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The United Republic of Tanzania

THE FEASIBILITY STUDY ON LOWER HAI AND LOWER ROMBO AGRICULTURAL DEVELOPMENT PROJECT

Volume 2

ANNEX REPORT

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ON

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PROJECT

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1. GENERAL

This Annex deals with the studies for the selection of development potential areas and development priority areas (the Project area). Through the studies in Phase-1 and Phase-2 of this Study, both the surface water resources and groundwater resources were thoroughly investigated in both Lower Hai and Lower Rombo areas. Then, groundwater development potentials and available surface water resources were estimated. The land resources were roughly estimated through preliminary investigation of soils and land use especially in the existing irrigation areas. Based on these investigations and analyses, development potential areas were identified, from which development priority areas were selected through formulation of preliminary development plans.

2. AGRICULTURAL DEVELOPMENT POTENTIAL AREAS FROM THE VIEW OF WATER RESOURCES

Rainfall amount is limited to 400 mm to 800 mm per annum in the lower Hai area or 700 mm to 1,000 mm in the lower Rombo area. The most of rainfall comes from April to May and from November to December. Surface water resources in the Lower Hai area are quite limited in the dry season and almost fully utilized for agriculture as well as domestic use. In the lower Rombo area, surface water is available only in the Lume river. Under such constraints of water resources, agriculture remains at very low productivity in the most of both the lower Hai and lower Rombo areas.

Taking the above situations into account, the investigation in Phase-1 and Phase-2 was concentrated on assessing the available groundwater resources and surface water resources for agricultural development and to select the development potential areas from the view points of water resources as well as land resources except for areas where existing irrigation facilities are planned to be rehabilitated or being rehabilitated by Zonal Irrigation Office under the technical and financial assistance of FAO.

2.1 Lower Hai Area

2.1.1 Potential area with groundwater resources

The reconnaissance survey should that the following two areas were expected to have groundwater.

(1) Sanya plain; downstream of Sanya river, and
(2) Mtakuja area; area along the Kikuletwa river near the border with Arusha Region.

According to the electric prospecting survey carried out in the Phase-1 stage, test drilling and a pump-up test were carried out at the points named as JC1 and JC2, which were points selected as the highest potential points of groundwater resources. The results are shown below:

(1) JC1 Point

Drilling depth	:	45.6 m
Static water level at lifting test	:	5.0 m below ground surface
Screen	:	7.1-18.1 m and 32.5-43.5 m below ground surface
Results of Constant Pumping Test		
Pumping hours	:	5.5 hr
Discharge	:	8.9 lit/sec
Drawdown	:	11.7 m or more
Results of Step-drawdown Test		
Discharge (lit/sec)	:	3.4 4.4 5.7

Drawdown (m)	:	2.8 3.5 5.5

(2) JC2 Point

Drilling depth	:	93.8 m
Static water level at lifting test	:	2.5 m below ground surface
Screen	:	19.0-24.5 m, 35.5-52.0 m and 61.5-67.0 m below ground surface
Results of Constant Pumping Test		
Pumping hours	:	5 hr
Discharge	:	22 lit/sec
Drawdown	:	2.1 m
Results of Step-drawdown Test		
Discharge (lit/sec)	:	5.90 11.1 14.0 20.0 22.0
Drawdown (m)	:	0.57 1.2 1.7 2.1 2.2

Analyzing these results, the relationship between time lapse and drawdown of groundwater level at various constant yields are developed as illustrated in Fig. 2-1 and Fig. 2-2. The results indicate that the JC2 point is promising to provide much amount of groundwater resources.

In order to understand precisely the underground aquiferous structures, supplemental electric prospecting was conducted and it was found that the area having the same aquiferous structures as JC2 point, extends along the lower reaches of the Sanya river as shown in Fig. 2-3, where agricultural activity is extensively performed at present. Fortunately a 33 kV power transmission line runs across the area. It is therefore judged that exploitation of groundwater is promising for agricultural development in this area.

As for the Mtakuja area, test drilling and pump-up test were carried out near the Kikuletwa river and it is found through the analysis of the pump-up test results that 5 lit/sec is expected to be available per one tubewell. The area where the groundwater is expected extends along the Kikuletwa river in a width about 1 km where agricultural farming is practiced, however the yield of one tubewell is relatively small for resources of irrigation development.

2.1.2 Potential area on surface water resources

Irrigation water for agricultural development are expected to be obtained in the following three sources:

Sanya river and Boloti swamp,
Weru Weru river, and
Kikuletwa river.

(1) Sanya river, Boloti swamp and their benefited area

Boloti swamp located in the upper Mungushi river in northern end of the Study area on the foot of Mt.Kilimanjaro is the only place to create a reservoir. Its surface area is about 1.2 km^2, and even in the dry season a little water stays in the swamp. However, the catchment area of the Rawashi river, which flow into the Boloti, is as small as 14 km^2 and annual run-off is estimated at only 2.3 MCM in drought year at return period of ten years.

In order to efficiently utilize the surface water resources of the Sanya river, of which most of water flows down during the rainy season from April to June and negligibly small in the other season, it is conceivable to divert water from the Lawati river, which is one of major tributary of the Sanya river, and to store in the reservoir for dry season irrigation. The Lawati river has a catchment area of 42.5 km^2 and its annual run-off in drought at return period of ten years is estimated at 7.2 MCM.

As regards land resources to utilize the above mentioned surface water resources, the following three areas are conceivable. One is a farming area which extends downstream of Boloti swamp, about 250 ha, hereinafter called Boloti area, second is Mungushi irrigation area, about 200 ha located along the right bank of the Sanya river in the middle reaches, and third is an area, about 1,100 ha astride the Sanya river downstream reaches in southern part of the Arusha-Moshi railway, hereinafter called Sanya plain.

(2) Weru Weru river and its benefited area

The Weru Weru river flow is hopeful in water resources for agricultural development as stated in Annex B. There is an existing headworks on the Weru Weru river at some 3 km upstream of the crossing point with Arusha-Moshi highway. About 0.5 m^3/sec or more has been diverted at the Kimashuku intake since the intake was improved in 1979. The Problem is, however, the water right, in which the Kimashuku irrigation system is granted only 0.06 m^3/sec (2 cusec), and the water allocation between users of the Weru Weru river water resources, such as Musa Mwijanga irrigation system, Kikafu Chini irrigation system and TPC. In order to make clear the water amount to be taken by the Kimashuku scheme and its development scale, water balance study is required among the irrigation areas.

(3) Kikuletwa river and its benefited area

The Kikuletwa river has abundant discharge of about 12 m^3/sec at the confluence with the Kware river collecting spring water of Rundugai. However, the river forms gorge of 20 to 30 m in depth which requires pumping-up of water in order to irrigate the area along the river. Further the area is much undulating and has a lot of hills of lahar.

In Arumeru District, Arusha Region, the Kikuletwa river is flooding in every rainy season since 1977 due to heavy sedimentation on the river and no or little water is flowing in Hai District even in the rainy season. If river training is performed in the reaches of the Kikuletwa river where river water is overtopping its both banks, flood in Arumeru District can be mitigated and it is obvious that the existing Katambai canal will get water for irrigating Mtakuja area.

Considering the above situations, from the view of surface water resources, Boloti area, Mungushi area, Sanya plain, Mtakuja area, and Kimashuku area are conceivable as potential area for agricultural development.

2.2 Lower Rombo Area

Boring tests were carried out at two points where groundwater resources were expected as the results of an electric prospecting survey, however the tests indicate that no or little groundwater is available in the shallow zone.

The Lume river is the only source of surface water in the lower Rombo area and serves irrigation water for the existing irrigation area, the so-called Ikuini scheme, of about 300 ha in which rehabilitation of irrigation facilities is executed with an assistance of FAO. The river discharge is 0.4 m^3/sec on an average in the rainy season 1988/89. However the discharge fluctuates much during the rainy season due to the steep gradient of the river and small catchment area. It seems to be difficult to stably irrigate entire area of 300 ha in Ikuini scheme even in the rainy season. In the dry season, the discharge becomes less than 0.1 m^3/sec. Due to such limited water resources, no extension of irrigation area could be expected. In order to get surplus water for irrigation, it is necessary to provide a reservoir to store excess water in the rainy season. However, no place suitable for a reservoir can be found on the Lume river.

2.3 Agricultural Development Potential Areas

It is concluded from the preliminary screening in view of water resources that the following areas are identified as potential development area:

Name of area	Land Resources (ha)	Water Source
Boloti	200	Boloti swamp
Mungushi	250	Sanya river
Sanya plain	1,400	Sanya river and groundwater
Kimashuku	1,800	Weru Weru river
Mtakuja	300	Kikuletwa river and groundwater

The location of each area is shown in Fig.2-4.

3. PRESENT SITUATION OF DEVELOPMENT POTENTIAL AREAS

3.1 General Features of the Development Potential Areas

All the development potential areas identified are located in the Lower Hai area. The characteristics common to all the development potential areas such as agro-economic background, crop yield, farm inputs and labour requirement, marketing and prices, and crop budgets are described in this Section.

Other present situations of each development potential area identified through the preliminary survey are summarized the following sections.

3.1.1 Agro-economic background

The development potential areas can be divided into following three (3) agro-economic zones:

The north zone including Boloti downstream and Mungushi areas, the northern side of the Moshi-Arusha highway, extends for an economic zone with Boma Ng'ombe, a current headquarter of Hai District, and Sanya Juu, previous headquarter, forming an axis. The commercial distribution network expands in this zone with the increased commercial production of maize and beans as well as coffee and bananas produced in the mountainous areas.

The south west zone including Sanya plain, the southwestern side of the highway, is mainly pasture lands where the traditional migrating livestock grazing is currently dominant, and gradually provides way to settlements with the area eventually being divided into farmland for settlers and areas for collective livestock grazing. This zone becomes a stable meat and egg supply base for Moshi as well as for the Hai District as a whole.

The south east zone including Kimashuku area, the southeastern side of the highway, is gradually incorporated into the Moshi economic zone as a food production base and residential areas in accordance with the expansion of Moshi's urban functions.

3.1.2 Crop yield

Attempts to assess the present crop yields for common crops such as maize, beans, onion and tomato in the development potential areas were based on the average yield of crops in Hai District last 10 years. Yield of maize is estimated as much varies year by year with the maximum of 1.8 ton/ha in 1985/86 and the minimum of 0.25 ton/ha in 1986/87. The average is 1.04 ton/ha. Yield of beans has the same tendency as that of maize with the maximum of 1.2 ton/ha in 1985/86, the minimum of

0.04 ton/ha in 1980/81, and the average of 0.49 ton/ha. Yield of onion and tomato are 11 ton/ha and 17 ton/ha, respectively.

3.1.3 Farm inputs and labour requirement

The farm inputs and labour requirement per ha of maize, beans, onion and tomato of the development potential areas are estimated on the basis of the data collected from Hai District and interview of the farmers as follows:

	Maize	Beans	Onion	Tomato
Seeds (kg)				
Pure Stand	25	50	10	1.25
Intercropping	20	25	-	-
Fertilizers (kg)				
Nitrogen (N)	0	0	110	110
Phosphate (P)	0	0	0	0
Potassium (K)	0	0	0	0
Agro-chemicals (lit)	0	0	4	3
Labour (md)				
Family	60	70	120	120
Hired	0	0	122	116
Total	60	70	242	236

3.1.4 Prices

Prices of agricultural products and inputs in 1988/89 are estimated as follows:

(Unit: Tsh.)

	Unit	Price
Crops		
Maize	kg	14.83
Beans	kg	40.67
Onion	kg	34.90
Tomato	kg	25.61
Inputs		
Seeds		
Maize	kg	85.00
Beans	kg	35.00
Onion	kg	500.00
Tomato	kg	6,000.00
Fertilizers		
Urea	kg	12.00
TSP	kg	9.60
Agro-chemicals	kg/lit	1,200.00
Tractor	ha	3,750.00
Labour		
Light	man-day	200.00
Heavy	man-day	400.00

3.1.5 Crop budgets

Crop budgets per ha for maize, beans, onion and tomato in the development potential areas were calculated from the farm input and labour requirement, crop yields and current prices. The crop budgets per ha are calculated as follows:

(Unit: Tsh.)

	Maize	Maize/ Beans*	Beans	Onion	Tomato
Gross Income	15,423	22,506	19,928	383,900	435,370
Production Cost	4,125	4,313	4,125	73,086	68,276
Net Return	11,298	18,194	15,803	310,814	367,094

Remarks: *; Intercropping, (See Table 3-1)

3.2 Sanya River Basin

Three areas such as the Boloti area, the Mungushi area and the Sanya plain are identified as areas to be benefited by the water resources of the Sanya river and the Boloti swamp. The Sanya plain is expected to obtain groundwater resources. The present situation of these areas are summarized in the following sub-sections.

3.2.1 Natural conditions

Annual rainfall amount is roughly 800 mm in the Boloti and the Mungushi areas. The Sanya plain has annual rainfall of about 500 mm on average, and most of the rainfall is concentrated in the rainy season from March to May.

In Boloti swamp downstream and Mungushi areas, stony and/or moderately deep to shallow medium to fine soils are found and these areas are slightly undulating to undulating topography. In Sanya plain, deep to moderately deep fine alluvial soils are found. The topography of this area is flat. The land suitability classes and area extent are classifies as follows:

(Unit: ha)

Area	S1	S2	N	Total
Boloti	0	380	80	460
Mungushi	0	310	60	370
Sanya Plain	1,310	140	1,700	3,150
Total	1,310	830	1,840	3,980

The lands classified as S1, 1,310 ha or 33% of the area, are suitable for agricultural development. The S2 lands, 830 ha or 21% of the area, are marginally suitable for agricultural development and special measures will be required. The lands classified as N are not suitable for agricultural development.

Preliminary land classification maps are shown in Fig.3-1 to 3-5.

3.2.2 Administration and population

Administratively, Boloti and Mungushi areas belong to Mungushi village, Masama South Ward and Sanya plain belongs to Sanya Station village of that ward.

According to the population census in 1988, populations of Mungushi village and Sanya Station village are 2,225 and 2,652, respectively. The population densities are as low as 75 and 49 per square km, respectively. It is low compared with the figures of Hai District and Kilimanjaro Region.

3.2.3 Agriculture and agro-economy

Boloti area, Mungushi area and Sanya plain which are selected as a development potential area are utilized for agriculture at present. The forming areas in net are 250 ha, 200 ha and 1,140 ha, respectively.

In Sanya river basin, maize and beans are cultivated in the rainy season, generally from April to September. Vegetables are also planted in limited area of the Mungushi area where irrigation water is available. The planting and harvesting areas to the net cultivated lands in Sanya river basin are estimated as follows:

(Unit: ha)

Area/Crops	Rainy Season		Dry Season		Total of
	Plant	Harvest	Plant	Harvest	Harvest
Boloti					
Maize/Beans*	250	200	-	-	200
Mungushi					
Maize/Beans*	200	160	-	-	160
Vegetables	-	-	30	30	30
Total	200	160	30	30	190
Sanya Plain					
Maize	680	340	-	-	340
Beans	460	230	-	-	230
Total	1,140	570	-	-	570

Remark: *; intercropping

In Sanya river basin, land preparation is mainly made by hired tractors. Planting, weeding and harvesting are done manually. Seeds of maize and beans are prepared on the farm and seeds of vegetables are generally purchased. Use of fertilizers and agro-chemicals is common only for vegetables in Mungushi area.

Present crop production of Sanya river basin is calculated from net cultivated lands, cropping intensity and above crop yields as follows:

(Unit: ton)

	Maize	Beans	Onion	Tomato
Boloti	166	50	0	0
Mungushi	133	40	165	255
Sanya Plain	354	113	0	0
Total	653	203	165	255

3.2.4 Irrigation

There is a small irrigation canal, a so-called traditional furrow, branching off the Mungushi river originating from the Boloti swamp in the Boloti area. The canal has no structures except the crossing point of the canal under the asphalt-paved road connecting between Sanya Juu and Boma Ng'ombe where a pipe culvert is provided. On-farm irrigation facilities are generally not provided.

The Mungushi area has an irrigation system which is located at the most upstream among the irrigation systems existing along the Sanya river and so the most advantageous in view of water-taking opportunity from the Sanya river. Most of the river water is taken by this intake in the dry season. A headworks is located at some 3 km downstream of the confluence point of the Lawati river to the Sanya river. The weir was firstly constructed by villagers and improved by the Hai District Office in 1982 and 1983. The weir is of concrete-made overflow type and no scouring sluice has been provided. The intake is located on the left bank of the river and is equipped with a steel-made slide gate. An irrigation canal runs along the left side of the Sanya river and supplies irrigation water to a narrow strip along the Sanya river. The irrigation canal is unlined. The irrigable area seems to be quite limited due to lack of on-farm canals and facilities.

In the Sanya plain, the existing five intakes and traditional furrows serve water for the farm lands. Out of five, the Sanya Chini Headworks located at about 1.5 km downstream of the crossing point of Arusha-Moshi highway is the biggest among all. The head works is of concrete-made type. The weir is of overflow type with no scouring sluices. The crest length of the weir is 26.8 m and the height is 1.5 m above the downstream apron of which length is 8.0 m. There are two intakes equipped with a steel-made slide gate; one is located at left bank and the other is right bank. Much sediment is deposited in front of the weir. An irrigation canal conveying irrigation water to the left bank area of the Sanya river is called as Johari furrow and the other irrigation canal serving the right side area is Ngomeni furrow. Both canal systems had been registered in Maji Office. Their amounts of water rights are 5 cusec, respectively. These canals run along the Sanya river and irrigate the areas astride the Sanya river. The canals are unlined trapezoidal canal and few structures are provided. Other intakes are free intake with no concrete structures or very poor concrete-made facilities. All the canals are unlined with no structures.

No drainage system is provided in the Sanya plain.

3.3 Mtakuja Area

3.3.1 Natural conditions

Annual rainfall is about 400 mm most of which occurs in the rainy season from March to May.

In Mtakuja area, deep to moderately deep fine alluvial and/or colluvial soils are found. The area is flat topography. The lands, 250 ha or 41% of the area, are suitable for agricultural development (S1). The lands marginally suitable for development (S2) are 100 ha or 17% of the area. The remaining lands are not suitable for agricultural development as shown in Fig.3-4.

3.3.2 Administration and population

Administratively, Mtakuja area (25.92 km^2) comes under Mtakuja village, Masama south ward and Mtakuja village. According to the population census in 1988, population of the Mtakuja village is 928 with a density of 36 persons per km^2 which is very low compared with the figures of Hai District and Kilimanjaro Region.

3.3.3 Agriculture and agro-economy

In Mtakuja area, about 300 ha of land is estimated to be under cultivation. Most of farmers have cultivation rights and no lessees are found. Average land holding size is roughly estimated at 2.0 ha, which is larger than the other development potential areas.

In Mtakuja area, present cropping pattern is almost the same as the Sanya plain area. Maize and beans are major crops cultivated and generally planted in April to May and harvested in August and September.

The planting and harvesting areas to the net cultivated lands in Mtakuja area is estimated on the basis of the data obtained from DED office in Hai District as follows:

(Unit: ha)

Crops	Rainy Season		Dry Season		Total of
	Plant	Harvest	Plant	Harvest	Harvest
Maize	60	30	-	-	30
Beans	240	120	-	-	120
Total	300	150	-	-	150

Land preparation is made by tractor, but other operations are done by manually. Seeds of maize and beans are obtained from own farms. No fertilizers and agro-chemicals are generally used.

Present crop production of Mtakuja area is calculated from net cultivated lands, cropping intensity and above crop yields. Production of maize and beans is estimated at about 31 ton and 59 ton respectively.

