of agricultural products, permanent products such as bananas, bamboos, and eucalyptus can be objects intended for compensation while seasonal agricultural products such as beans and corn are not sometimes compensated depending on the state of planting and harvest. In the case where part of the forest reserve is submerged by the impoundment of the reservoir, the deforestation rights of trees worth using will be sold by the Forest Department, and they will be deforested by a private company. Other miscellaneous trees might be deforested by

the electric power company before the area is submerged.

12.5.2 Outline of Compensation of Kihansi Project

(1) Present State of Planned Power Station Site

According to the results of the on-site survey, the area which will be affected by the construction of the power station has been cultivated for many years by the slash-and-burn method of agriculture for making a self-sufficient living. The persons holding land will lose their cultivating rights since part of their cultivated fields will be submerged by the impoundment of the reservoir. Two or three people near the lower dam site are living. They were all resettled in Ukami and Uhafiwa villages during "Operation Vijiji" (Villagezation) in 1974. However, they seem to have come home to their old places. They cultivate seasonal products such as beans, corn, and Irish potatoes, and have lived in thatch houses (huts), growing bananas, bamboos and eucalyptus trees.

Another considerable valuable property which will be affected by the project is the forest reserve. Part of the reservoir will be submerged by the impoundment of the upper reservoir over Kihansi River and its tributary named Ruaha River. The Forest Department should be informed of the submerged area before the completion of the power station for the effective utilization of forest resources. Since part of the forest reserve which will be submerged is National Land, it cannot be an object intended for compensation.

There are no objects intended for compensation, such as irrigation and public facilities near the planned power station site.

(2) Evaluated Amount of Compensation Money

The amount of compensation money is formally evaluated in the above-mentioned way, and the expected amount of compensation money can be grasped, showing T.SHS 969,000 (about US$7,000) in total according to the present state of permanent agriculture products and houses (Table 12-6).

Table 12-6 Expected Amount of Compensation Money

Item	Location	Estimated Quantity	Government Rate	Total Value
Banana	The Kihansi Project is dotted with banana clumps.	About 3,000 clumps	T.SHS 220/clump	About T.SHS 660,000
Bamboo Clusters	Very sparsely located in the area.	About 60 clusters	T.SHS 112/cluster	T.SHS 66,000
Eucalyptus trees	Found on the upper dam site, and near the confluence of Kihansi and Ruaha rivers. Also along the road on the way to the lower dam.	About 1,000 trees	T.SHS 110/tree	T.SHS 110,000
Huts (Houses)	The area about 300m upstream from lower dam.	4	T.SHS 4,000 house	T.SHS 20,000
		Grand total		T.SHS 796,600
		Estimated total ADD 20% increase of possible variation on rates		T.SHS 800,000 T.SHS 160,000
		Grand total of estimated coasts of compensation		T.SHS 960,000

12.6 Overall Evaluation

According to the on-site survey of the environment, there are two villages with a population of 3,400 and 540 houses. The planned power station site consists of these residents' burned/cultivated fields and their unused fields, and a great deal of nature there has been already changed. Residents live on a hill far away from the power station except huts for agricultural work, and they scarcely have to move their houses. There are almost no residents and facilities to be affected by the construction of the power station since Kihansi and Ruaha Rivers have no irrigation facilities. Part of the forest reserve with an area of 2.3 km^2 will be submerged by the planned impoundment of the upper reservoir, covering only less than 1% of the total area of the forest reserve with an area of 300 km^2.

Aquatic animals such as fishes, etc., are rarely seen in Kihansi and Ruaha Rivers since the water quality of both steep rivers with exposed rocks at the riverbed shows relatively strong acidity and sterility due to surface soil and burned/cultivated fields. The inhabitation of large-sized animals has not been confirmed since the planned power station site area is widely cleared away as burned/cultivated fields and their unused fields.

The power station is expected to largely contribute to the development of this region since public facilities such as roads, etc., are to be established following the construction and operation of the power station. The upper reservoir will provide waterfowls with new habitats, and residents with the possibility of the cultivation of fishes such as introduced species and of water-borne traffic respectively. However, the occurrence of harmful plants and vermin should be carefully controlled.

It is possible to lawfully acquire land required for the establishment of the power station under the provisions of

the Land Act of the United Republic of Tanzania. Since the compensation system for acquired land has been established and the amount of compensation money is small, this will not become a controversial issue at all. But proper substitute fields for cultivated fields to be submerged by the reservoir are expected to be prepared for preventing neighbor cultivated fields from being excessively used by the slash-and-burn method of agriculture.