3.3.4 Irrigation

There is one canal system, so-called Katambai canal along the Kikuletwa river in Mtakuja village. Irrigation has been practiced since 1945 when Katambai canal was constructed by the villagers.

This canal has been getting its water from the Kikuletwa river and irrigation was being practiced mainly during the month of March to June (rainy season). From the year 1980 to 1986, however, water reaching Katambai intake was getting reduced year after year and in recent years since 1987, no water was reaching the intake due to flood in upstream along the Kikuletwa river caused by heavy sedimentation and disorderly development of traditional furrows with no control structures.

The intake to the Katambai canal has also no structures. Water is just being taken without any control to the canal by some earthen weir on Kikuletwa river. No related structure and on-farm facilities are provided.

3.4 Kimashuku Area

3.4.1 Natural conditions

Annual rainfall is some 800 mm and the most comes in the rainy season from March to May.

Deep to moderately deep fine soils cover the upper part of this area with slightly undulating topography. While, stony and/or moderately deep to shallow soils are found in the lower part. This area is slightly undulating to undulating topography. Lands suitable for agricultural development are 1,040 ha or 33% of the area. Area of 1,190 ha or 38% of the area, are marginally suitable for agricultural development as shown in Fig.3-5.

3.4.2 Administration and population

Administratively Kimashuku area comes under the Kimashuku village, Machame south ward. According to the population census in 1988, population of the Kimashuku village is 1,844 with a density of 37 persons per km^2 which is very low compared with the figures of Hai District and Kilimanjaro Region.

3.4.3 Agriculture and agro-economy

In Kimashuku area, 1,600 ha of lands are estimated under cultivated and other lands such as road, river, etc. and non-arable lands are estimated at 630 ha and 940 ha, respectively.

About 95 % of farmers have cultivation rights and 5 % is lessee. Average land holding size is roughly estimated at 0.8 ha per household.

Major crops cultivated in this area are maize and beans, the same as the other areas. They are generally planted in April and May and harvested in August and September. Vegetables are cultivated in the dry season in limited area where irrigation water is available.

The planting and harvesting areas to the net cultivated lands in Kimashuku area is estimated as follows:
(Unit: ha)

(Unit: ha)

Crops	Rainy Season		Dry Season		Total of
	Plant	Harvest	Plant	Harvest	Harvest
Maize/Beans*	1,600	1,120	-	-	1,120
Maize	-	-	50	15	15
Vegetables	-	-	50	50	50
Total	1,600	1,120	100	65	1,185

Remark: *; intercropping

The present farming practices in Kimashuku area are almost the same as those of the Sanya plain area mentioned in Section 3.2.

The present production of crops is calculated from net cultivated lands, cropping intensity and above crop yields as follows:

(Unit: ton)

	Maize	Beans	Onion	Tomato
Kimashuku	946	280	275	425

3.4.4 Irrigation

The Kimashuku area has been covered with an irrigation system taking water from the Weru Weru river. The intake is located at some 3 km upstream the crossing point of the Arusha-Moshi highway. The intake consists of a fixed overflow weir and a gated-intake. It is maintained well. Irrigation canals are unlined. On-farm irrigation facilities have not been developed yet. It seems that actual irrigation practice is limited to the area of 100 ha or less along the irrigation canals.

4. PRELIMINARY AGRICULTURAL DEVELOPMENT PLAN

4.1 Development Concept

The major constraints for agricultural development in the development potential areas are shortage of available water resources compared with the total irrigation requirement for all the arable lands due mainly to short duration of the rainy season and uneven distribution of rain. Therefore, the farmers in the areas are still obliged to carry out the extensive farming.

In consideration of the present constraints, preliminary agricultural development plan for the development potential areas was formulated to aim at:

(1) Removal and/or improvement of the present constraints for agricultural development,
(2) Increasing the production of staple food crops such as maize and beans as well as cash crops such as vegetables by means of crop intensification and diversification through irrigated farming, so as to contribute to the policy for self-sufficiency in food, and
(3) Raising of living standard of the farmers by increasing of crop production.

4.2 Sanya River Basin Development Scheme

Sanya scheme consists of the surface water resources development of the Sanya river and the Boloti swamp and the development of groundwater resources in the Sanya plain, which is divided into three sub-development schemes, the Boloti scheme, the Mungushi scheme, and the Sanya plain scheme.

4.2.1 Water resources development and development scale

The development of the Sanya plain has three alternatives in terms of water resources such as surface water development, groundwater development and the conjunctive use of both water resources. In order to determine optimal agricultural development scale of surface and groundwater resources in the Sanya plain, several alternative studies were carried out from the economic and technical points of view. The details are presented in Annex F. In this Annex, the pictures on the Sanya scheme is presented. In the water balance study, surface water resources are utilized at maximum extent by creating a reservoir at the Boloti swamp and groundwater are used when the surface water is short against the irrigation water demand in the area. Fig.4-1 shows the preliminary layout of the Boloti reservoir.

(1) Water balance study

A water balance study between surface water resources and irrigation water demand was made on the basis of the monthly run-off of the Rawashi river, which is a river flowing to the Boloti swamp, and the Sanya river, simulated by Tank Model Method for the period from 1978 to 1988 and the irrigation water demand estimated based on the tentative proposed cropping patterns applying the method mentioned in FAO Irrigation and Drainage Paper No.24.

The results of a preliminary water balance study are summarized as follows:

Area	Irrigable Area (ha)		
	1st crop	2nd crop	3rd crop
Boloti	250	0	0
Mungushi	200	0	0
Sanya plain	1,140	400	400

The results indicate that if surface water resources are used at the maximum possible extent, area of about 400 ha for two croppings in the dry season as well as the whole area in the rainy season can be irrigated.

(2) Development scale

Even in the maximum development of surface water resources by the construction of the Boloti reservoir, only 400 ha out of total area of 1,140 ha in the Sanya plain can be irrigated in the dry season. Meanwhile, the area where ample groundwater is expected is located in the lower half of the Sanya plain, especially along the Sanya river as shown in Fig.2-3.

Peak irrigation requirement is tentatively estimated at 1.2 lit/sec/ha for second cropping during the period from July to December and 1.4 lit/sec/ha for third cropping from November to April. Therefore, one tubewell can irrigate 42 ha for second cropping and 36 ha for third cropping. Sixteen (16) tubewells can be distributed in the promising area of about 600 ha shown in Fig.4-2 sc as to keep the desirable tubewell interval of 0.5 km. Thus, irrigation areas are 600 ha for second cropping and 580 ha for third.

The development scale is summarized as follows:

Reservoir capacity	7.3 MCM
Irrigation area	

Boloti scheme	
First cropping only	250 ha
Mungushi scheme	
First cropping only	200 ha
Sanya plain	
First cropping	1,140 ha
Second cropping	1,000 ha (400 ha by surface water and 600 ha by ground water)
Third cropping	980 ha (400 ha by surface water and 580 ha by groundwater)

(3) Development of surface water resources

1) Boloti reservoir

The storage capacity of the Boloti swamp requires about 7 MCM in order to use the surface water resources at maximum extent to ensure the irrigation area as much as possible in the Sanya plain. The storage capacity of 7 MCM corresponds to the water depth of about 4.9 m. The dam height from the lowest ground surface is roughly estimated at 7 m considering the freeboard and the flood water depth. The dam features are shown as follows:

Dam type	:	homogeneous earthfill
Crest length	:	2,700 m
Crest width	:	4 m
Upstream slope	:	1 : 2.5
Downstream slope	:	1 : 2
Stripping depth	:	0.5 m
Spillway	:	concrete-made side channel over-flow type provided at left bank

2) Diversion canal

A diversion weir and a diversion canal are provided to convey water from the Lawati river to the Boloti reservoir. Design discharge of the canal is set at 3 m^3/sec so as to divert most of river water in the drought year. Main features of diversion weir and the canal are presented estimated as follows:

Diversion weir	:	concrete-made gravity type equipped with one intake gate
Diversion canal	:	Trapezoidal lined canal, 2 km
side slope	:	1 : 1
bottom width	:	1 m
lining height	:	1.2 m - 1.5 m

3) Outlet canal

Design discharge of the outlet canal to the Sanya river is peak water demand of Mungushi area and Sanya plain, which is estimated at 0.7 m^3/sec. The route of the canal will be set as straight as possible from the Boloti to the Sanya in north-east to south-west direction. The length is approximately 1.6 km and the major features are as follows:

Canal type	:	Trapezoidal lined canal
Canal height	:	0.7 to 1.0 m
Side slope	:	1 : 1
Bottom width	:	0.6 m

(4) Development of groundwater resources

Specifications of production well are approximately as follows:

Design discharge	:	50 lit/sec on an average
Depth of tubewell	:	about 65 m
Drilling diameter	:	500 mm
Casing diameter	:	350 mm
Total head required	:	20 m on an average
Pump type	:	Submergible
Filter	:	Gravel-filling

Power for pump operation will be taken through a transformer and three phases low tension line of 400 V from the transmission line of 33 KV which runs across the Sanya plain. Transformer(s) having a capacity of 250 KV in total and about 12 km of low tension line will be required.

4.2.2 Agricultural development plan

For the agricultural development in the project, availability of water resources is the most limiting factor in Sanya river basin areas. Out of Sanya river basin, Sanya plain area, where surface and groundwater resources are available and the lands are mainly classified as suitable for intensive agriculture because of flat topography and deep and fine soil characteristics, will be proposed to cultivate food and cash crops three (3) times a year from the viewpoints of effective utilization of water resources as well as higher return of crop production.

On the other hand, Boloti and Mungushi areas, where only surface water is available and the lands are classified as marginally suitable for intensive agriculture, will be proposed to increase and stabilize yield and production of food crops in the rainy season and to maintain the cultivated area for vegetables in the dry season in Mungushi area through efficient utilization of available water resources. The proposed land use in Sanya river basin is as follows:

(Unit: ha)

Area/Crops	1st	2nd	3rd	Total
Boloti				
Maize/Beans*	250	-	-	250
Mungushi				
Maize/Beans*	200	-	-	200
Vegetables	-	30	-	30
Sanya Plain				
Maize	1,140	-	780	1,920
Beans	-	800	-	800
Vegetables	-	200	200	400
Total	1,590	1,030	980	3,600

Remark: *; intercropping

Proposed cropping pattern of each area in Sanya river basin is formulated on the basis of above concepts and agro-climatic conditions as shown in Fig.4-3.

4.2.3 Irrigation development plan

(1) Irrigation system

Excess water of the Lawati river, which is a major tributary of the Sanya river, is diverted through a diversion to the Boloti reservoir. Then when water of the Sanya river is insufficient to the irrigation requirement for the project area, water stored in the reservoir is released to the Sanya river. Water is taken at the Mungushi intake and the Sanya Chini intake and is distributed through irrigation canals to the fields. When water flowing these canals is short against the irrigation water demands in the Sanya plain, tubewells to be provided along major canals will serve groundwater for the area as required.

(2) Boloti scheme

The Boloti scheme has a total irrigation area of about 250 ha. The preliminary layout of the proposed irrigation system is shown in Fig.4-4. A main canal is provided along the right bank of the Mungushi river about 1.4 km from the Boloti reservoir to the present diversion point of the existing canal from the Mungushi river so as to connect existing canal with the Boloti reservoir. The design discharge is about 0.2 m^3/sec. The existing canals will be utilized as much as possible and rehabilitated and improved with concrete lining in the reaches commanding more than 100 ha. Field ditches are provided at the interval of 100 m to 150 m in perpendicular to the contour lines, supposing that contour furrow or contour corrugation irrigation method is applied, because the topographic gradient is steep. A road will be provided along the main canal and some of or some parts of secondary canals.

Headworks	:	A gated structure provided on the Boloti dam
Canal type	:	trapezoid
Total length of main canal	:	about 2.2 km
Total length of secondary canal	:	about 2 km
Lining length	:	about 4.2 km
Road	:	about 4.5 km
On-farm development	:	about 250 ha

(3) Mungushi scheme

Mungushi scheme has a total irrigation area of about 200 ha. The preliminary layout of the proposed irrigation system is shown in Fig.4-5. Mungushi intake existing on the Sanya river will be used as it is. Most parts of the existing canals will be used as a main canal. Major works on this scheme are the rehabilitation of existing canals with provision of concrete lining and the construction of on-farm facilities. The length of main canal is about 2.1 km. Maximum diversion requirement is roughly estimated at 0.16 m^3/sec. Field ditches are provided in the same manner as the Boloti scheme.

Canal type	:	trapezoid
Total length of main canal	:	about 2.1 km
Total length of secondary canal	:	about 3 km
Lining length	:	about 4 km
Road	:	about 2.1 km
On-farm development	:	about 200 ha

(4) Sanya plain scheme

The Sanya plain scheme has a total of 1,140 ha in net. The preliminary layout of the proposed irrigation system is shown in Fig.4-2. Sanya Chini headworks will be rehabilitated with provision of scouring sluices in both sides. A right main canal and a left main canal are laid out along the Sanya river so as to cover the entire irrigation areas of 560 ha and 580 ha, respectively. The design discharge of both canals is about 0.4 m^3/sec at their head. On the ways, water is diverted to secondary canals or tertiary canals. Tubewells will be provided along main and secondary canals or the head of tertiary canals.

Major works on this scheme are improvement of Sanya Chini headworks, the construction of main and secondary canals, including rehabilitation and improvement of existing canals, drains, and road networks, and on-farm development.

Main canal	:	Trapezoidal lined canal
Length of left main	:	about 7 km
Length of right main	:	about 7 km
Secondary canal	:	Trapezoidal lining canal
Length in left bank area	:	about 5.5 km
Length in right bank area	:	about 5 km
Road	:	about 30 km
Drain	:	earthen canal type, 11 km
On-farm development	:	1,140 ha

4.3 Mtakuja scheme

4.3.1 Water resources

There are two alternatives in the water resources such as the surface water resources of the Kikuletwa river and the groundwater resources. According to Annex C, the design yield of one tubewell is estimated at only 5 lit/sec, which roughly corresponds to the irrigation area of 4 ha to 5 ha, only. On the other hands, if surface water resources can be obtained by river training works, most of the suitable area of about 300 ha can be irrigated at least in the rainy season. It is obvious that the development of surface water resources is more advantageous than that of groundwater resources.

4.3.2 Agricultural development plan

In Mtakuja area, only the surface water resources of Kikuletwa river during the rainy season are available and the groundwater resources are not suitable for irrigation because of their less potential yields (5 lit/sec). Therefore, increasing and stabilizing of yield and production of food crops during the rainy season be proposed to Mtakuja area through efficient utilization of available surface water resources from Kikuletwa river in the rainy season. Therefore, planting of 240 ha of beans and 60 ha of maize in March/April for harvesting in July/August be proposed to Mtakuja area.

Proposed farm inputs, anticipated crop yields, production are stated in sub-Section 4.2.2.

4.3.3 Irrigation development plan

The layout of irrigation canal system is shown in Fig.4-6. Water flowing through the Kikuletwa river will be diverted at the Katambai intake and conveyed through the Katambai canal and field ditches to fields. Necessary works are the river training of the Kikuletwa river, the construction of headworks, rehabilitation and improvement of existing canals and on-farm development.

According to the reconnaissance survey, the river training shall be carried out about 12 km length from the intake point of No.9 canal, which serves the irrigation area of Majengo village of Arumeru District of Arusha Region, to the downstream of Mtakuja area.

As for the irrigation facilities, headworks equipped with a intake gate should be constructed with an intake gate and the existing Katambai canal should be totally rehabilitated and improved with lining in the most of the section. Design discharge at the head of Katambai canal is about 0.2 m^3/sec.

Furrow or border irrigation method can be applied in the fields where the soil is medium and fine texture and the ground surface is flat. Field ditches will be provided at an interval of 100 m to 150 m.

Road will be provided along the main canal. Drain will be provided along the border of the irrigation area.

Major works are roughly estimated as follows:

River training	:	about 15 km
Headworks	:	Overflow weir type with scouring sluice
Main canal	:	Trapezoidal lining canal
length	:	about 5 km
Road	:	6 m wide, morrum road about 5 km
Drain	:	about 4 km
On-farm development	:	about 300 ha

4.4 Kimashuku scheme

4.4.1 Water balance study and development scale

As explained in Section 3.4, the Kimashuku scheme utilizes the water resources of the Weru Weru river, from which the Musa Mwijanga irrigation system is also taking water in its downstream. Further, Weru Weru river water is taken by TPC after the confluence of the Weru Weru river and the Kikafu river, and Kikafu Chini irrigation system is taking water from the Kikafu river.

Taking the above situation, the water balance study between water resources and irrigation water demands is made in order to clarify the available water resources and development scale of the Kimashuku scheme under the following assumptions and conditions:

(1) TPC can take water of 2.83 m^3/sec as granted in the water rights.

(2) In the Kikafu Chini Irrigation system which serves for about 250 ha and have water right granted 0.56 m^3/sec (20 cusecs). Thus assumption is made that irrigation is applied throughout the year for three croppings according to the irrigation requirements estimated in the limit of water right of 0.56 m^3/sec.

(3) Mwijanga system, water granted by authorized water right is only 0.014 m^3/sec (0.5 cusec). The irrigation area is about 570 ha. One cropping season in the rainy season is supplementary irrigated.

(4) Irrigation water requirement is estimated on the proposed cropping pattern, supposing that all the areas are cultivated with maize.

The results indicate that available water resources for the Kimashuku area are limited mainly in the rainy season when total commanding area of about 1,600 ha can be irrigated. If water is taken in the dry season for some hundred hectares, irrigation water shortage will reveal in TPC in most of every dry seasons.

Actually the Kimashuku intake is taking water of about 0.4 m^3/sec to 0.8 m^3/sec in the dry season since the intake was improved in 1979. The diverted amount nearly corresponds to the amount of water by which about 300 ha can be irrigated when on-farm development is carried out. While, discharge at TPC intake is actually less than water amount of 2.83 m^3/sec granted in the water right in the most of the dry season in 1984 to 1987 and TPC has sometimes requested to increase the water allocation.

It is therefore necessary for water users to adjust the water allocation and the water rights.

4.4.2 Agricultural development plan

From the water resources availability viewpoint, all of Kimashuku area can be irrigated by surplus surface water of Weru Weru river during the rainy season. However, during the dry season, only limited area can be irrigated because of low water resources availability and complicated water right. Therefore, increasing and stabilizing of yield and production of food crops during the rainy season will be proposed to all of Kimashuku area through efficient utilization of available surface water resources from Weru Weru river in the rainy season. Therefore, interplanting of 1,600 ha of maize and beans in March/April for harvesting in July/August will be proposed to this area.

4.4.3 Irrigation development plan

The preliminary layout of the irrigation canal system is shown in Fig.4-7. The existing intake will be used as it is, and existing major canals will be rehabilitated and improved with provision of lining and the related structures such as checks, turnouts, culverts and drops except for the section much meandering, in which new canal will be constructed. The maximum diversion discharge at the headworks is estimated at 1.3 m^3/sec. A road having 6 m wide will be provided along the major canals where existing road is not available.

From the land resources such as topography and soils, the upper half of the area is suitable for irrigation farming and the gradient of the ground surface ranges from 2% to 3%. Thus furrow or narrow-stripped basin irrigation methods are applicable in most of the area. While the lower half is marginally suitable for irrigation farming. The gradient of the ground surface ranges roughly from 3% to 10% and soil depth is rather shallow. Thus applicable irrigation method may be contour furrow or contour corrugation. Taking the above into account, field ditches to supply water to fields will be laid out in parallel to the contour line at the interval of 100 m to 150 m in the upper half of the area. In the lower half of the area, the field ditches will be laid out in perpendicular to the contour line at the interval of 100 m to 150 m.

Major features of works are summarized as follows:

Main canal	:	Trapezoidal lining canal
length	:	about 12 km
Secondary canals	:	Trapezoidal lining canal about 10 km to commanding area of 100 ha, Trapezoidal earthen canal, about 3 km
Road	:	6 m wide, morrum road about 25 km
On-farm development	:	about 1,600 ha

4.5 Project Cost and Benefit

4.5.1 Project cost

Preliminary cost estimate of each scheme is made on the basis of the cost of Ndungu Agricultural Development Project, which is being implemented under the financial and technical assistance of the Government of Japan taking into account change of the exchange rate of Tanzanian shilling and material price and labour charges. The exchange rate adopted in the preliminary cost estimate is Tsh.145 = US$ 1.0 = Yen 145.

The results of cost estimate are shown in Table 4-1 and summarized as follows:

(Unit: million Tsh.)

Name of Scheme	Direct Construction Cost
Sanya scheme	1,377
Boloti dam	483
Boloti scheme	67
Mungushi scheme	55
Sanya plain scheme	772
Mtakuja scheme	132
Kikuletwa scheme	466

4.5.2 Benefit

For calculation of project benefit of each development potential area, the proposed farm inputs, anticipated crop yield are estimated as follows:

	Maize	Beans	Onion	Tomato
Seeds (kg)				
Pure Stand	30	60	12	1.50
Intercropping	24	30	-	-
Fertilizers (kg)				
Nitrogen (N)	90	50	150	100
Phosphate (P)	30	120	50	150
Potassium (K)	30	50	50	100
Agro-chemicals (lit)	1	1	8	6
Labour (md)				
Family	99	119	149	134
Hired	20	24	150	137
Total	119	143	299	271
Yield (ton/ha)	5.0	2.0	17.0	25.0

Based on the anticipated yields, annual crop production with project condition are estimated as follows:

(Unit: ton)

	Maize	Beans	Onion	Tomato
Sanya River Basin	12,050	2,270	3,675	6,125
Mtakuja	750	480	0	0
Kimashuku	6,475	1,600	375	625

Remark: *; Sanya, Mungushi and Boloti

The expected crop budgets per ha for maize, beans, onion and tomato were calculated from the production costs, anticipated crop yield and current prices. The expected crop budgets per ha are calculated as follows:

(Unit: Tsh.)

	Maize	Maize/ Beans*	Beans	Onion	Tomato
Gross Income	74,150	99,990	81,340	523,500	640,250
Production Cost	19,360	37,896	24,384	95,462	95,401
Net Return	54,790	62,094	56,956	428,038	544,850

Remark: See Table 4-2, *; intercropping

Project benefits to be expected is defined as the difference of profit from crop production between present and with project conditions. Project benefits for the development potential areas are calculated as follows:

(Unit: 1,000 Tsh.)

Area	Present	With Project	Increment
Sanya River Basin	24,185	386,148	361,963
Mtakuja*	2,235	28,255 *	26,020
Kimashuku	20,377	99,350	78,973

Remark: See Table 4-3, 4-4, and 4-5. *; The flood mitigation benefit in Majengo and Kiteto areas of 1,000 ha in Arumeru District brought by river training is taken into account, this benefit is roughly estimated on the assumption that the area is utilized for cultivation of maize under rainfed condition in the rainy season.

5. SELECTION OF PROJECT AREA (DEVELOPMENT PRIORITY AREA)

Sanya plain extending along the downstream reaches of the Sanya river is one of the most suitable area in topographic and soil conditions for irrigation farming in the lower Hai area. Within this area Sanya Chini railway station is located and the Arusha-Moshi highway and the Kilimanjaro International Airport are located near the area. Thus agricultural products are easily transported to Moshi and Arusha even to Kenya through the highway and to Dar es Salaam by railway. Also, the area is located nearest to Boma Ng'ombe; the capital of Hai District, where one of the major markets in the Hai District is situated. Electric transmission line of 33 KV is running across the Sanya plain. Villagers of Sanya plain constructed traditional furrows system for a long period and are constructing furrows even now. They are doing their best to efficiently utilize limited surface water resources as much as possible with poor financial situation.

Boloti area is not so suitable for irrigation farming from the view of topography and soil conditions. Water resources of the Boloti swamp is being used in the Boloti area for a long period. Accordingly, when the Boloti swamp is developed as a reservoir for irrigation farming in the Sanya plain which does not belong to the basin of the Boloti swamp, amount of water corresponding to the water resources of the present Boloti should be allocated to the Boloti area and it may be required to carry out the development for efficient use of limited water.

Development of the Mungushi area is also necessary concerning the development of the Sanya plain for efficient use of limited water resources, when the Boloti swamp is developed as a reservoir, considering the present condition that the Mungushi intake is taking much water but the irrigation area is quite limited due to no on-farm water distribution facilities.

Mtakuja area is isolated from the center of Hai District and left behind the development. Before 1980, the Mtakuja area was blessed with irrigation water obtained from the Kikuletwa river, but in recent years, no or little water is available even in the rainy season due to flooding in the upstream. Farmers are obliged to cultivate under rainfed condition.

Kimashuku area is located near Moshi city; the capital of Kilimanjaro Region and Arusha-Moshi highway is running across the upper area of the Kimashuku area. Therefore, the area is geographically the most advantageous among the development potential areas. However, water amount granted by the water right is only 2 cusec(0.057 m^3/sec), although water of 0.5 to 0.8 m^3/sec is being taken by the Kimashuku intake in the dry season. Due to this, TPC, which is the biggest water user of the Weru Weru river, is suffering in securing sufficient irrigation water for sugarcane cultivation in his plantation area. It is, therefore, necessary to take certain countermeasures to supplement irrigation water to TPC as well as review and adjustment of water right instead of increase of water diversion for the Kimashuku area.

From the project cost and benefit per ha as shown in the following table, the Sanya scheme is the most beneficial.

(Unit: 1,000 Tsh./ha)

	Direct Cost	Annual Benefit
Sanya Scheme*	866	228
Mtakuja scheme	440	87
Kimashuku scheme	291	49

Remark: *; Boloti, Mungushi and Sanya Plain

Taking the above into account, the feasibility study is made for the Sanya plain scheme including the Boloti and the Mungushi areas. The Mtakuja area will also be roughly studied and countermeasure will be proposed considering the severe situation of water resources in recent years which should be improved as early as possible.

Table 3-1 PRELIMINARY ESTIMATE OF PRESENT CROP BUDGET PER HA (1/2)

			Unit		Amount	Price	Cost
MAIZE							
Production Cost							
	Seed		kg		25	0.00	0
	Fertilizers	Nitrogen (N)	kg		0	26.09	0
		Posphorus (P)	kg		0	48.00	0
		Potassium (K)	kg		0	47.06	0
	Agro-chemicals		lit		0	1,200.00	0
	Tractor	Ploughing	ha		1	3,750.00	3,750
	Labour			Family	Hired		
		Planting	md	10	0	200.00	0
		Weeding	md	20	0	400.00	0
		Fertilizing	md	0	0	200.00	0
		Harvesting	md	20	0	200.00	0
		Shelling	md	10	0	200.00	0
	Miscellaneous	10% of above cost					375
	Total						4,125
Gross Income			kg		1,040	14.83	15,423
Net Income							11,298
BEANS							
Production Cost							
	Seed		kg		50	0.00	0
	Fertilizers	Nitrogen (N)	kg		0	26.09	0
		Posphorus (P)	kg		0	48.00	0
		Potassium (K)	kg		0	47.06	0
	Agro-chemicals		lit		0	1,200.00	0
	Tractor	Ploughing	ha		1	3,750.00	3,750
	Labour			Family	Hired		
		Planting	md	10	0	200.00	0
		Weeding	md	20	0	400.00	0
		Fertilizing	md	0	0	200.00	0
		Harvesting	md	20	0	200.00	0
		Threshing	md	20	0	200.00	0
	Miscellaneous	10% of above cost					375
	Total						4,125
Gross Income			kg		490	40.67	19,928
Net Income							15,803
MAIZE/BEANS							
Production Cost							
	Seed	Maize	kg		20	0.00	0
		Beans	kg		25	0.00	0
	Fertilizers	Nitrogen (N)	kg		0	26.09	0
		Posphorus (P)	kg		0	48.00	0
		Potassium (K)	kg		0	47.06	0
	Agro-chemicals		lit		0	1,200.00	0
	Tractor	Ploughing	ha		1	3,750.00	3,750
	Labour			Family	Hired		
		Planting	md	13	0	200.00	0
		Weeding	md	50	0	400.00	0
		Fertilizing	md	0	0	200.00	0
		Harvesting	md	26	0	200.00	0
		Shelling	md	8	0	200.00	0
		Threshing	md	10	0	200.00	0
	Miscellaneous	15% of above cost					563
	Total						4,313
Gross Income		Maize	kg		832	14.83	12,339
		Beans	kg		250	40.67	10,168
		Total					22,506
Net Income							18,194

Table 3-1 PRELIMINARY ESTIMATE OF PRESENT CROP BUDGET PER HA (2/2)

		Unit		Amount	Price	Cost
ONION						
Production Cost						
Seed		kg		10	500.00	5,000
Fertilizers	Nitrogen (N)	kg		110	26.09	2,870
	Posphorus (P)	kg		0	48.00	0
	Potassium (K)	kg		0	47.06	0
Agro-chemicals		lit		4	1,200.00	4,800
Tractor	Ploughing	ha		1	3,750.00	3,750
Labour			Family	Hired		
Seedbed (10)	Preparation	md	4	1	200.00	200
	Sowing	md	1	0	200.00	0
	Attendant	md	12	3	200.00	600
Field Layout	Make furrow	md	6	7	400.00	2,800
Seedling Beds	160 beds	md	10	10	400.00	4,000
Transplanting		md	15	15	400.00	6,000
Weeding	2 times	md	15	45	400.00	18,000
Fertilizing	2 times	md	8	2	200.00	400
Spraying	8 times	md	15	5	200.00	1,000
Irrigation	12 times	md	14	14	200.00	2,800
Harvesting		md	20	20	200.00	4,000
Miscellaneous	30% of above costs					16,866
Total						73,086
Gross Income		kg		11,000	34.90	383,900
Net Income						310,814
TOMATC						
Production Cost						
Seed		kg		1.25	6,000.00	7,500
Fertilizers	Nitrogen (N)	kg		110	26.09	2,870
	Posphorus (P)	kg		0	48.00	0
	Potassium (K)	kg		0	47.06	0
Agro-chemicals		lit		3	1,200.00	3,600
Tractor	Ploughing	ha		1	3,750.00	3,750
Labour			Family	Hired		
Seedbed	Preparation	md	4	1	200.00	200
	Sowing	md	4	1	200.00	200
	Attendant	md	12	3	200.00	600
Field Preparation	Furrow/Basins	md	13	13	400.00	5,200
Transplanting		md	20	5	200.00	1,000
Weeding	3 times	md	15	45	400.00	18,000
Fertilizing	2 times	md	4	1	200.00	200
Spraying	4 times	md	8	2	200.00	400
Irrigation	16 times	md	30	10	200.00	2,000
Harvesting	3 Pickings	md	10	35	200.00	7,000
Miscellaneous	30% of above costs					15,756
Total						68,276
Gross Income		kg		17,000	25.61	435,370
Net Income						367,094

Table 4-1 PRELIMINARY COST ESTIMATE

Unit: Tsh. Million

NAME OF SCHEME AND WORKS	DIRECT CON RUCTION CO
1 SANYA SCHEME	
1.1 BOLOTI DAM AND THE RELATED FACILITIES	
BOLOTI DAM AND SPILLWAY	419
DIVERTION WEIR AND CANAL	53
OUTLET STRUCTURE AND CANAL	11
SUB-TOTAL	483
1.2 BOLOTI SCHEME	
MAIN AND SECONDARY CANALS	32
ROAD	5
ON-FARM DEVELOPMENT	30
SUB-TOTAL	67
1.3 MUNGUSHI SCHEME	
MAIN AND SECONDARY CANALS	28
ROAD	2
ON-FARM DEVELOPMENT	24
SUB-TOTAL	55
1.4 SANYA PLAIN SCHEME	
IMPROVEMENT OF SANYA CHINI HEADWORKS	10
TUBEWELLS	456
MAIN AND SECONDARY CANALS	145
DRAINS	13
ROAD	34
ON-FARM DEVELOPMENT	114
SUB-TOTAL	772
TOTAL	1378
2. MTAKUJA SCHEME	
RIVER IMPROVEMENT	46
HEADWORKS	17
MAIN AND SECONDARY CANALS	33
ROAD	6
ON-FARM DEVELOPMENT	30
TOTAL	131
3. KIMASHUK SCHEME	
MAIN AND SECONDARY CANALS	221
DRAINS	19
ROAD	34
ON-FARM DEVELOPMENT	192
TOTAL	466

Table 4-2 PRELIMINARY ESTIMATE OF CROP BUDGET WITH PROJECT CONDITION PER HA(1/2)

		Unit		Amount	Price	Cost
MAIZE						
Production Cost						
Seed		kg		30	85.00	2,550
Fertilizers	Nitrogen (N)	kg		90	26.09	2,348
	Posphorus (P)	kg		30	48.00	1,440
	Potassium (K)	kg		30	47.06	1,412
Agro-chemicals		lit		1	1,200.00	1,200
Tractor	Ploughing	ha		1	3,750.00	3,750
Labour			Family	Hired		
	Planting	md	12	2	200.00	480
	Weeding	md	24	5	400.00	1,920
	Fertilizing	md	3	1	200.00	100
	Harvesting	md	35	7	200.00	1,400
	Shelling	md	25	5	200.00	1,000
Miscellaneous	10% of above cost					1,760
Total						19,360
GrcMaize		kg		5,000	14.83	74,150
Net Income						54,790
BEANS						
Production Cost						
Seed		kg		60	35.00	2,100
Fertilizers	Nitrogen (N)	kg		50	26.09	1,305
	Posphorus (P)	kg		120	48.00	5,760
	Potassium (K)	kg		50	47.06	2,353
Agro-chemicals	Insecticide	lit		1	1,200.00	1,200
Tractor	Ploughing	ha		1	3,750.00	3,750
Labour			Family	Hired		
	Planting	md	12	2	200.00	480
	Weeding	md	24	5	400.00	1,920
	Fertilizing	md	3	1	200.00	100
	Harvesting	md	40	8	200.00	1,600
	Threshing	md	40	8	200.00	1,600
Miscellaneous	10% of above cost					2,217
Total						24,384
Gross Income		kg		2,000	40.67	81,340
Net Income						56,956
MAIZE/BEANS						
Production Cost						
Seed	Maize	kg		24	85.00	2,040
	Beans	kg		30	35.00	1,050
Fertilizers	Nitrogen (N)	kg		140	26.09	3,653
	Posphorus (P)	kg		150	48.00	7,200
	Potassium (K)	kg		80	47.06	3,765
Agro-chemicals		lit		2	1,200.00	2,400
Tractor	Ploughing	ha		1	3,750.00	3,750
Labour			Family	Hired		
	Planting	md	16	3	200.00	640
	Weeding	md	60	12	400.00	4,800
	Fertilizing	md	6	1	200.00	240
	Harvesting	md	48	10	200.00	1,920
	Shelling	md	20	4	200.00	800
	Threshing	md	20	4	200.00	800
Miscellaneous	15% of above cost					4,839
Total						37,896
Gross Income	Maize	kg		4,000	14.83	59,320
	Beans	kg		1,000	40.67	40,670
	Total					99,990
Net Income						62,094

Table 4-2 PRELIMINARY ESTIMATE OF CROP BUDGET WITH PROJECT CONDITION PER HA(2/2)

		Unit		Amount	Price	Cost
ONION						
Production Cost						
Seed		kg		12	500.00	6,000
Fertilizers	Nitrogen (N)	kg		150	26.09	3,914
	Posphorus (P)	kg		50	48.00	2,400
	Potassium (K)	kg		50	47.06	2,353
Agro-chemicals		lit		8	1,200.00	9,600
Tractor	Ploughing	ha		1	3,750.00	3,750
Labour			Family	Hired		
Seedbed (10)	Preparation	md	4	1	200.00	160
	Sowing	md	1	0	200.00	56
	Attendant	md	12	3	200.00	600
Field Layout	Make furrow	md	6	7	400.00	2,800
Seedling Beds	160 beds	md	10	10	400.00	4,000
Transplanting		md	15	15	400.00	6,000
Weeding	2 times	md	15	45	400.00	18,000
Fertilizing	2 times	md	16	4	200.00	800
Spraying	8 times	md	30	10	200.00	2,000
Irrigation	12 times	md	20	20	200.00	4,000
Harvesting		md	20	35	200.00	7,000
Miscellaneous	30% of above costs					22,030
Total						95,462
Gross Income		kg		15,000	34.90	523,500
Net Income						428,038
TOMATO						
Production Cost						
Seed		kg		1.50	6,000.00	9,000
Fertilizers	Nitrogen (N)	kg		100	26.09	2,609
	Posphorus (P)	kg		150	48.00	7,200
	Potassium (K)	kg		100	47.06	4,706
Agro-chemicals		lit		6	1,200.00	7,200
Tractor	Ploughing	ha		1	3,750.00	3,750
Labour			Family	Hired		
Seedbed	Preparation	md	4	1	200.00	160
	Sowing	md	4	1	200.00	160
	Attendant	md	12	3	200.00	600
Field Preparation	Furrow/Basins	md	13	13	400.00	5,200
Transplanting		md	20	5	200.00	1,000
Weeding	3 times	md	15	45	400.00	18,000
Fertilizing	2 times	md	10	5	200.00	1,000
Spraying	4 times	md	16	4	200.00	800
Irrigation	16 times	md	30	10	200.00	2,000
Harvesting	3 Pickings	md	10	50	200.00	10,000
Miscellaneous	30% of above costs					22,016
Total						95,401
Gross Income		kg		25,000	25.61	640,250
Net Income						544,850

Table 4-3 PRELIMINARY ESTIMATE OF INCREMENTAL BENEFIT IN SANYA RIVER BASIN AREA

			Present			With Project			Increment		
			Rainfed	Irrigated	Total	Rainfed	Irrigated	Total	Rainfed	Irrigated	Total
Planted Area (ha)											
Boloti	1st Crop	Maize/Beans	250	0	250	0	250	250	-250	250	-
Mungushi	1st Crop	Maize/Beans	200	0	200	0	200	200	-200	200	-
	2nd Crop	Vegetables	30	0	30	0	30	30	-30	30	-
Sanya	1st Crop	Maize	684	0	684	0	1,140	1,140	-684	1,140	-
		Beans	456	0	456	0			-456	0	-
	2nd Crop	Beans	0	0	0	0	800	800	0	800	-
		Vegetables	0	0	0	0	200	200	0	200	-
	3rd Crop	Maize	0	0	0	0	784	784	0	784	-
		Vegetables	0	0	0	0	196	196	0	196	-
Total			1,620	0	1,620	0	3,600	3,600	-1,620	3,600	-
Harvested Area (ha)									0	0	
Boloti	1st Crop	Maize/Beans	200	0	200	0	250	250	-200	250	-
Mungushi	1st Crop	Maize/Beans	160	0	160	0	200	200	-160	200	-
	2nd Crop	Vegetables	30	0	30	0	30	30	-30	30	-
Sanya	1st Crop	Maize	342	0	342	0	1,140	1,140	-342	1,140	-
		Beans	228	0	228	0	0	0	-228	0	-
	2nd Crop	Beans	0	0	0	0	800	800	0	800	-
		Vegetables	0	0	0	0	200	200	0	200	-
	3rd Crop	Maize	0	0	0	0	784	784	0	784	-
		Vegetables	0	0	0	0	196	196	0	196	-
Total			960	0	960	0	3,600	3,600	-960	3,600	-
Crop Budget (Ths./ha)											
Maize/Beans			18,194	62,094	-	18,194	62,094	-	0	0	-
Maize			11,298	54,790	-	11,298	54,790	-	0	0	-
Beans			15,803	56,956	-	15,803	56,956	-	0	0	-
Vegetables			338,954	486,444	-	338,954	486,444	-	0	0	-
Benefit (Tsh. 1,000)											
Boloti		1st Crop	3,639	0	3,639	0	15,524	15,524	-3,639	15,524	11,885
Mungushi		1st Crop	2,911	0	2,911	0	12,419	12,419	-2,911	12,419	9,508
		2nd Crop	10,169	0	10,169	0	14,593	14,593	-10,169	14,593	4,425
Sanya Plain		1st Crop	7,467	0	7,467	0	62,461	62,461	-7,467	62,461	54,994
		2nd Crop	0	0	0	0	142,854	142,854	0	142,854	142,854
		3rd Crop	0	0	0	0	138,298	138,298	0	138,298	138,298
Total			24,185	0	24,185	0	386,148	386,148	-24,185	386,148	361,963
					15,211			242,861			227,650

Table 4-4 PRELIMINARY ESTIMATE OF INCREMENTAL BENEFIT IN MTAKUJA AREA

		Present			With Project			Increment		
		Rainfed	Irrigated	Total	Rainfed	Irrigated	Total	Rainfed	Irrigated	Total
Planted Area (ha)										
1st Crop	Maize	60	0	60	0	60	60	-60	60	-
	Beans	240	0	240	0	240	240	-240	240	-
	Total	300	0	300	0	300	300	-300	300	-
Harvested Area (ha)								0	0	
1st Crop	Maize	30	0	30	0	60	60	-30	60	-
	Beans	120	0	120	0	240	240	-120	240	-
	Total	150	0	150	0	300	300	-150	300	-
Crop Budget (Ths./ha)										
Maize		11,298	54,790	-	11,298	54,790	-	0	0	-
Beans		15,803	56,956	-	15,803	56,956	-	0	0	-
Benefit (Tsh. 1,000)										
1st Crop		2,235	0	2,235	0	16,957	16,957	-2,235	16,957	14,722
Flood mitigation benefit*				0			11,298			11,298
Total				2,235			28,255			26,020
				7,450			94,183			86,733

Remark: *; The flood mitigation benefit in Majengo and Kiteo areas of 1,000 ha in Arumeru District brought by river training is taken into account, this benefit is roughly estimated at on the assumption that the area is utilized for cultivation of maize under rainfed condition in the rainy season.