As mentioned above, the power station is expected to affect the natural and social environment scarcely as a whole while this power station project aims at the stable supply of power, largely contributing to the development of regional societies.

As a part of the maintenance of the power station, the effects of the power station should be environmentally monitored for grasping changes in the environment.

DATA–1

NATIONAL PARKS AND OTHER WILDLIFE AREAS

SUMMARY

1. NATIONAL PARKS

A NATIONAL park represents a particular kind of land use intended to permit the maximum appreciation of protected areas of high value because of the nature and quality of their **flora, fauna** or **landscapes.**

A national park therefore is **"any area expressly acquired and managed primarily for recreation, or preservation or conservation of the natural environment, historical or archaeological sites".** In these areas, visitors are allowed to enter, under special conditions, for **inspirational, educational** and **recreational purposes.**

The parks have also been set aside for **future generations** as well as for both **aesthetic and economical value.**

2. CONSERVATION AREAS:

The word **conservation** (which means proper use of our natural resources) may be misleading to some people. But for our purpose here, there is only one conservation area — Ngorongoro. The area attempts to integrate in the best way, the interests and rights of the pastoral Maasai, the conservation of natural resources and tourism.

As a result the Ngorongoro Conservation Area has been zoned to include particular land use areas that are compatible with each of these interests.

Agriculture is prohibited, but Maasai activities such as livestock grazing and residence are allowed. Preservation of natural resources, research, and tourism continue in conjunction with human activities.

3. GAME/WILDLIFE RESERVES:

There are more than 15 Game and/or Wildlife Reserves, among which is the world's largest — the Selous Wildlife Reserve. Game Reserves are administered by the Game Department assisted by their respective Regional Directorates. Apart from protecting the animals and plants, Game Reserves have been set aside as limited natural resource use sites.

Therefore, some human activities can take place in the reserve, yet residence — except for reserve employees — is prohibited. Licensed professional hunting is allowed only between July and December.

The following are the Game Reserves and their areas:—

RESERVE'S NAME	AREA (SQ KM)	REGION(S) FOUND
1. Selous	55,000	Coast, Morogoro, Lindi, Mtwara and Ruvuma
2. Saadani	300	Coast
3. Rungwa	9,000	Singida
4. Kizigo	4,000	Singida
5. Moyowosi	6,000	Kigoma
6. Ugalla	5,000	Tabora/Rukwa
7. Uwanda	5,000	Rukwa
8. Maswa	2,200	Shinyanga
9. Burigi	2,200	Kagera
10. Biharamulo	1,300	Kagera
11. Rumanyika Orugundu	800	Kagera
12. Ibanda	200	Kagera
13. Umba	1,500	Tanga
14. Mkomazi	1,000	Kilimanjaro
15. Kilimanjaro	900	Kilimanjaro
16. Mount Meru	300	Arusha
17. Saa Nane Island	0.5	Mwanza

4. GAME CONTROLLED AREAS:

Approximately 50-60 Game controlled Areas exist in Tanzania. They cover about 121,655 Sq. Km. spread across the country. These areas are administered by the Game Department through Regional Directorates.

Licensed hunting for all game species is approved except for specifically designated animals. The licence can be obtained from the Director of Game Division.

Game control against crop or property is allowed. All such game control must be reported to the game officials as soon as possible.

5. FOREST RESERVES:

Forest Reserves are supervised by the Forestry Department, and in these areas human habitation is limited to reserve employees only. The purposes of setting aside Forest Reserves are many and varied. They include the following:-

(i) **Natural National Heritage and Tourism:** To the non-resident to Tanzania, the most apparent reason for conserving these forests

is for their uniqueness. This is an attraction to the visitor. The Kilimanjaro forest is a good example.

(ii) **Watershed:** Providing water to the surrounding agricultural lands and fishing areas. Without it, soil erosion, followed by floods may easily occur. The area may no longer store water for release to the surrounding areas in the dry seasons. In view of these circumstances, deserts may soon follow. In this regard, the Ngorongoro highlands, the Mount Meru and Kilimanjaro forests support the argument.

(iii) **Climate:** Forests have an effect on rainfall. The larger the forest the more its effect to agriculture. They are also a major source of the Oxygen supply.

(iv) **Research:** Admittedly, forests give us a standard with which to compare the ecological changes with human activities on the natural environment.