Table 4-5 PRELIMINARY ESTIMATE OF INCREMENTAL BENEFIT IN KIMASHUKU AREA

		Present			With Project			Increment		
		Rainfed	Irrigated	Total	Rainfed	Irrigated	Total	Rainfed	Irrigated	Total
Planted Area (ha)										
1st Crop	Maize/Beans	1,600	0	1,600	0	1,600	1,600	-1,600	1,600	-
2nd Crop	Maize	50	0	50	0	0	0	-50	0	-
	Vegetables	50	0	50	0	0	0	-50	0	-
Total		1,700	0	1,700	0	1,600	1,600	-1,700	1,600	-
Harvested Area (ha)								0	0	
1st Crop	Maize/Beans	1,120	0	1,120	0	1,600	1,600	-1,120	1,600	-
2nd Crop	Maize	15	0	15	0	0	0	-15	0	-
	Vegetables	50	0	50	0	0	0	-50	0	-
Total		1,185	0	1,185	0	1,600	1,600	-1,185	1,600	-
Crop Budget (Ths./ha)										
Maize/Beans		18,194	62,094	-	18,194	62,094	-	0	0	-
Maize		11,298	54,790	-	11,298	54,790	-	0	0	-
Vegetables		338,954	486,444	-	338,954	486,444	-	0	0	-
Benefit (Tsh. 1,000)										
1st Crop		20,377	0	20,377	0	99,350	99,350	-20,377	99,350	78,973
2nd Crop		17,117	0	17,117	0	0	0	-17,117	0	-17,117
Sub-total		37,494	0	37,494	0	99,350	99,350	-37,494	99,350	61,856
TPC				-17,117			0			17,117
Total				20,377			99,350			78,973
				12,736			62,094			49,358

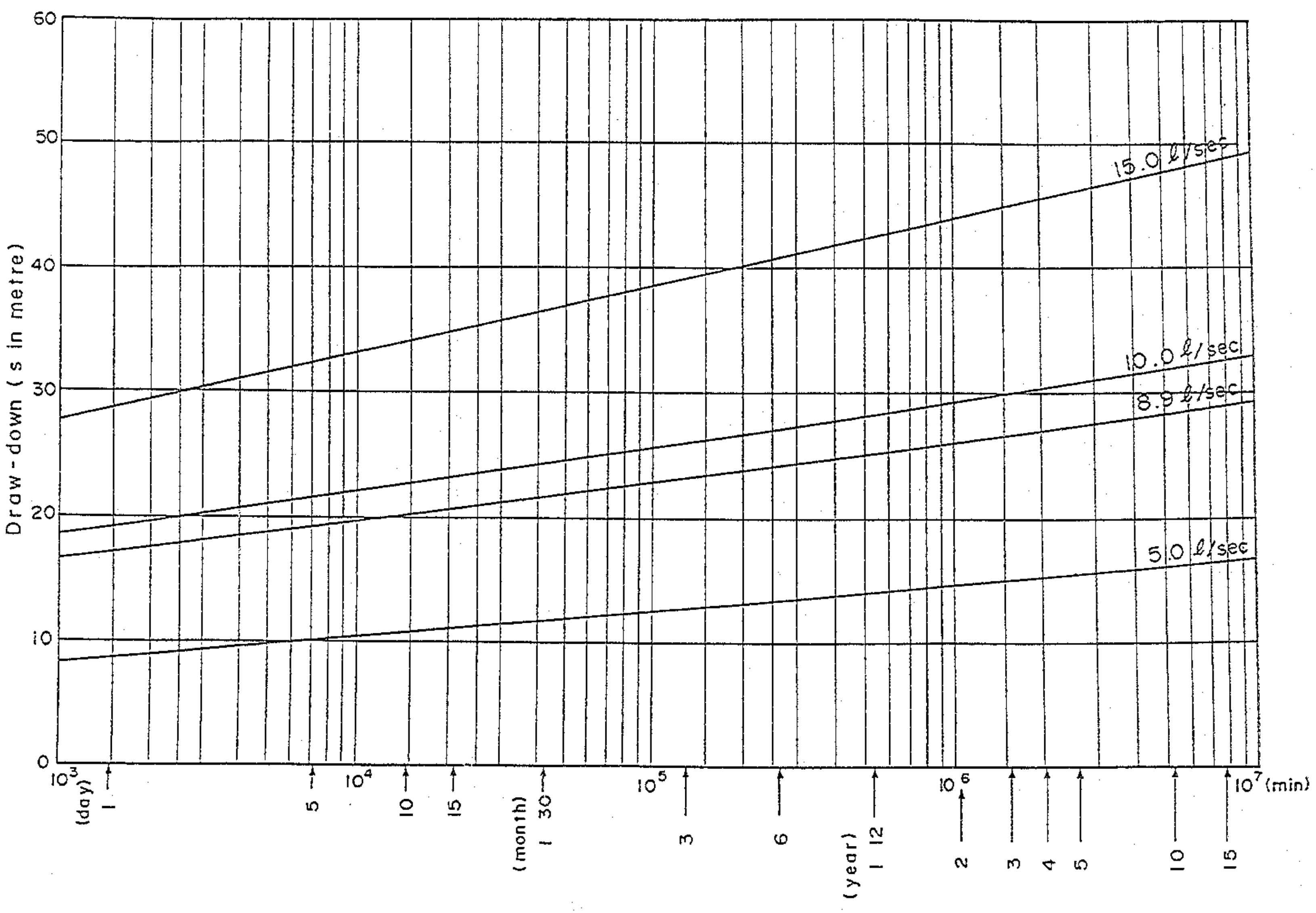


Fig. 2-1 T-S CURVE IN EACH YIELD OF THE JC1/89 WELL

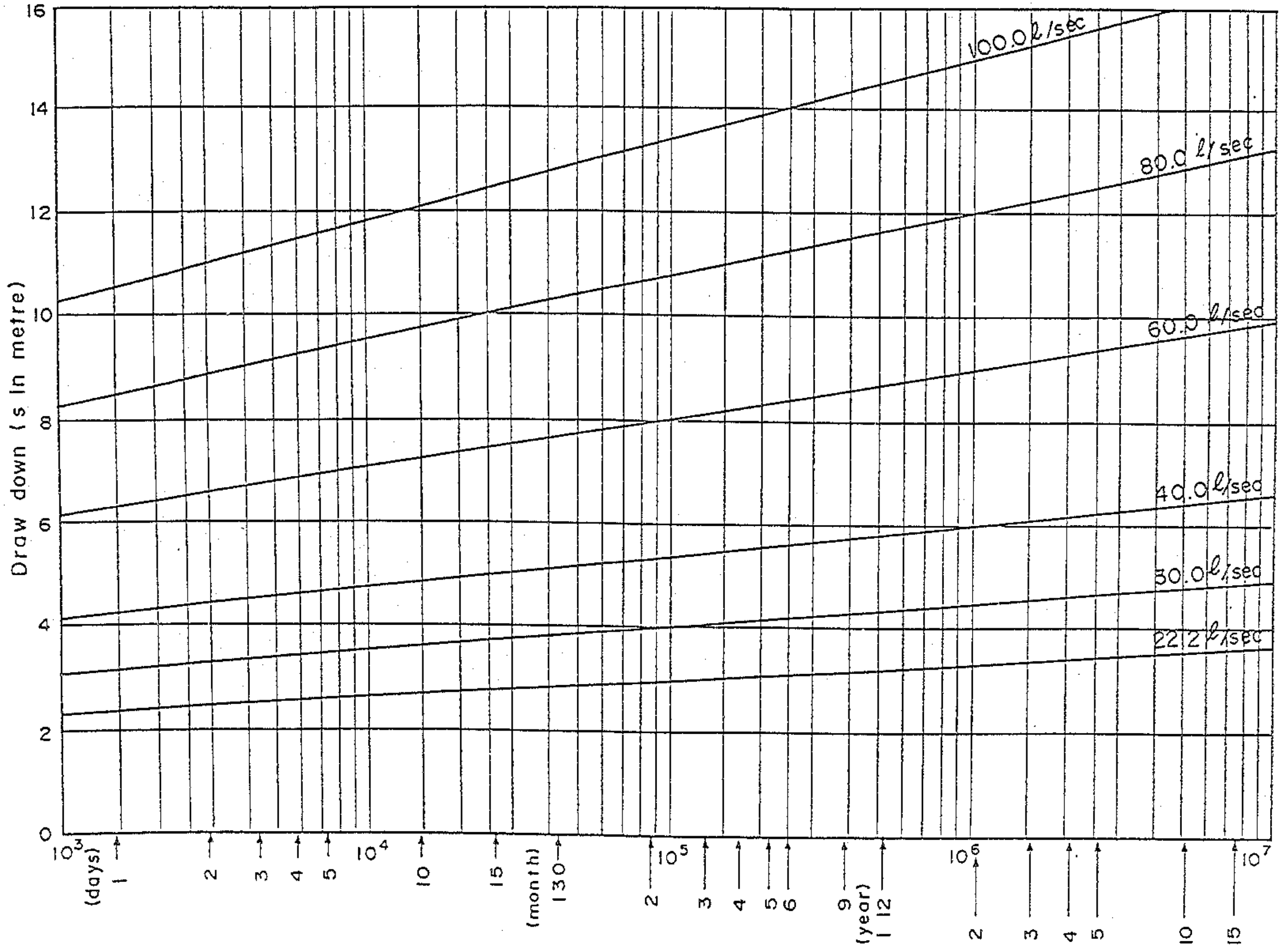


Fig. 2-2 T-S CURVE IN EACH YIELD OF THE JC2/89 WELL

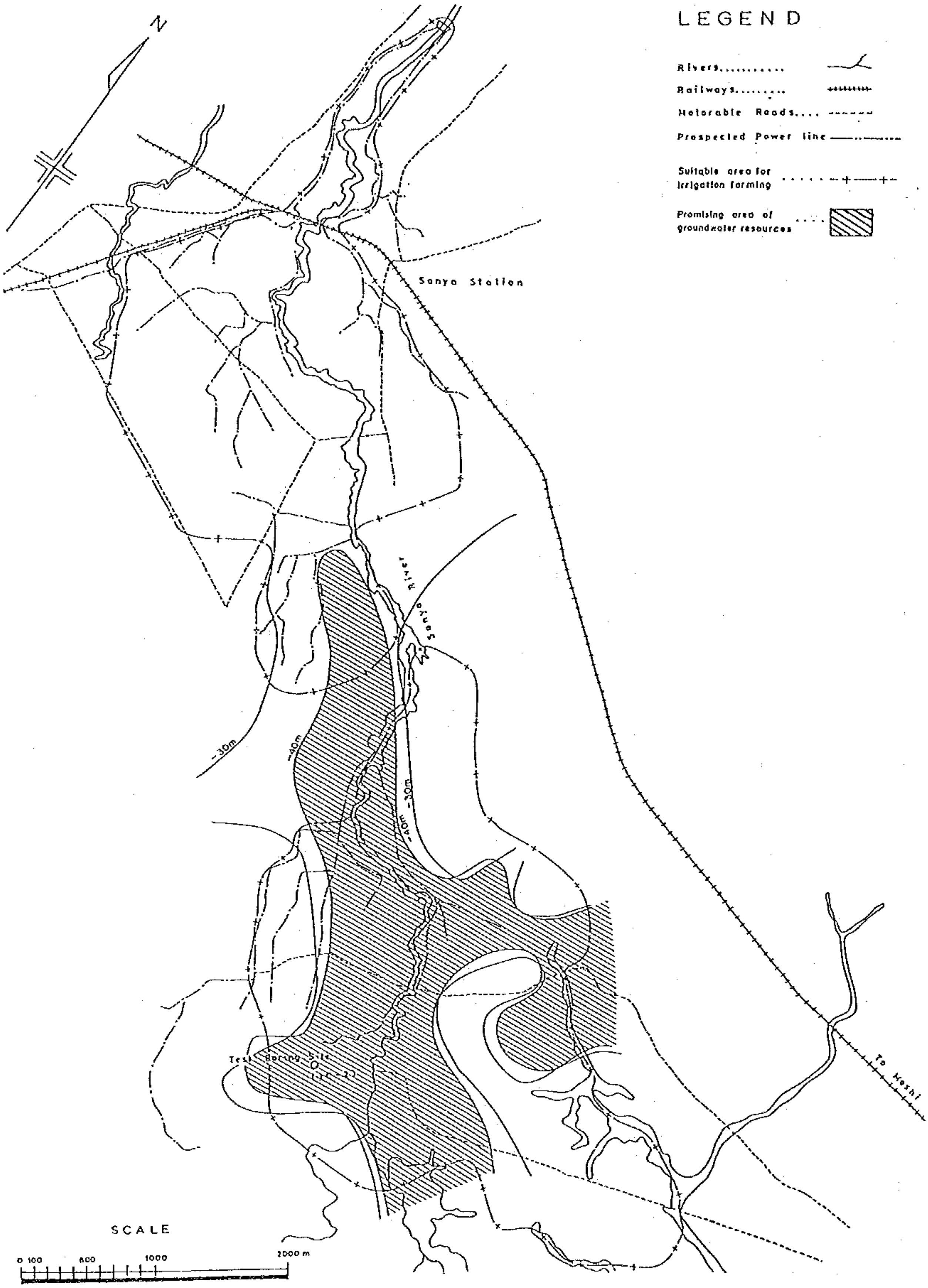
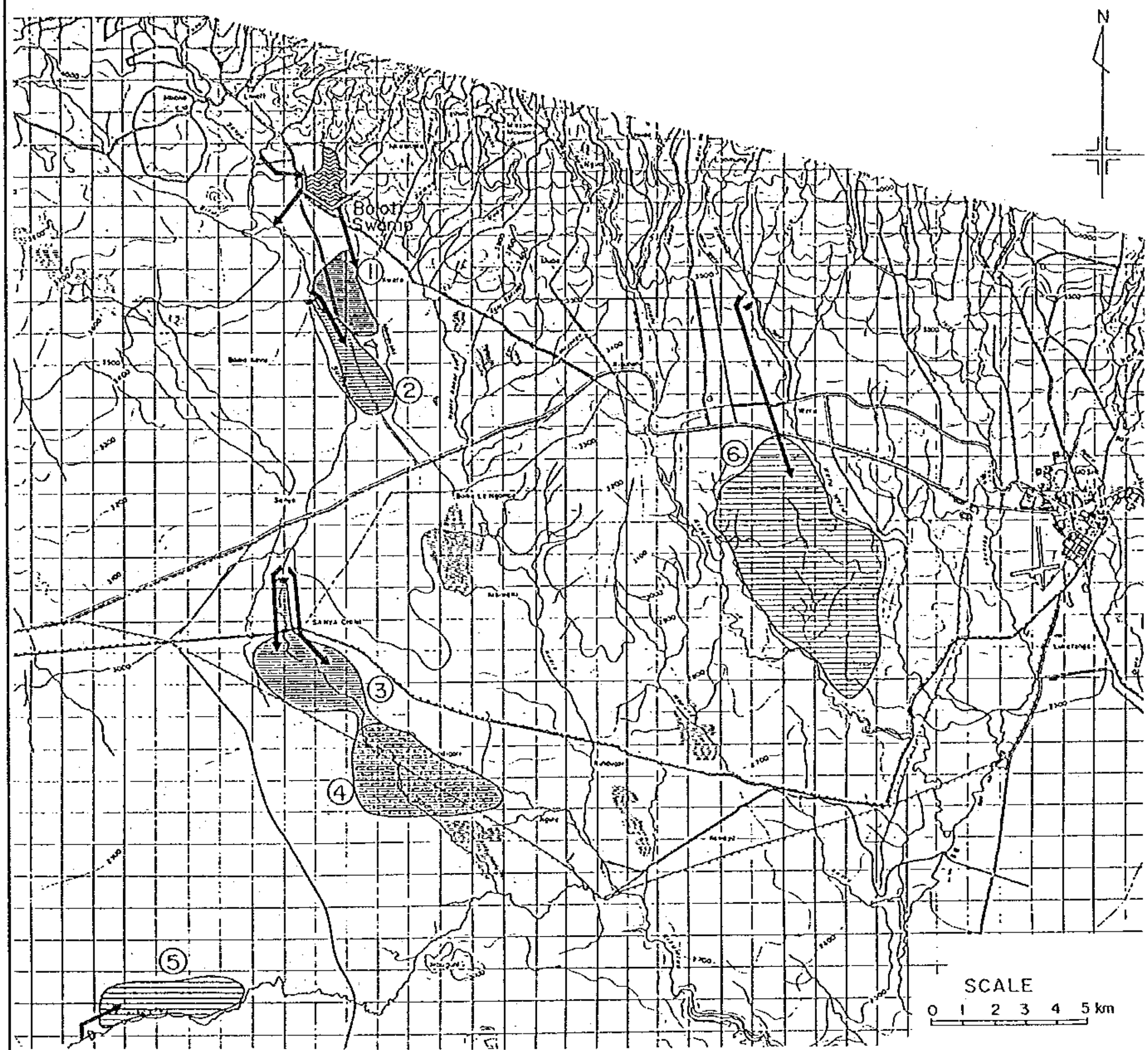