(v) **Genetic Storehouse:** Through conservation of forests, we conserve an invaluable genetic wealth. The genetic diversity allows possibilities for the discovery and development of:-

— medicines from plant and animal material; for example the Traditional Medicine Research Department at Muhimbili Medical Centre is involved in this field;
— alternative sources of fuel and rubber;
— food crops;
— animal species important for husbandry and medical research;
— insect species important for the control of crop pests. For instance in early 1988, Tanzania imported from Nigeria some insects — *wasps* — which were used to control pests that were attacking cassava plants;
— predators of pests: many animal species living in the forest that feed on insects (insectivores) which are pests to man and his food crops. Birds, bats and predators of insects are examples. Total destruction of forests means the loss of many insectivorous species which are beneficial to man.

In Tanzania, forest reserves are scattered all over the country. Some of these are administered by the local governments in the regions.

Timber and animal harvesting can be done in these areas after obtaining a licence from the Directors of Forestry and Game Departments respectively. The total area under Forest Reserves is about 134,075 Sq. Km. This area includes both productive and protective areas.

DATA－2

TANZANIA COMMON WILD ANIMALS

ANIMALS \ PARK	SERENGETI	MANYARA	TARANGIRE	ARUSHA	K'NJARO	MIKUMI	RUAHA	KATAVI	GOMBE	MAHALE	RUBONDO	UZUNGWA	NGO'RO	SELOUS
1. Aardvark	•		•			•	•	•		○		•		•
2. Baboon	•	•	•	○	•	•	•	•	•	•	•	•	•	•
3. Bat-eared Fox	•	•	•			•	•	•		•		•	•	•
4. Black and White Colobus Monkey	•,			•	•				•	•	•	•		•
5. Blue Monkey	•	•	•	•	•	•	•	•	○	•	•	•	•	•
6. Buffalo	•	•	•	•	•	•	•	○	•	•	•	•	•	•
7. Bush Pig	•	•	•	•	•	•	•	•	•	•	•	•	•	•
8. Bush buck	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9. Civet	•	•	•	•	•	•	•	•	•		•	•	•	
10. Chimpanzee								•	•					
11. Cheetah	•	•	•			•	•	•				•	•	•
12. Dik Dik	•	•	•,	•		•	•	•	•	•	•	•	•	•
13. Duiker	•	•	•	•	•	•	•	•	•	•		•	•	•
14. Eland	•		•		•	•	•	•				•	•	•
15. Elephant	•	•	•	•	•	•	•	•		•	•	•	•	•
16. Genet	•	•	•	•	•	•	•	•		•		•	•	•
17. Gerenuk	•	•	•			•	•	•		•		•	•	•
18. Giraffe	•	•	•	•	•	•	•	•		•	•	•	•	•
19. Grants Gazelle	•	•	•	•		•	•	•		•		•	•	•
20. Grysbok (sharpe's)										•				•
21. Greater Kudu	•		•				•							•
22. Hartebeest	•	•	•			•	•	•		•		•	•	•
23. Hippo	•	•	•	•		•	•	•		•	•	•	•	•
24. Honey Badger	•		•		•	•	•	•		•		•	•	•
25. Hyrax	•	•	•	•	•	•	•	•	•	•	•	•	•	•
26. Hyena	•	•	•	•		•	•	•		•		•	•	•
27. Impala	•	•	•	•		•	•	•		•		•	•	•
28. Jackal	•	•	•	•	•	•	•	•		•		•	•	•
29. Klipspringer	•	•	•	•	•	•	•	•		•		•	•	•
30. Leopard	•	•	•	•	•	•	•	•	•	•		•	•	•
31. Lesser Kudu	•		•				•							•
32. Lion	•	•	•			•	•	•		•		•	•	•
33. Mongoose	•	•	•	•	•	•	•	•		•		•	•	•
34. Oryx			•			•	•	•				•	•	•
35. Oribi	•	•	•			•	•	•					•	•
36. Red Colobus Monkey									•	•		•		
37. Reedbuck	•	•	•	•	•	•	•	•		•		•	•	•
38. Roan Antelope	•		•			•	•	•		•		•	•	•
39. Rhino	•	•	•	•		•	•	•		•	•	•	•	•
40. Sable Antelope	•		•			•	•	•		•		•	•	•
41. Sanje Mangabey												•		
42. Serval	•	•	•	•	•	•	•	•		•		•	•	•
43. Sitatunga											•			•
44. Steenbok	•					•	•	•		•				•
45. Squirrel	•	•	•	•	•	•	•	•	•	•	•	•	•	•
46. Suni	•	•	•	•	•	•	•	•		•		•	•	•
47. Sykes Monkey									•			•		
48. Topi	•					•		•				•	•	•
49. Thomson's Gazelle	•	•	•			•	•				•		•	
50. Warthog	•	•	•	•	•	•	•	•	•	•	•	•	•	•
51. Waterbuck	•	•	•	•	•	•	•	•	•	•	•	•	•	•
52. Wildebeest	•	•	•	•		•	•	•		•		•	•	•
53. Wild Dog	•						•						•	•
54. Vervet Monkey	•	•	•	•	•	•	•	•	•	•	•	•	•	•
55. Zebra	•	•	•	•		•	•	•		•		•	•	•
56. Zorilla	•	•	•			•	•	•		•		•	•	•