Fig. 2-3 PROMISING AREA OF GROUNDWATER RESOURCES IN SANYA PLAIN



① Boloti Area
② Mungushi Area
③ Sanya Plain
④ Sanya Plain (Groundwater available area)
⑤ Mtakuja Area
⑥ Kimashuku Area

Fig. 2-4 AGRICULTURAL DEVELOPMENT POTENTIAL AREAS

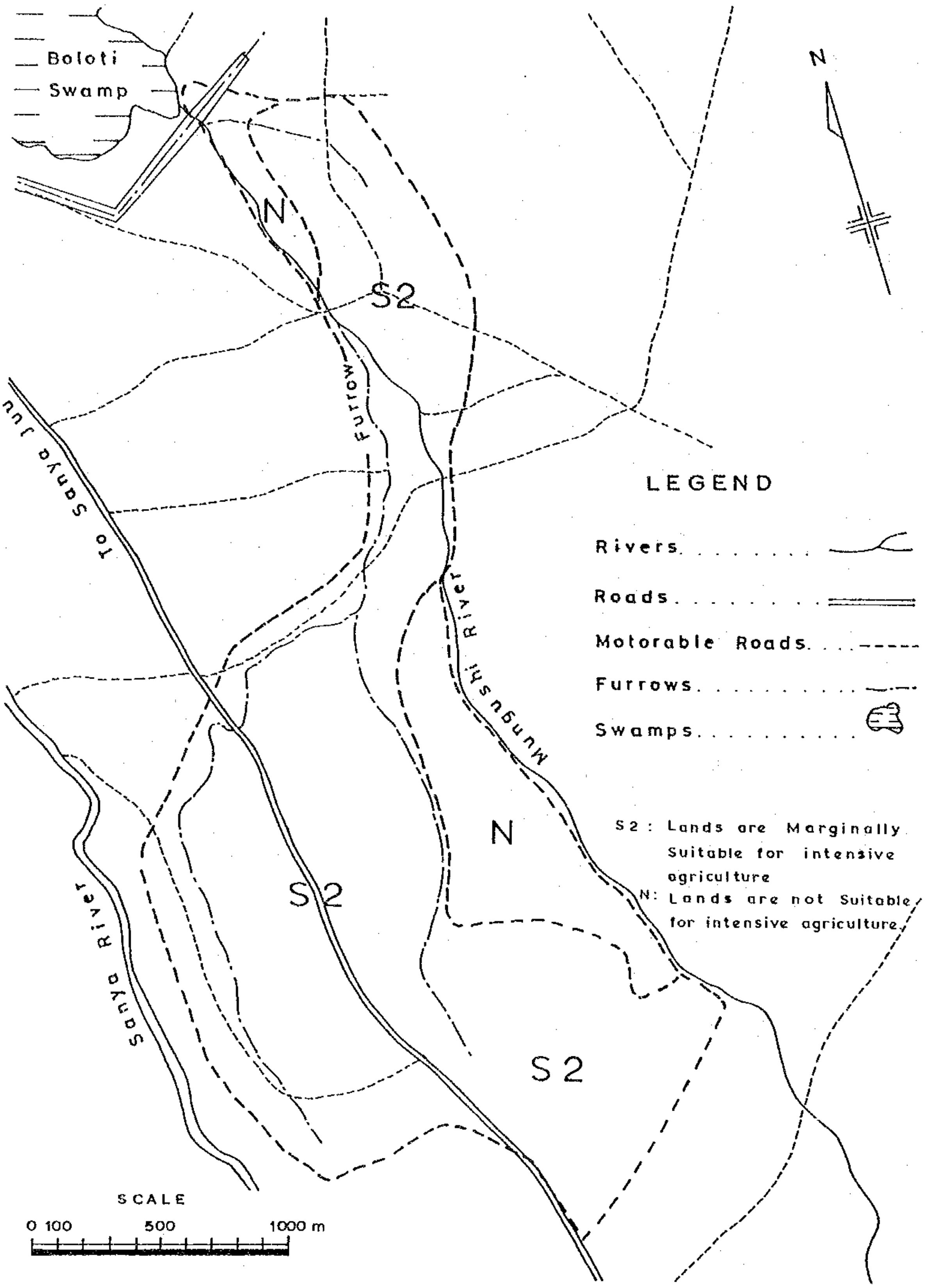


Fig. 3-1 LAND SUITABILITY MAP OF BOLOTI DOWNSTREAM AREA

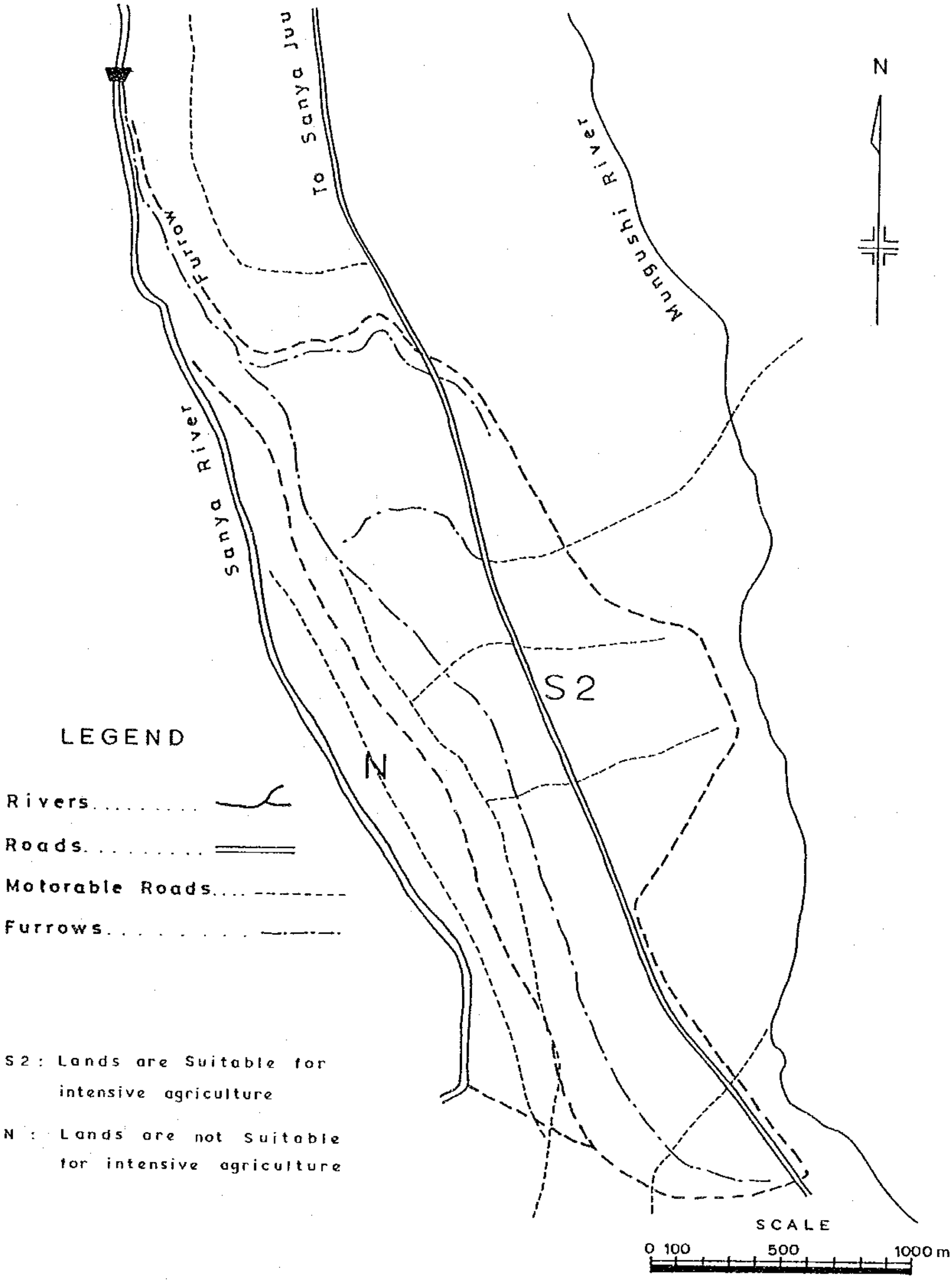


Fig. 3-2 LAND SUITABILITY MAP OF MUNGUSHI AREA

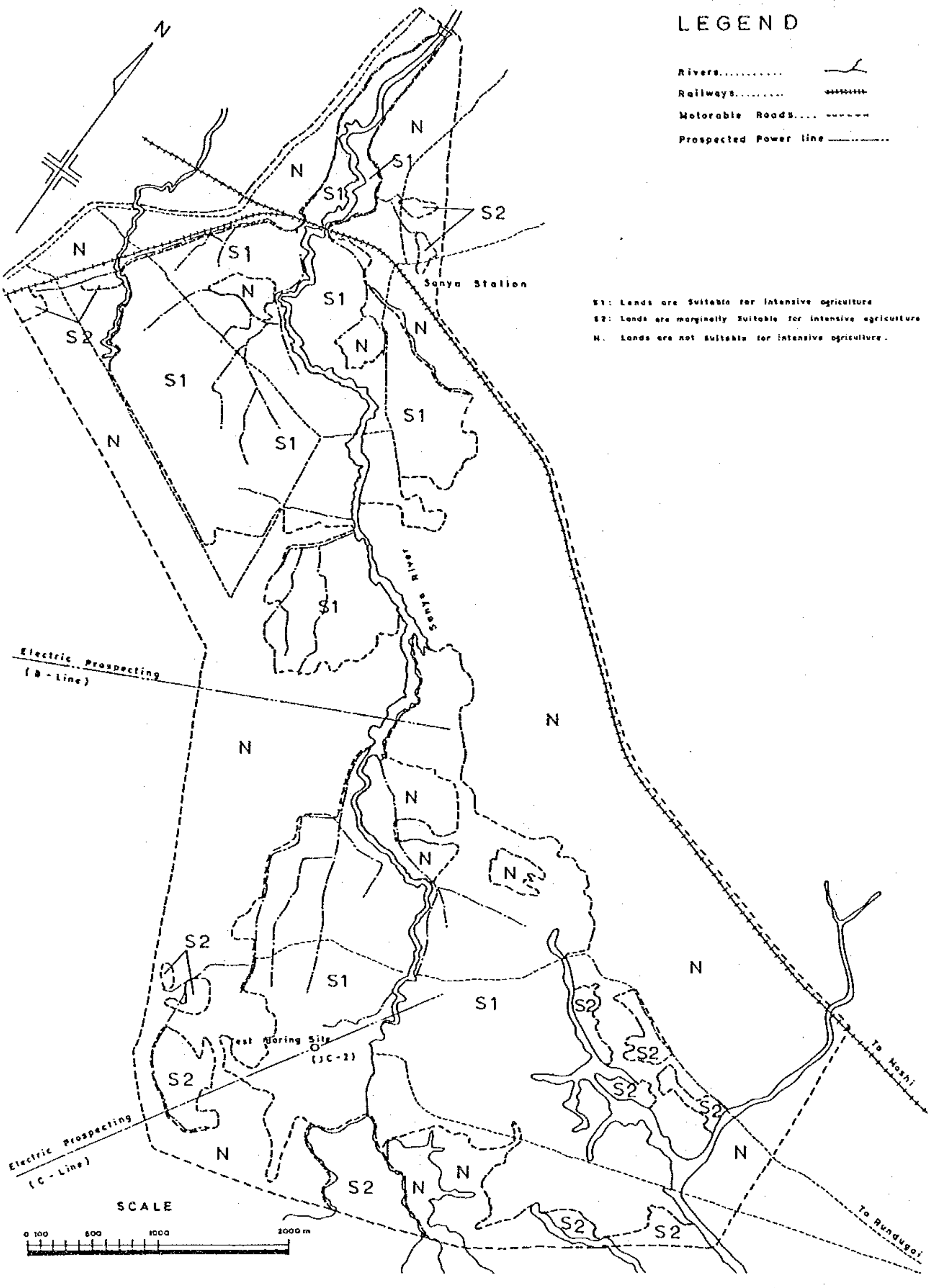


Fig. 3-3 LAND SUITABILITY MAP OF SANYA PLAIN AREA

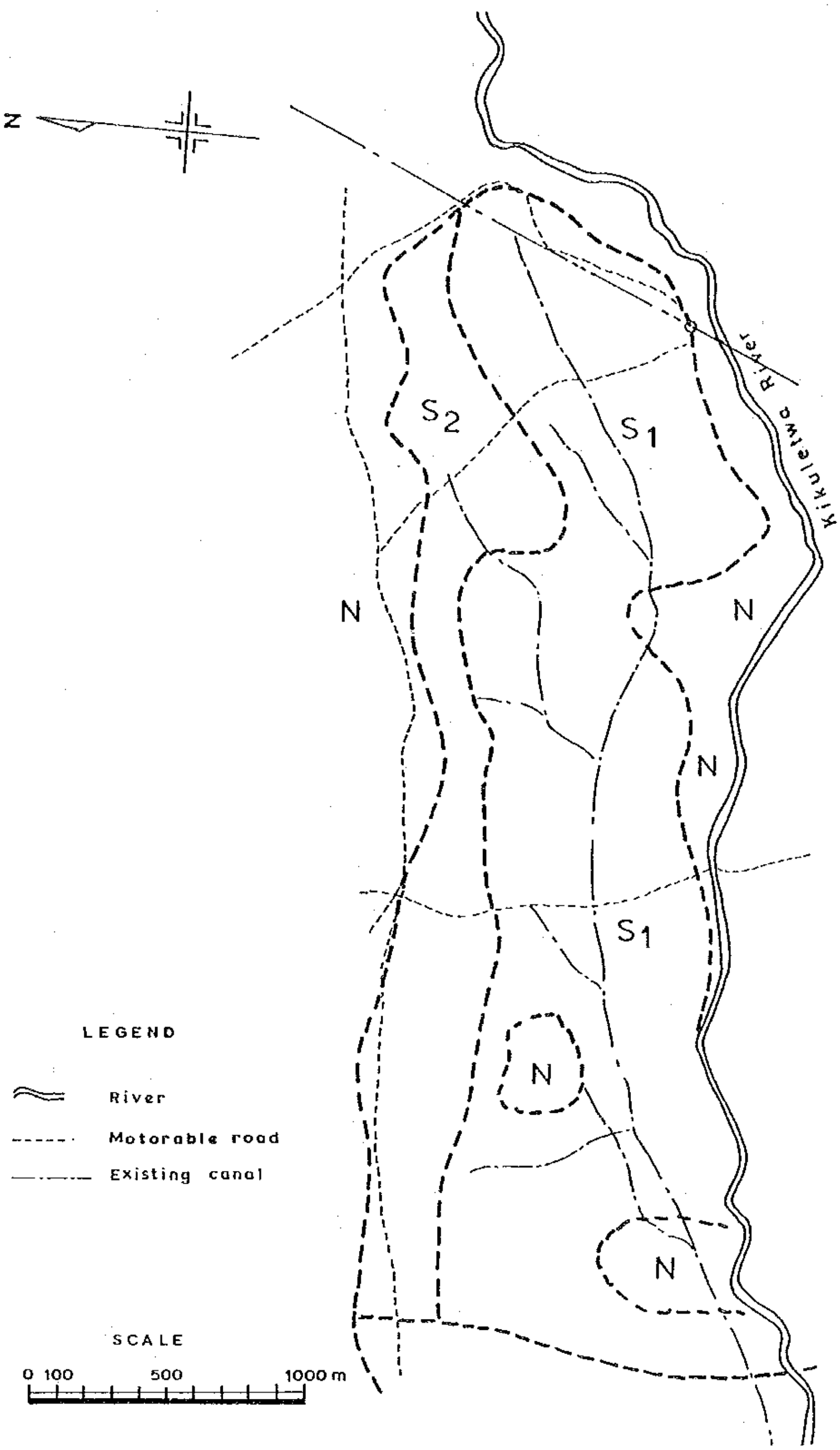


Fig. 3-4 LAND SUITABILITY MAP OF MTAKUJA AREA

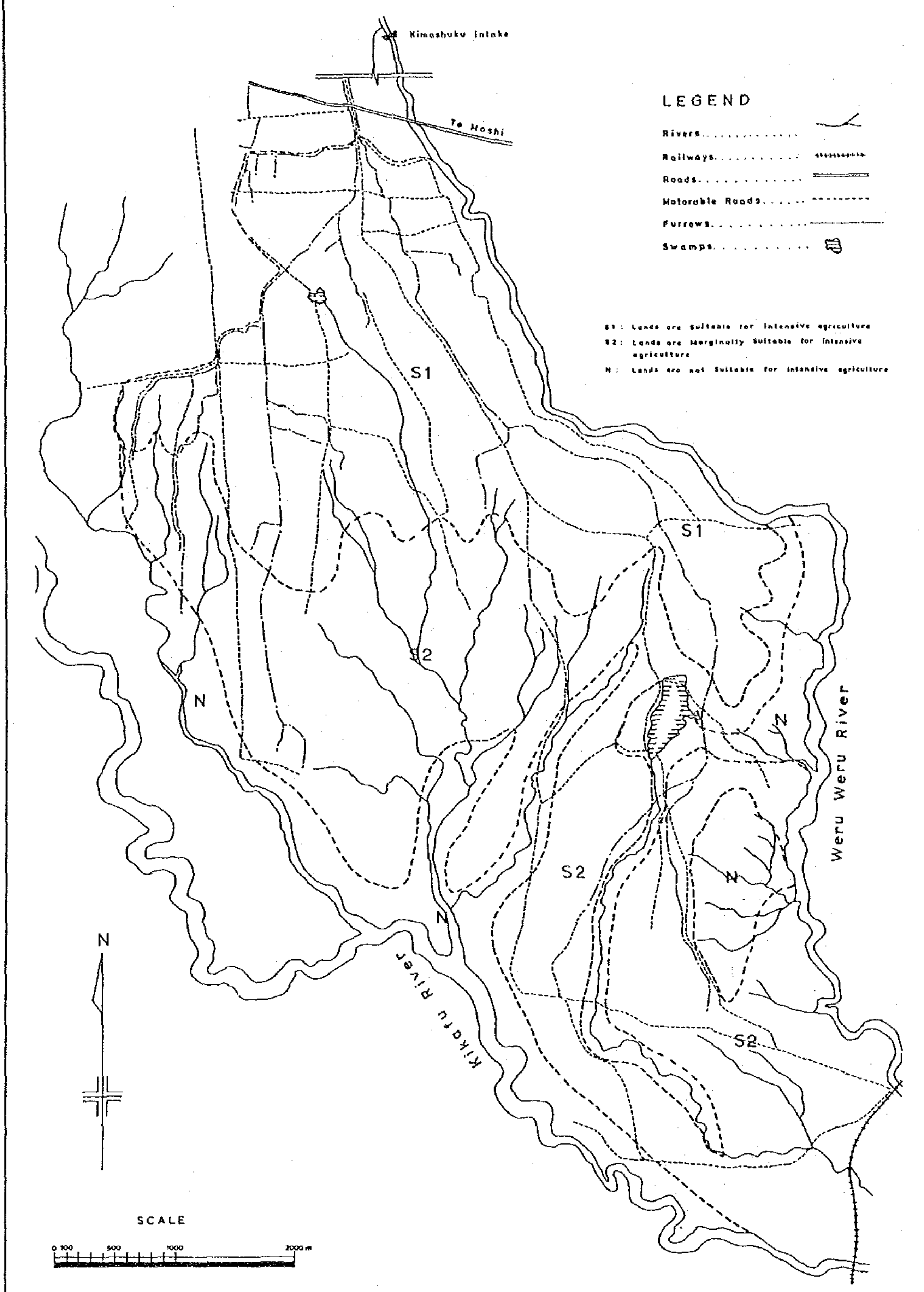


Fig. 3-5 LAND SUITABILITY MAP OF KIMASHUKU AREA

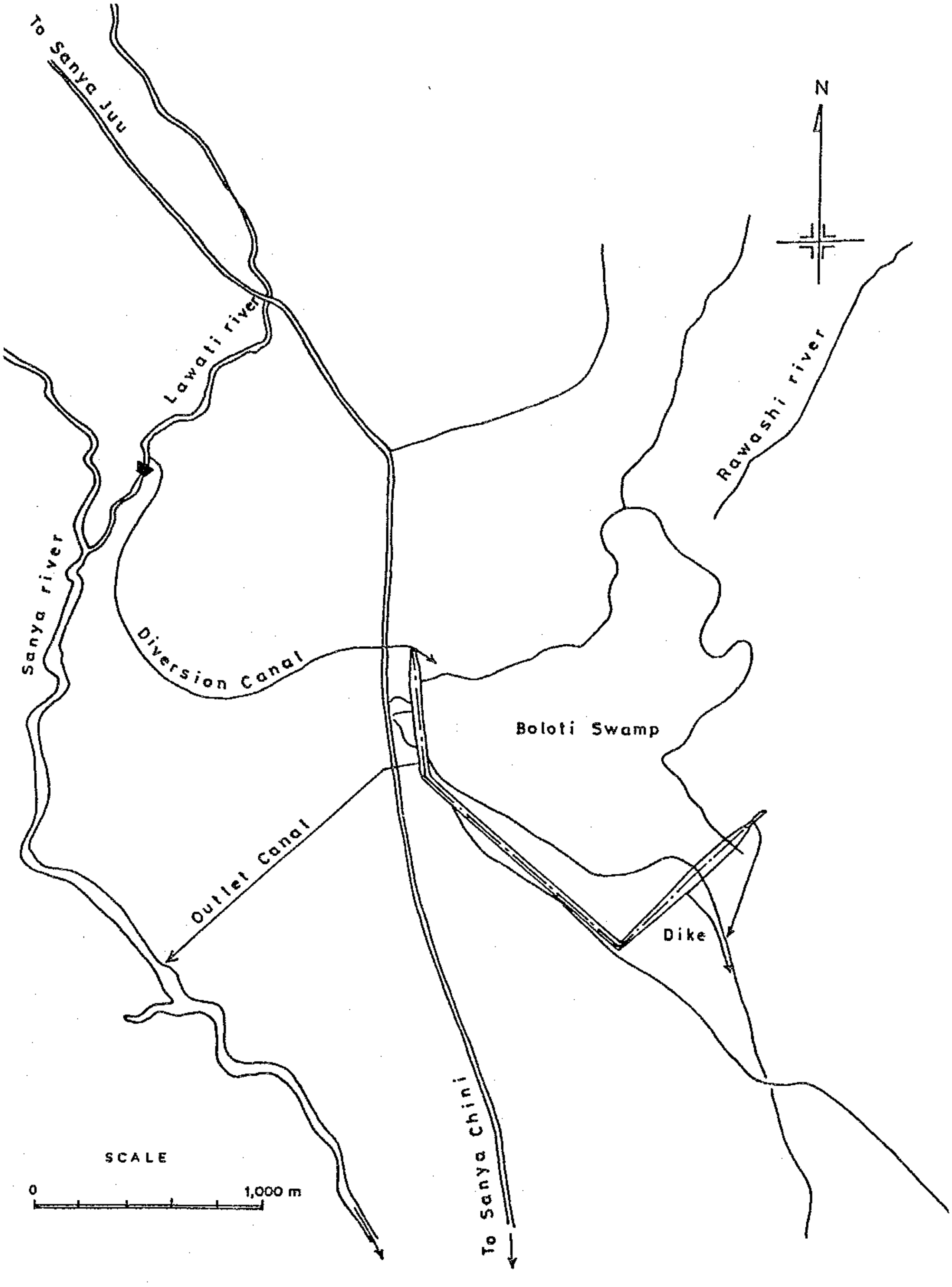


Fig. 4-1 PRELIMINARY LAYOUT OF BOLOTI RESERVOIR SYSTEM

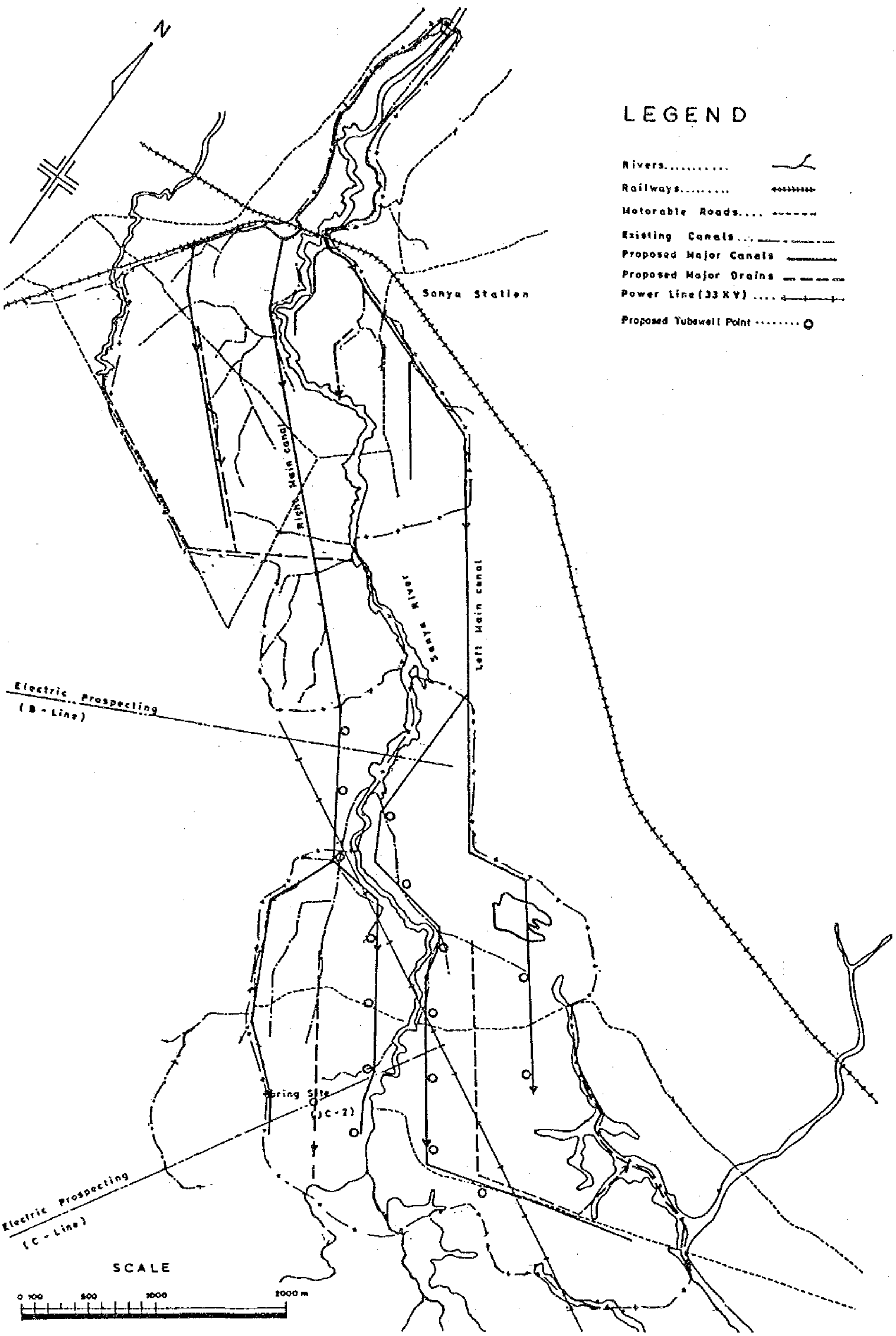


Fig. 4-2 PRELIMINARY LAYOUT OF SANYA PLAIN SCHEME

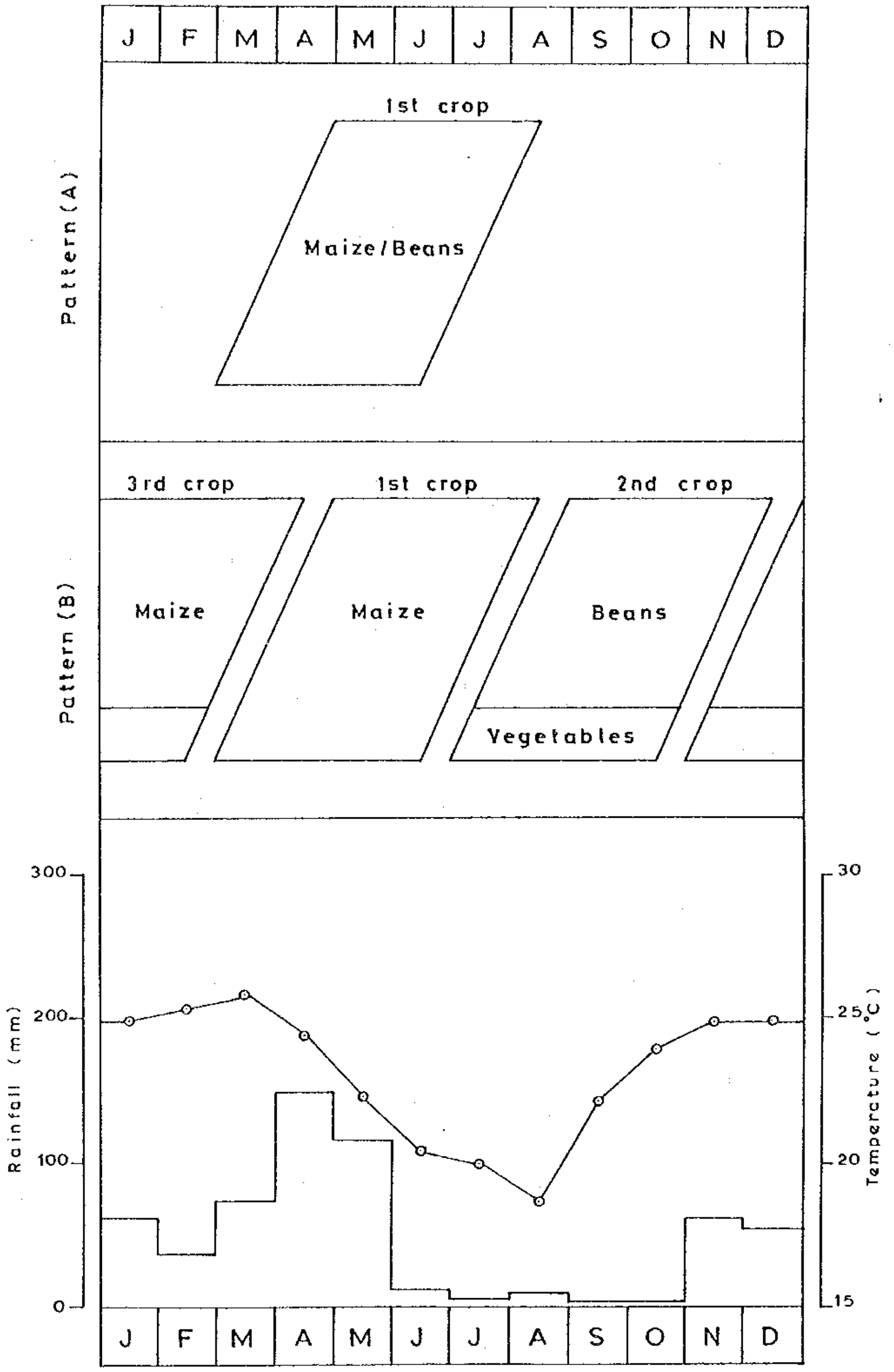


Fig. 4-3 PRELIMINARY PROPOSED CROPPING PATTERN

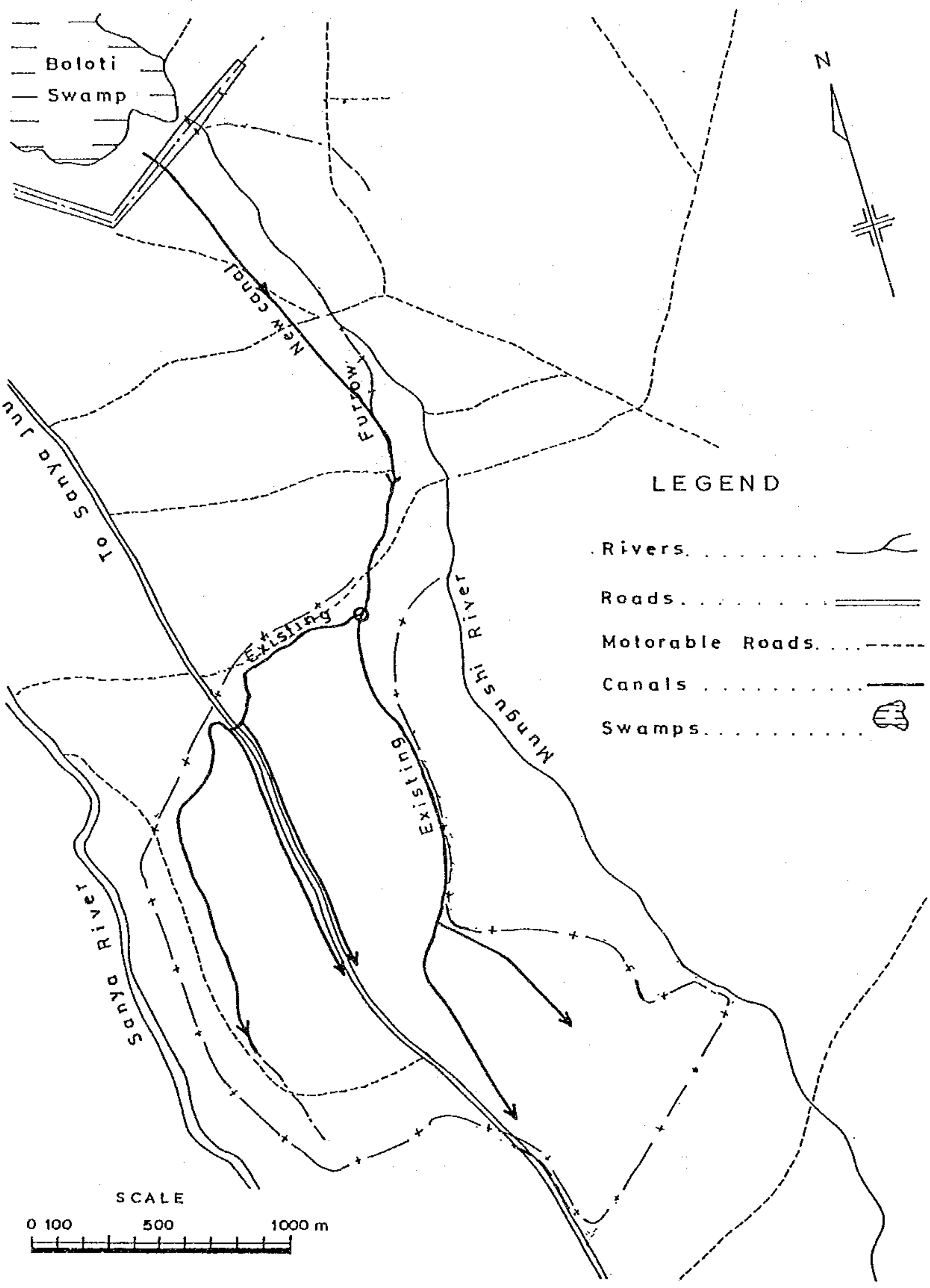


Fig. 4-4 PRELIMINARY LAYOUT OF BOLOTI SCHEME

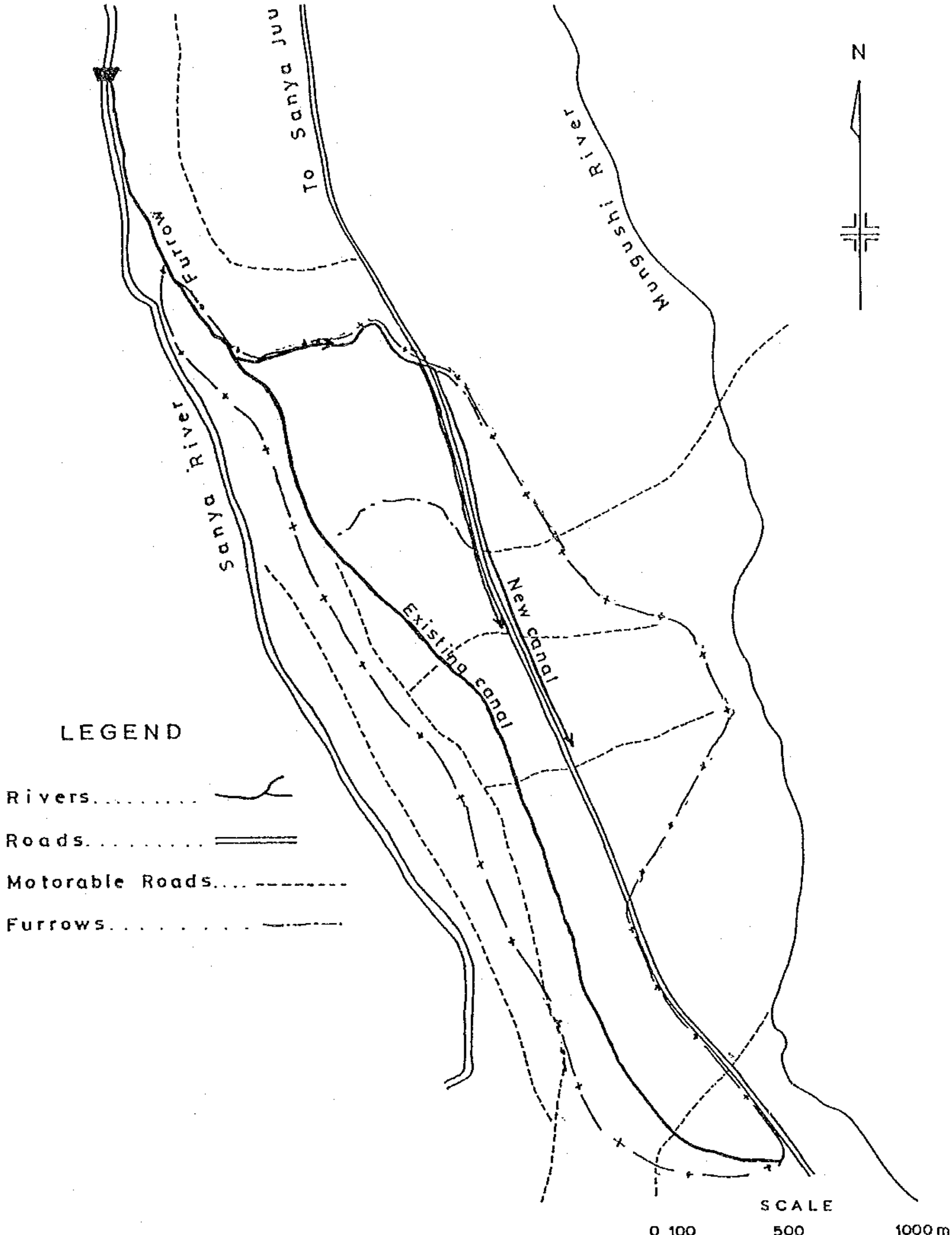


Fig. 4-5 PRELIMINARY LAYOUT OF MUNGUSHI SCHEME

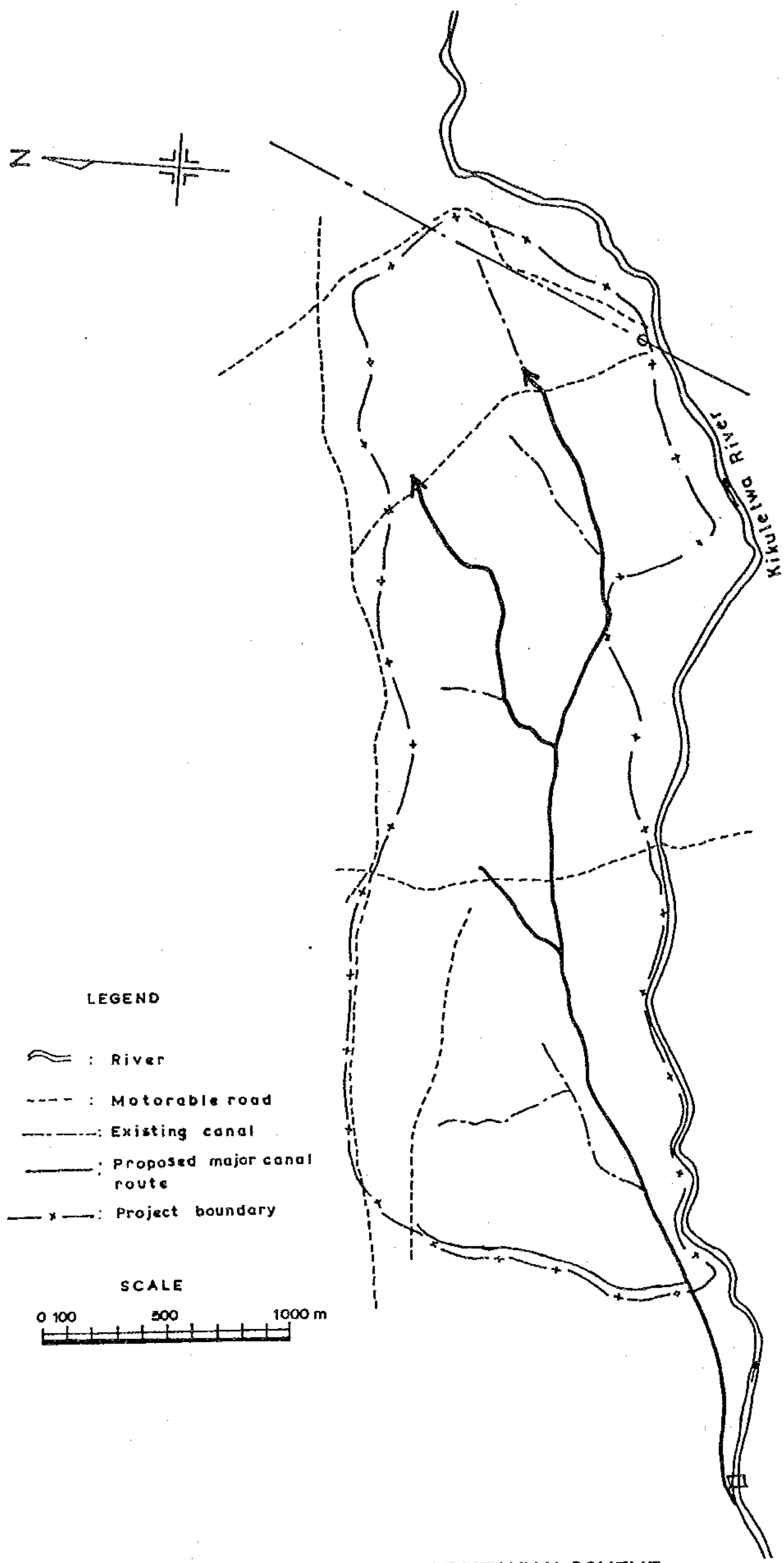


Fig. 4-6 PRELIMINARY LAYOUT OF MTAKUJA SCHEME

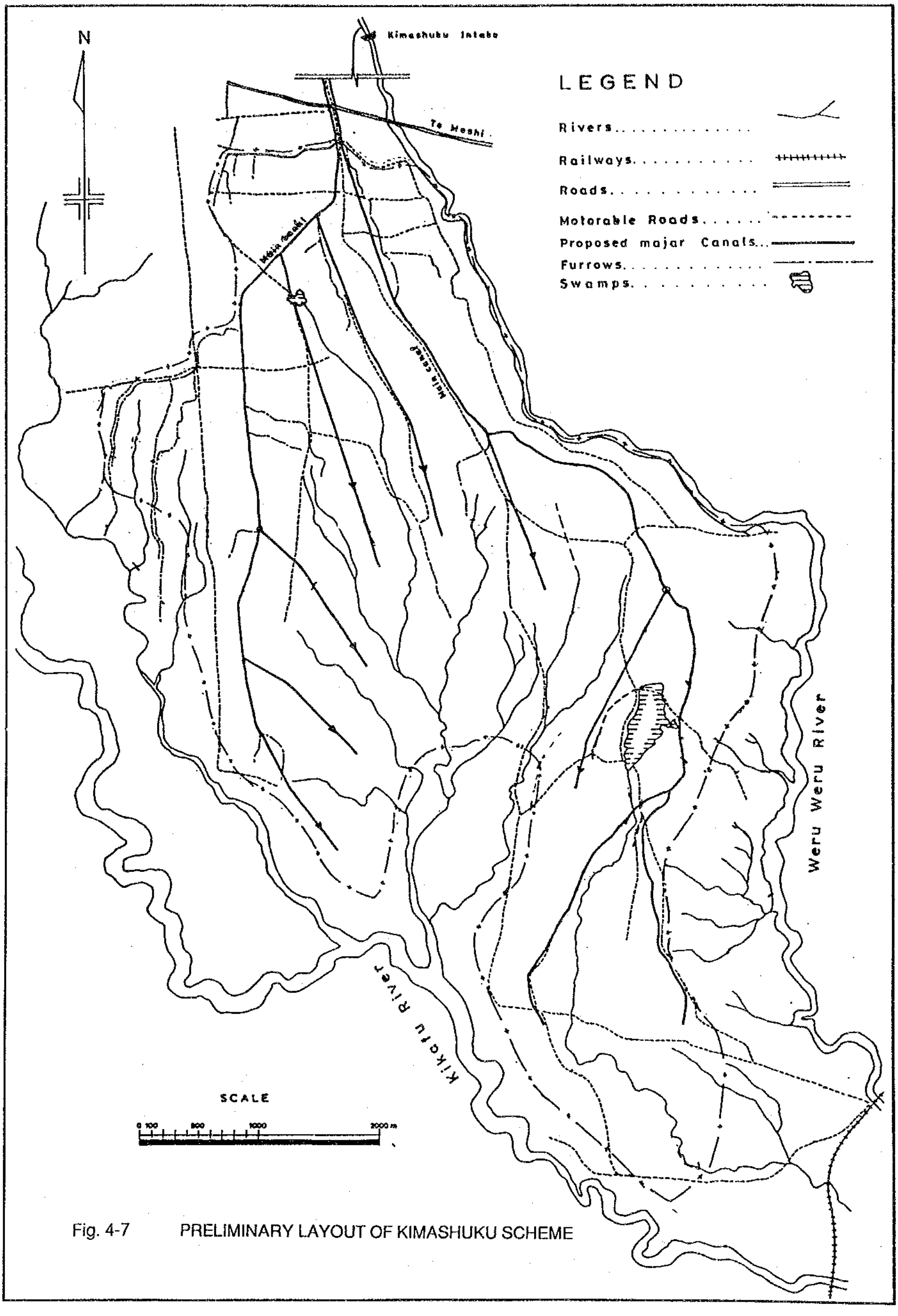


Fig. 4-7 PRELIMINARY LAYOUT OF KIMASHUKU SCHEME

ANNEX B

METEOROLOGY AND HYDROLOGY

ANNEX B

METEOROLOGY AND HYDROLOGY

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1. TOPOGRAPHY AND VEGETATION

The Lower Hai area is located on the southwest of the 5,895 m high Mt. Kilimanjaro and the Lower Rombo area is located on the east of this mountain. The zones are situated on elevations of 700-1,200 m and 1,000-1,700 m, respectively. Both zones, based on their topography, climate, vegetation and population density, extend from the highlands to lowlands in the Kilimanjaro region dividing into three areas: mountainous area, highlands and lowlands. The boundaries between the above three areas are about 1,800 m and 900 m in elevation, respectively.

The history of development of the two areas, the highlands and the lowlands, is different, i.e., the highlands were developed at an early period and the lowlands are being developed at the present time, due to the climate conditions, in particular the rainfall amount, whereby the area with more rainfall was selected for initial development.

The vegetation is generally classified by elevation as follows:

Elevation	Remarks
Above 4,900 m	Snowdrifts and frozen lakes
3,000 m - 4,900 m	Barren lands or high mountain vegetation zones
1,500 m - 3,000 m	Forest zone
Below 1,500 m	Perennial crops especially coffee and banana

The mountainous area is desolate and covered with alpine flora, and the peak has perpetual snow and small-scale glacier. The highlands change from a forested belt to a coffee cultivation belt to a banana cultivation belt. Maize and beans are cultivated in the lowlands. Mt. Meru with an elevation of 4,565 m is located on the west of Mt. Kilimanjaro. This mountain resembles Mt. Kilimanjaro in terms of its rainfall amount as related to elevation and land use. The rainfall and surface flow from this mountain act as an important water resource for Lower Hai.

2. CLIMATE

2.1 Climate

2.1.1 Lower Hai area

Meteorological records at the Moshi and KIA stations in Hai District are summarized in Fig. 2-1 and 2-2. These stations are located on the eastern and western edges of the Study area, respectively. The climatic characteristics change with location from the wet condition in Moshi to the dry condition in KIA. The location of the station is shown below.

Name of Station	Latitude	Longitude	Altitude
Moshi Meteorological Station	3°21'	37°20'	813 m
Kilimanjaro International Airport Station (KIA)	3°27'	37°01'	897 m

Climatic season is roughly distinguished as the rainy season during October-May and the dry season during June-September. Annual rainfall averages about 1,000 mm at the Moshi station, and gradually decreases to 600 mm at KIA station.

The monthly mean temperature is around 24-26 °C during October-April. It goes down from May and its lowest temperature is about 20 °C in July. The monthly mean relative humidity is generally 45 %-65 % at Moshi station and 55 %-75 % at KIA station. In general, a 10 % difference exists through the years between these two station.

The evaporation amount is recorded at Moshi, KIA and Lyamungu stations using an A-class pan. Observed evaporation amounts are almost similar at the Moshi and KIA stations, being 6-9 mm/day in the rainy season and 3-5 mm/day in the dry season. At the Lyamungu station, evaporation is 2-3 mm in the rainy season and 4-5 mm in the dry season, because the station's altitude is higher than Moshi's and KIA's.

2.1.2 Lower Rombo area

Formal meteorological observation has never been performed in the Rombo area. Only temperature data has been collected by Naranja junior high school, the results of which suggest that the condition of Naranja closely resembles Moshi station's area.

2.2 Rainfall

2.2.1 Rainfall observation station

There are 27 rainfall observation stations in Lower Hai and Lower Rombo (Table 2-1). These stations are located mainly at cultivation zones between 1,500 m and 1,000 m in elevation. The mean monthly rainfall amount at principal stations is shown in Fig. 2-3, and radar charts on the rainfall amount for Lyamungu, West Kilimanjaro and Rombo Mkuu are shown in Fig. 2-4.

From these figures, there are two rainy seasons : a major rainy season in March-April and a minor rainy season in October-January. These tendencies are summarized in the following.

(1) Western foot of Mt. Kilimanjaro: rainfall peak in April-May, the absolute amount for the peak and the mean annual rainfall amount are lower at the western stations than those at the eastern ones.
(2) Southern foot of Mt. Kilimanjaro: remarkable rainfall peak in April-May.
(3) Eastern foot of Mt. Kilimanjaro (Lower Rombo zone): equal peak in April-May and November-January, with the absolute value at the peak not as great as that for the western foot and southern foot. In addition, the absolute value of the peak decreases in a northern direction.

2.2.2 Annual rainfall amount

Based on the data on the rainfall at each of the above-mentioned stations, an isohyet map was prepared for the Mt. Kilimanjaro vicinity as shown in Fig. 2-5. From this map, the rainfall in the vicinity of Mt. Kilimanjaro appears as 500-2,000 mm, and the rainfall amount of the northern slopes is lower than that on the southern slopes.

The areas where the rainfall is 2,000 mm are located in a belt near the southern slopes of Mt. Kilimanjaro where the elevation is 2,000 m, surrounding the hillside. The rainfall amount decreases in an up and down and east and west directions from this belt. The areas where the rainfall is 1,500-1,000 mm are situated in the upper reaches of the below-mentioned Karanga river, the Weru Weru river, the Kikafu river, the Kware river, the Sanya river (Lower Hai) and the Lume river (Lower Rombo).

The decreasing rainfall in the western section of Mt. Kilimanjaro increases again in the Mt. Meru hills located to the west of the Study area, reaching 700-1,400 mm. The rain fall in this area flows into the Sanya river and the Kikuletwa river and plays an important role in the recharge of groundwater for the Lower Hai.

2.2.3 Long-term tendency of rainfall

Based on the data from 1935 to 1987 concerning Lyamungu Observation Station, the rainfall and the appearance of fluctuation during this period are shown in Fig. 2-6.

The annual mean rainfall of this period ranges from a high of 2,800 mm to a low of 900 mm. In the long-term, there is a tendency of a small decrease from the initial period to the later periods of observation.

The observed monthly rainfall values of these five years from Lyamungu Station and those from other stations were compared and the correlations were investigated as follows:

Correlation in the Rainfall Data between Lyamungu station and Other Stations

Name of Station	Correlation	No. of Spec.	Degree of Freedom
Lyamungu vs. Kibongoto	87 %	56	54
Lyamungu vs. Lerongo	86 %	56	54
Lyamungu vs. KIA	70 %	56	54
Lyamungu vs. Moshi	91 %	56	54

From these results, it can be said that the long-term tendency of the rainfall amount at the other stations are the same as that found at the Lyamungu Station.

Using the data from Lyamungu St., the non-exceeding probability was calculated by the Iwai method (Table 2-2). The annual rainfall amount corresponding to the return period of 10, 5, and 2 year is summarized as follows:

Return Period (Year)	Rainfall (mm)
10	1,137
5	1,282
2	1,580

2.2.4 Maximum daily rainfall

Maximum daily rainfall for non-exceeding probability year is estimated by the Iwai method. The results are shown in the following table.

(Unit:mm/day)

Name of Station	Non-Exceeding Probability (Year)					
	5	10	25	50	100	200
Moshi	146	171	203	224	-	-
KIA	91	118	147	190	225	264
Lyamungu	144	167	196	216	-	-