K'NJARO = Kilimanjaro　　NGO'RO = Ngorongoro

Chapter 13 ECONOMIC EVALUATION AND FINANCIAL ANALYSIS

Chapter 13

ECONOMIC EVALUATION AND FINANCIAL ANALYSIS

Contents

List of Tables

List of Figures

Chapter 13 ECONOMIC EVALUATION AND FINANCIAL ANALYSIS

13.1 Economic Evaluation

13.1.1 Methodology and Basic Conditions

(1) Methodology

In general, economic evaluation of a development project is designed to measure its socio-economic impact on the country as a whole by comparing two cases; the project is implemented and the project is not implemented.

The economic evaluation employs indices such as net present value of the project, benefit/cost ratio and economic internal rate of return which are calculated from benefits and costs of the project using the "Discounted Cash Flow method".

To determine benefits and costs of a project, market prices obtained should be converted to real benefits and costs, since these are generally distorted due to taxes, government subsidies, import control, import duties, public charges, minimum wages, and other government intervention and monopolistic pricing.

The World Bank and other international financing organizations employ international market prices to estimate real project costs and benefits. The method of economic evaluation employed by the World Bank and other international financing organizations may be summarized as shown in Fig. 13-1.

Phase 1: To exclude items to be transferred to national income from market prices.

Phase 2: To convert market prices for trade goods, non-trade goods, skilled labor, unskilled labor and other items to real (border) prices.

Phase 3: To determine the internal rate of return on the basis of real benefits and costs, and compare it with opportunity cost of capital in the country.

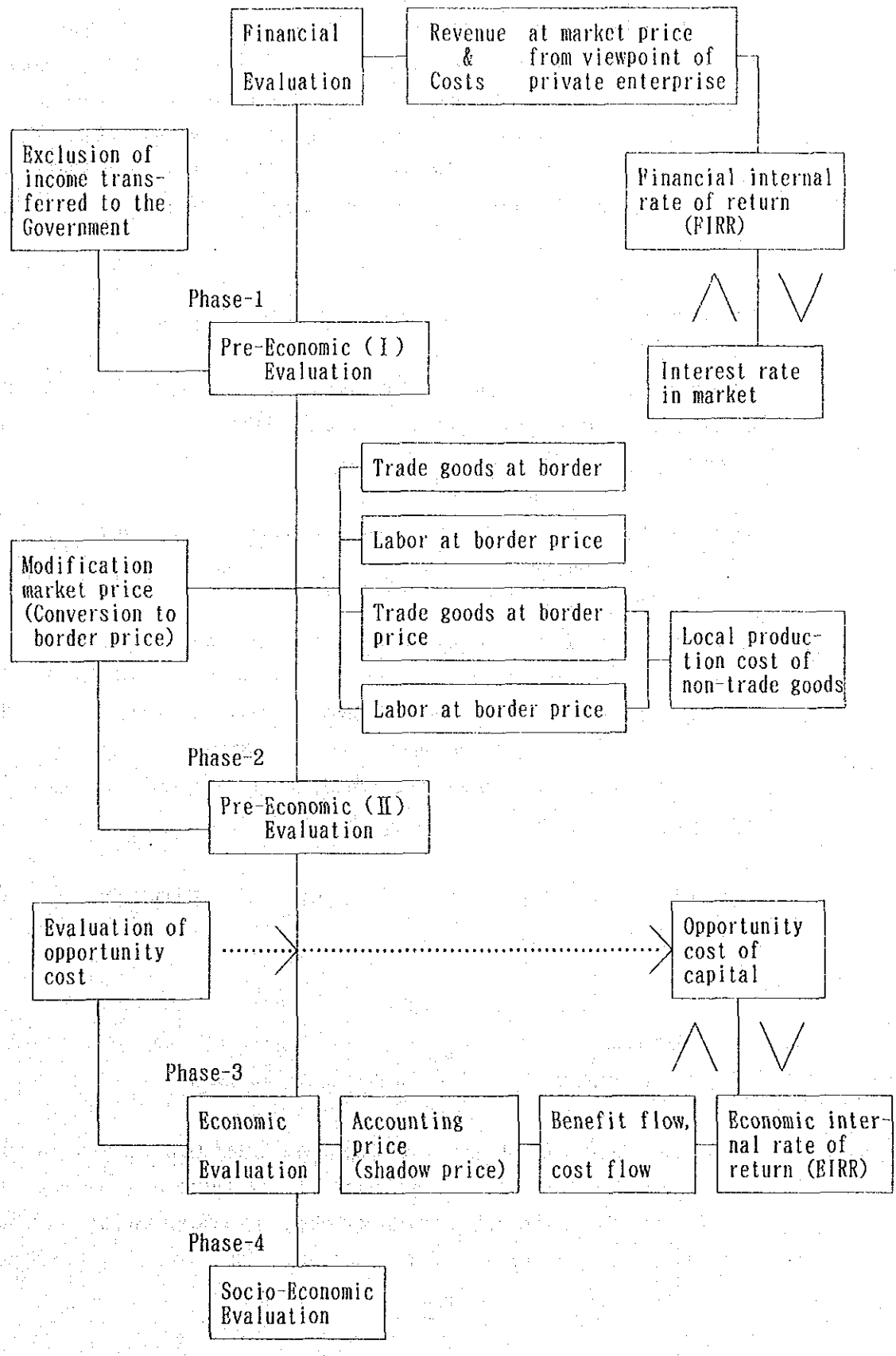
Phase 4: To carry out a socio-economic evaluation considering national saving and income distribution.