Kibongoto	109	125	139	157	170	182
Lerongo	91	106	120	138	151	163
Furuma Monastery	138	154	176	192	-	-
Masama Sawe	150	174	197	229	253	277

3. SURFACE WATER

3.1 River Discharge

3.1.1 Lower Hai area

In Lower Hai, distributed from east to west are the Karanga, the Weru Weru, the Kikafu, the Kware and the Sanya rivers, each running in a N-S or a NW-SE direction. In addition, the Kikuletwa river, which is adjacent to the southern edge of the Study area, has an eastward flow (Fig. 3-1). The first three of these rivers are perennial, while the last two are either dry or have a scant flow during the dry season.

Reference materials concerning the river discharge of Tanzania is the Hydrological Yearbook, of which four volumes have been published. The years covered by each volume are shown in the following.

Volume No.	Years
1	955-1959
2	960-1965
3	965-1970
4	970-1975

The data recorded in these volumes concerning Lower Hai are shown below.

Major Rivers and Gauging Station

River Name	No. of Station	Catchment Area (km^2)	Observation Period
Karanga	1DD03	221	Oct.'54-Oct.'59
Weru Weru	1DD5A	85	Oct.'58-Oct.'59
	1DD6A	68	Mar.'68-Dec.'72
	1DD07	54	Nov.'57-Oct.'59
Kikafu	1DD08	198	Nov.'54-Oct.'59
Kware	1DD09	76	Nov.'54-Oct.'59
	1DD10	34	Nov.'54-Oct.'59
Kikuletwa	1DD54	2,220	Feb.'67-Oct.'70 Apr.'88-
	1DD01	3,880	Nov.'55 -

Among these observation points, the Kikuletwa river, at 1DD54, (downstream of TANESCO Electric Power Plant) is the only river of which water depth is still being observed. Other than this, the same observation is being carried out at 1DD01, downstream from the point of confluence of the Kikuletwa and Karanga rivers. However the conversion from water depth to discharge has not been worked out for the last 10 years.

The monthly mean discharge data for each river, obtained from the Hydrological Yearbook, are shown in Table 3-1 and Fig. 3-2, and the river discharge per 100 km^2 of catchment area is shown in Fig. 3-3.

Described below is the summary of the river condition based on discharge records.

(1) Weru Weru river (Registered Stations: 1DD5A, 1DD6A, 1DD07)

This is a perennial river showing a flow peak during the major rainy season from March to July. The discharge at the point established the furthest upstream, 1DD6A, is 1.34-4.41 m^3/sec and that of 1DD5A downstream of the above is 0.13-3.19 m^3/sec. In any given month, the amount at the downstream point is smaller. The riverside area between the two points has become cultivated land, and thus, the above-mentioned decrease in the discharge is principally due to irrigation use of this cultivated land. The period of base flow is estimated as being from August to October.

(2) Kikafu river (Registered Station: 1DD08)

This is the perennial river with the most abundant discharge in the Lower Hai. This discharge, at 1DD08, ranges 0.99-21.62 m^3/sec. From April to July, it exceeds 4 m^3/sec, reaching its peak in May, and then gradually decreases down to the base flow in September-October. In the Phase-1 observation period, the Kikafu river showed a discharge of 1.89 m^3/sec near its intersection with Moshi-Arusha Road. Then, just before the point of confluence with the Weru Weru river further downstream, the discharge was 1.52 m^3/sec. This shows a decrease at the downstream site. In between the two stations, an irrigation intake was recognized. The above-mentioned decrease in discharge is thought to be due to the irrigation intake for the cultivated land. However, the static water level of the bored wells (75/81 and 23/82) on the eastern shore of the Kikafu river near its intersection with Moshi-Arusha Road is close to the level of the river bottom of the Kikafu. Therefore, it is thought that the groundwater found in these wells is recharged from the Kikafu river and that the reason for the decreased discharge mentioned above is the groundwater recharge.

(3) Kware river (Registered Station: 1DD09, 1DD10)

The discharge of this river at the upstream point (1DD10) is 0.04-1.8 m^3/sec, and at the downstream point is 0.02-2.11 m^3/sec. Differing from other rivers, the downstream discharge is large in the major rainy season, while the upstream discharge is large just before the major and minor rainy seasons.

The discharge peak is in May, and in September-November the discharge in the Kware river decreases to 0.02-0.05 m^3/sec. The Kware river is named the "Mungushi river" at the upstream and even further upstream from that, it is named the "Boloti Swamp". The Rawashi river flows into this swamp.