For this project, economic evaluation up to Phase 3 is carried out (See Fig. 13-1).

In economic evaluation of hydroelectric power development projects, it is more realistic to measure and compare benefits and costs of the project using the long-term marginal cost method or the tariff system method, if benefits can be accounted for.

However, if benefits cannot be easily accounted for and the project is incorporated in a long range electric power development program which is a part of a national socio-economic development policy to satisfy future power demand (i.e., if the project is not implemented, other means of power supply are to be substituted for it), an alternative plant approach will be employed to measure and evaluate economic costs of the proposed project and the alternative project.

Fig. 13-1 Flow Chart of Economic Evaluation of the Project



For this project, the alternative plant approach is employed. Usually, the capacity benefit (kW benefit) of a hydro-power plant is evaluated at the fixed cost of an appropriate alternative thermal power plant which has an equivalent capacity to the firm capacity of the hydro-power plant. The energy benefit (kWh benefit) is taken to be equal to the variable cost of an alternative thermal power plant which produces an equal amount of energy.

(2) Conversion to Border Price (Economic Cost)

The construction cost described in Chapter 8 shall be converted to border prices according to the following conditions:

i) Exclusion of Import Duties and Interest during Construction

The foreign currency portion of the construction cost, described in Table 8-13 and Table 8-23, Chapter 8, includes 20% import duties. To estimate the economic cost, those import duties shall be excluded, as well as the interest during construction.

ii) Conversion of Local Currency Portion to Border Price

To convert the local currency portion of the construction cost to the border prices, Shadow Exchange Rate (SER) shall be used.

SER, a concept in economic evaluation based on the UNIDO-Method, is originally a shadow price to convert international market prices indicated in foreign currency to those in local currency

portion and is equal to the reciprocal of Standard Conversion Factor (SCR) based on OECD-Method. In this report, SER is used as a factor to convert the local currency portion of the construction cost to the border prices in foreign currency.

The cost estimation of the project is based on price level as of June, 1989 and the official exchange rate at that time was US$1 = 140 Tsh. On the other hand, the actual parallel rate at that time was around US$1 = 210 Tsh. Accordingly, SER for this project is calculated as follows:

SER = 140 Tsh/210 Tsh ≒ 0.67

This SER is nearly equal to the SCR (0.70) which was estimated by the World Bank for the Mwanza Shinyanga Rural Development Project in Tanzania, so 0.67 shall be adopted as SER for the project.

(3) Alternative Thermal Power Plant

As an alternative thermal power plant to evaluate the benefit of the Project, the indigenous coal thermal power plant at mine mouth was selected as described in Section 8.2.1, Chapter 8. Basic concept and conditions of the 100 MW coal-fired thermal power plant including the transmission line selected as the alternative thermal power plant are as follows:

- Construction Cost (Economic Cost)
  Thermal Power Plant : $97,140 \times 10^3$ US$
  (971,4 US$/kW)
  * Transmission Line : $59,763 \times 10^3$ US$

- Service Life
  Thermal Power Plant : 25 years
  Transmission Line : 35 years

- Construction Period
  Thermal Power Plant : 4 years
  Transmission Line : 2 years

- Operation & Maintenance Cost
  Thermal Power Plant : 3% of Construction Cost
  Transmission Line : 1.5% of Construction Cost

- Fuel Cost : 0.0203 US$/kWh

- Station Service Rate
  kW : 6.0%
  kWh : 6.0%

- Forced Outage Rate : 4.0%

- Scheduled Outage Rate: 12.0%

- Transmission Loss Rate
  Capacity Loss Rate : 6.2%
  Energy Loss Rate : 6.2%

* Estimated Cost between Songwe, Kiwira field and Dar Es Salaam.

(4) Other Basic Conditions

The other basic conditions for confirming the economic evaluation of this project are as follows:

i) Operation and Maintenance Costs of the Hydroelectric Power Station

Civil Structure : 0.5% of the construction cost
Hydraulic
Equipments : 1.5% of the construction cost
Electro-Mechanical
Equipments : 1.5% of the construction cost

ii) Service Life of the Hydroelectric Power Plant

Civil Structure : 50 years
Hydraulic Equipments : 35 years
Electro-Mechanical Equipments: 35 years

iii) Station Service Rate, Scheduled Outage Rate and Forced Outage Rate of the Hydroelectric Power Station

Station Service Rate
kW : 0.3%
kWh: 0.3%
Scheduled Outage Rate: 2.0%
Forced Outage Rate : 0.3%

iv) Transmission Loss Rate of the Hydroelectric Power Plant

Capacity Loss Rate: 1.8%
Energy Loss Rate : 1.8%

v) Discount Rate

The discount rate shall be set at 10%.

13.1.2 Economic Analysis

(1) Benefit of Project

The firm peak power and the annual firm energy to estimate the benefit of the project are as follows.

Power Generation increase in the Lower Kihansi Project due to regulating effect of the Upper Kihansi Project is considered as all belonging to the Upper Kihansi Project.

	Firm Peak Power	Annual Firm Energy
Upper Kihansi Project	86.1 MW	335.7×10^6 KWh
Lower Kihansi Project	101.8 MW	551.0×10^6 KWh
Total	187.9 MW	886.7×10^6 KWh

Evaluated KW benefit and KWh benefit considering the transmission loss rate, the station service rate, the forced outage rate and scheduled outage rate of this project and the alternative thermal power plant are as follows:

KW benefit: 1,247.5 US$/KW + O & M Cost
(971.4 US$/KW x 1.28423)

KWh benefit: 0.2254 US$/KWh
(0.0203 US$/KWh x 1.11039)

Benefit flow of this project considering the service life is presented in Table 13-1.

(2) Cost of Project

Economic cost of the initial investment for the project which was converted from the construction cost indicated in Chapter 8 is as follows:

Upper Kihansi Project	$174,058 \times 10^3$ US$
Lower Kihansi Project	$125,581 \times 10^3$ US$
Total	$299,639 \times 10^3$ US$

Cost flow of the total investment cost throughout the service life and the operation and maintenance cost are presented in Table 13-1.

(3) Result of Analysis

The results of evaluation of surplus benefit (B-C), benefit-cost ratio (B/C) and equalizing discount rate (Economic intenal rate of return: EIRR) based on the cost flow and the benefit flow of the project (Table 13-1) are as follows:

B-C: $146,347 \times 10^3$ US$ (Discount rate: 10%)
B/C: 1.76 (Discount rate: 10%)
EIRR: 39.31%

As indicated by indices of B-C and B/C, the costs of construction and operation of this project are smaller than those of an alternative thermal power plant which can provide equivalent service, and it can be concluded that the project is much superior to the alternative plan. It can be also concluded that the project can continue to maintain its superiority as long as the discount rate which reflects the capital opportunity cost does not exceed 39.31%.