(4) Sanya river (Registered Station:1DD13) and its branches, the adjoining Rawashi river and Boloti Swamp

The discharge of the Sanya river at 1DD13 station, crossing point with Moshi-Sanya Juu road, is 0.00-1.24 m^3/sec at its peak in May, and 0.00-0.08 m^3/sec at its lowest in August-October. The Sanya river joins with the Lawati river and flows southward over the southwestern slopes of Mt.Shira. The records on the discharge of this river are insufficient to estimate a reliable hydrogeological picture as they covered only the 1957-1960 period.

The discharge of the Rawashi, after passing over the southwestern slopes of Mt. Shira in a westward direction, flows into the Boloti Swamp which is adjacent to the Sanya river to the east. From the Boloti Swamp, it flows into the Kware river through the portion called the Mungushi river, and then runs parallel to the Sanya river.

(5) Kikuletwa river (Registered Station: 1DD54)

This river is perennial in the Arusha region, but dry from near the regional border with Kilimanjaro. This drying up might be caused by the deposition of sediment materials into the Kikuletwa river. Immediately downstream from the border, there is no discharge seen even in the rainy season. However, about 20 km downstream from this border, river flow begins, fed by mainly water originating in small springs. In the vicinity of the Rundugai Springs mentioned below, the discharge is 11.14-15.66 m^3/sec. In this vicinity, the peak is in May, and the discharge in September-October is at a low of 11.14-11.21 m^3/sec, with not much change seen in the amount throughout the year. The reason for this is that the majority of the discharge in this river originates from the Rundugai Springs.

(6) Rundugai springs

The Rundugai Springs are found near the point of confluence of the Kware, Sanya and Kikuletwa rivers. From the distribution pattern of these springs, the groundwater supply to these springs is thought to be related to the basin of the Kware and Sanya rivers. From the aspect of geology, the above also appears to be related to the bed of lahar found between the two rivers.

The shape of Precambrian basement rock found widely spread south of the southern shore of the Kikuletwa river in Arusha Region greatly influences the stream of the Kikuletwa and the groundwater mechanism of this area, as well as the distribution of the Rundugai Springs.

3.1.2 Lower Rombo area

The only perennial river in Lower Rombo is the Lume river, even though this river, upon close inspection, is not actually perennial, since the discharge practically disappears in the downstream in the dry season. All other rivers are dry except following rain or directly after the rainy season. There is no public observation records on this river.

3.2 Discharge Measurement

3.2.1 Lower Hai area

In order to understand the surface water use and the mechanism of groundwater recharge, in the Phase-1 Study, a field measurement on the stream flow was carried out. The subject rivers were the Karanga, the Weru Weru, the Kikafu, the Kware and the Sanya, their branches, the Rundugai Springs and the Kikuletwa river (Fig. 3-4, Fig. 3-5, Fig. 3-6). In Phase II, supplementary measurement was done on the Weru Weru, the Kware, the Sanya and the Rundugai Springs. The period of the Phase-1 measurement was the dry season, November to December, 1988, and that of the Phase-2, measurement June to July, 1989 was directly following the major rainy season.

(1) Karanga, Weru Weru and Kikafu rivers (Fig. 3-4)

In the Phase-1 Study, discharge measurement for these three rivers was carried out, and in Phase-2, supplementary study on only the Weru Weru river was done. In the minor rainy season in 1988, just before the point of confluence of the Karanga and Weru Weru rivers, the discharge did not exceed 0.42 m^3/sec. However, further downstream, after discharge is increased by the inflow of the Weru Weru and the Kikafu rivers, just before the point of confluence with the Kikuletwa, no discharge was observed after intake of 1.76 m^3/sec and 0.81 m^3/sec by the TPC (Tanganika Plantation Company).

As for the Weru Weru river during the Phase-1 study period, at 2.5 km north of the Moshi-Arusha Road intersection, discharge was 0.82 m^3/sec, while downstream, after intake of water by the Kimashuku Irrigation System, it was 0.28 m^3/sec at the crossing point of the said road. Then, further downstream after joining with a branch river and just before confluence with the Karanga river, discharge increased to 0.34 m^3/sec (0.76-0.42). This increase is thought to be due to supply from the branch of the Weru Weru river.

The discharge of the Kikafu river, in the minor rainy season near the Moshi-Arusha Road was 1.89 m^3/sec, but downstream of this, just before the point of confluence with the Karanga, it decreased to 1.52 m^3/sec. This decrease is thought to be due to water intake in between both points for the cultivated land.

In the Phase-2 Study, the observed discharge of the Weru Weru river at the point located north of the Moshi-Arusha Road was 4.32 m^3/sec. No water was used for the Kimashuku scheme during this period.

(2) Sanya river and its branch, the Lawati river (Fig. 3-5)

The Sanya river system is composed of some tributaries, the Lawati, the Garanga, the Fuka and the Biriri rivers. The Garanga river flows on the western slopes of Mt. Shira and joins the Sanya river at the upper reaches of the Sanya Juu. The Fuka river joins the Sanya river at its 3 km downstream from the Sanya Juu. The Biriri river, which has approximately 200 km^2 of the catchment area in the Sanya plain, joins the Sanya river down stream of the Mungushi Weir.

In the Phase-1 Study, a discharge of 0.44 m^3/sec was measured in the Garanga river at the forest boundary, about 14 km upstream of the Sanya Juu, even in the minor rainy season. However, this amount decreases to only 5 lit/sec at the Sanya Juu. In between this 14 km, irrigation intakes divert water to the Garanga and other estates. The decrease of the river discharge was mainly due to the irrigation diversion by these intakes.

The measured discharge of the Fuka and Lawati rivers at the bridges of Moshi-Sanya Juu Road was 1 lit/sec and 0.11 m^3/sec, respectively. Most of this amount is diverted to irrigate the Mungushi area in the downstream, and only a few lit/sec remains in the river. No flow occurs from the Biriri river, and subsequently the discharge at the Sanya Chini is almost nothing.

In the Phase-2 Study in June 1989, the discharge at the Sanya Juu, the Fuka and the Lawati were 0.08 m^3/sec, 0.32 m^3/sec and 0.75 m^3/sec, respectively. About 0.16 m^3/sec was diverted to the Mungushi area, 0.15 m^3/sec flowed from the Biriri river and 1.30 m^3/sec was observed at the Sanya Chini. The discharge of the Rawashi river measured, which flows into the Boloti swamp, was 0.23 m^3/sec. This water is used to irrigate the southern part of the swamp, and the Mungushi area located between the Sanya river and the Moshi-Sanya Juu road.

(3) Rundugai Springs (Fig. 3-6)

The Rundugai Springs appear near the point of confluence of three rivers, the Kware, the Sanya and the Kikuletwa rivers, and the spring groundwater flows into these rivers.

The discharge of the Kware in the minor rainy season does not exceed 4 lit/sec at of the point of origin of the springs. However, just before its point of confluence with the Kikuletwa, excluding 1.0 m^3/sec of intake of water for the Rundugai Irrigation System, it increases to 3.7 m^3/sec. The increased amount is due to both the addition of the water flowing from the Kware riverbed and that from the springs. The reason for the increased discharge downstream of the Kware just after the major rainy season is not so clear, as it could be either due to the increase in spring water or to the fact that the intake for cultivation is low at this time.

The spring water on the banks of the Sanya river originates near the point of confluence with the Kikuletwa and then passes through the Sanya and enters the Kikuletwa river.

(4) Kikuletwa river

The Kikuletwa river flow begins to some 10 km upstream of its confluence with the Sanya river, gradually increases its discharge as it collects the spring water from both banks, and just below the confluence with the Kware reaches 11 m^3/sec.

3.2.2 Lower Rombo area

In the Phase-1 and Phase-2 Studies, discharge measurement was carried out for all rivers at the intersecting with the Himo-Tarakia Road. As to the Lume river, only one perennial flow in the Lower Rombo area, the discharge measurement was made in several points from the upstream to the downstream points of the Lume river (Fig. 3-7).

As shown in Fig. 3-7, no surface flow was observed in the most of the rivers throughout the year except for the Lume river. According to the information collected from the local people, only some flood flow is observed immediately after heavy showers but in very short term.

The discharge of the Lume is 0.19-0.50 m^3/sec in the Phase-1 and 0.10-0.19 m^3/sec in the Phase-2. The discharge increases to the mid-stream point, however from this point it suddenly deceases . The reason for this decrease is not exactly clear. As it is not due to the circulation of water used for irrigation, it must be due to water recharge to the riverbed.

3.3 Water Rights

In the highland (altitude of more than 1,000 m - 1,200 m) of Hai and Rombo districts as well as Moshi district, river water is intensively utilized for the cultivation of perennial crops such as banana and coffee plantations established during the British administration.

The Water Utilization (control and regulation) Act was enacted in 1974 and then supplemented by a subsidiary legislation in the Government Notice No. 242 published in October 1975.

Water rights in Hai and Rombo Districts are listed in Table 3-2 and are summarized for each river system in the Study area as follows:

Name of River System	No. of Water Rights	Amount (m^3/sec)
Lower Hai Area		
Weru Weru river system	36	3.86
Kikafu river system	23	1.68
Karanga river system	21	0.37
Sanya river system	15	0.45
Kikuletwa river system	2	*
Lower Rombo Area		
Motale river	1	0.01
Mlembea river	1	**

Note: * Not quantified.
** Amount is not clearly mentioned. Instead, pipe diameter 3" is mentioned.

Large water users are the Tanganika Planting Company (TPC) and Kikuletwa Hydropower Station.

(1) TPC

TPC has two intakes along the Weru Weru river as mentioned before. According to TPC water right (No. 3329 I DDA), TPC has been granted to take 2.83 m^3/sec (100 cusecs) from the Weru Weru river or such less quantity as may be available, plus 50 % of the river flow at the intake in excess of 2.83 m^3/sec, up to a maximum of 17 m^3/sec (600 cusecs).

TPC has reported river discharge and intake discharge to the Water Office every month as shown in Fig. 3-8. This figure shows that discharge of the Weru-Weru river in the dry season often falls lower than the water rights' amount. The reason for water shortage may be attributed to withdrawal of water by existing furrows or new furrows and/or insufficient rainfall in the upper catchment area in recent years. Reflecting such circumstances, several discussions concerning water allocation to TPC and other users have been made between TPC and the Water Office.

Accordingly, any development to be served by the Karanga, the Weru Weru, and the Kikafu rivers should take into consideration the existing water rights.

(2) Kikuletwa Hydropower Station

The Kikuletwa Hydropower Station was established at the confluence of the Kikuletwa and the Kware rivers by plantation owners of the colonial era. This station is presently operated by TANESCO.

Flow from both rivers is used to generate electric power. Water rights of Kikuletwa Hydropower Station have not been quantified. It is only stated that the Station is granted to use almost all of the spring water.

The power station has three generators (750, 400, and 200 kW) which are frequently out of order. From August 1987 to January 1989, JICA carried out the "Kilimanjaro Small Water Power Project Study" investigating the hydropower potential in the entire Kilimanjaro Region. This study includes the Kikuletwa Hydropower Station. It was learnt that the most effective development plan for this station would be the one with an output of 1,500 kW utilizing discharge of the Kikuletwa and the Kware rivers.

(3) Ikuini Rehabilitation Project in the Lower Rombo area

Instead of water rights tabulated in Table 3-2, the Ikuini Rehabilitation Project has water rights of 0.32 m^3/sec for the irrigation area of 600 ha according to the "FAO/Field Document No.2".

3.4 Water Quality

Water was checked for pH, temperature and electrical conductivity in the field. Additionally, detailed analyses were executed at the Agricultural Research Laboratory of the Ministry of Agriculture & Livestock Development in Lyamungu. Table 3-3 and 3-4 show the results of the field survey and laboratory tests of water samples from rivers, springs and JC2 test drilling. The sampling points of the Rundugai area are shown in Fig. 3-9.

According to U.S. Salinity Laboratory criteria for the electric conductivity, most fresh water is classified as Class 1, "Low salinity water". The spring water from Rundugai and the river water from the Kikuletwa and the Kware, which originates from springs, are classified as Class C2-C3; "Medium to high salinity water". Water sampled from the Biriri showed an extremely high salinity for river water. It is considered that this water was once stored in a pond or a swamp, and gradually flowed out to the river.

Electric conductivity of 1,060 mho/cm^2, classified as Class C3, "High Salinity Water", was observed in groundwater at the JC2 test well. Its quality is considered to be fairy similar to the quality of salinity found in the springs located in the southern part of Rundugai. Water classified as Class C3 can be used for crops with moderate/poor permeability soil. However, it requires leaching.

Although laboratory tests of water samples were performed to find its constituents results were limited by a shortage of chemical reagents. The total dissolved solids of 815 mg/lit at JC2 is larger than the highest desirable amount of 500 mg/lit, set by WHO, but less than the maximum permissible amount of 1,500 mg/lit. Thus, this water can be used for drinking.

3.5 Tank Model Simulation

In order to estimate surface water potentiality, simulation analysis was performed by Sugawara's tank model simulation method for the Karanga, Weru Weru, Kikafu, Kware and Sanya rivers.

The input data and basic assumptions for this calculation are as follows.

(1) All tank factors are decided by calibration based on the rainfall records from Lyamungu station and discharge records from the rivers' gauging station during 1957-1960.

(2) Aerial evapotranspiration is adopted from the results of the Feasibility Study for Lower Moshi Agricultural Development.

(3) Many small farms exist in the upper reaches of these rivers. They take water by small furrows not only for irrigation, but also for drinking and domestic water. This water taken greatly influences the outflow of the rivers. This amount was assumed as the same amount as the registered water right in Water Office.

All of the model factors and calibrated results are shown in Fig. 3-10 and 3-11.

Simulation was performed by these models incorporated with the rainfall records during 1969-1988. These results are shown in Table 3-5 as monthly mean discharge.

4. POTENTIALS OF SURFACE WATER AND GROUNDWATER RECHARGE

4.1 Potentiality of the surface water

Chapter 3 discussed the river's conditions based on collected records, discharge observations in the field, registered water right, water quality analysis and simulation analysis.

The results are summarized as follows:

(Unit: m^3/sec)

River/ Water source	Discharge Record or Simulation	Discharge Observation	Water right
Lower Hai			
Karanga	0.27 - 10.72	0.00 - 0.42	0.37
Weru Weru	1.34 - 4.41	0.34 - 1.18	3.83
Kikafu	0.99 - 21.62	1.52 - 1.89	1.68
Kware	0.02 - 2.11	0.00 - 3.70	-
Rawashi	0.03 - 0.47	-	-
Sanya	0.00 - 1.24	0.08 - 5.00	0.45
Lawati	0.09 - 1.47	0.11 - 0.75	-
Kikuletwa	11.14 - 15.66	12.0	almost all
Rundugai	11.14 - 15.66	12.0	almost all
Lower Rombo			
Motale	-	-	0.01
Muronbea	-	0.10 - 0.50	-
Lume	-	0.10 - 0.50	0.32

The discharge records show values ranging from the minimum of the dry season to the maximum of the rainy season during the period 1954-1959. In the case of the Rawashi, the Sanya and Lawati rivers, these discharge data show the results of tank model simulation. The discharge measurement were performed in December 1988, at the end of dry season, start of rainy season, and in June 1989, after the rainy season.

4.1.1 Weru Weru, Kikafu, and Karanga rivers

From the collected records and discharge measurements in the field, these three rivers provide basically a reasonable amount of intake water for irrigation in the Hai area. However, as stated in the section on water rights, as the TPC has made requests to the Water Office in Moshi for the improvement of the upstream water management of these rivers and for the guarantee of the rights they hold, more realistic water use system of the surface flow from these rivers during the dry season must be considered.

4.1.2 Sanya river and Boloti swamp

Basically, all of the tributaries in the Sanya river system are seasonal rivers whose flow is quite small during the dry season. However, the topographic conditions of the Boloti swamp are considered to be very suitable to create a reservoir. This is the only possible way to utilize effectively the surface water in this river system.

Boloti swamp is located on the northern edge of the project area, and has a surface area of about 1.2 km^2. The bottom is covered with impermeable lahar and the swamp is flooded throughout the dry and rainy seasons. The only river flowing into this swamp is the Rawashi which has 14 km^2 drainage area.

However, it provides only 4.3 MCM of average annual flow which is insufficient to fill up water for the proposed reservoir capacity of about 7 MCM. Consequently it is proposed to supply water from the Lawati river which has about 42.5 km^2 of drainage basin with about 13.6 MCM of average annual discharge. Total inflow, based on the simulation results of the Lawati river and the Rawashi river, is tabulated on Table 3-4 (7).

4.1.3 Rundugai springs

There are abundant spring water in the Rundugai area located along the right bank of downstream Kware river between Moshi-Arusha railroad and the Kikuletwa river. The northern springs flow into the Kware river and the southern springs flow into the Kikuletwa river.

The gauging station, 1DD54, immediate downstream of the power station, is installed after the point of confluence of the Kikuletwa and the Kware rivers. The discharge during the 1979-1987 period, which was estimated from water level records, is shown in Table 3-1.

From these results, the spring capacity as the base flow amount can be estimated to be 11 m^3/sec constantly throughout the year. This shows that in the downstream of the hydropower station water can be used for irrigation after consultation with water office because it seems no water right have already been granted. Meanwhile, the discharge at the power intake of the Kware river is approximately 3 to 4 m^2/sec at least as the results of discharge measurement carried out by the team and the interviews from farmers concerned.

4.1.4 Lume river

The only river offering the possibility for surface water use in the Lower Rombo area is the Lume river. However, FAO has already petitioned for the water rights to the existing project. According to the results of discharge measurements in the field, it is very difficult to consider new water use and establish new water right.

4.2 Groundwater Recharge

Fig. 4-1 shows the whole catchment area for the recharging of groundwater. The groundwater recharging zone of the Sanya scheme is considered to include the southern skirt of Mt.Shira, from the mountainous area to the foot; the eastern area of Mt.Meru, which includes the catchment area of the Biriri River, a branch of the Sanya River, and the Ngurdoto Crater. The basin area is around 975 km^2.

Rainfall on the ground flows out through the stream, evaporates and/or infiltrates into the ground. Accordingly, the equations of water balance are expressed as follows:

$$W = P - O - E$$

Where, W : Groundwater recharge
P : Precipitation
O : Surface runoff
E : Evapotranspiration

Using this balance formula, rough groundwater recharge amount is calculated.

(1) Precipitation

Annual isohyet in the Study area and Sanya plain area is shown in Fig. 4-1. Annual rainfall in this recharge zone varies from 500 mm in the Sanya plain to 1,500 mm of the mountainous area of Mt. Shira. Distribution of the area in altitude is as follows:

0' - 3,000'(900 m)	:	16%
4,000'(1,200 m)	:	36%
5,000'(1,500 m)	:	29%
6,000'(1,800 m)	:	2%
7,000'(2,100 m)	:	17%

Average annual rainfall in the basin is estimated at 731 MCM in total, taking into account of rainfall of 750 mm/year based on the isohyet map prepared, as shown below.

$$750 \times 10^{-3} \times 975 \times 10^{6} = 731.25 \times 10^{6} \ (m^3/year)$$

(2) Surface runoff

Surface runoff is calculated from discharge records and the water use in the upstream of the Sanya river. Average discharge of the Sanya river from 1954-1958 is shown in Section 3.1. Annual discharge of the Sanya river is calculated from this table as 9.2×10^6. Because the amount of water use cannot easily be determined, the water rights which were discussed in Section 3.3, are applied for this purpose, showing a total annual amount of 0.45 m^3/sec. The total amount of irrigation water used is calculated at 8.2 MCM taking into account of seven (7) months Jul. through Nov. and Feb. through Mar. of consecutive irrigation applied based on the irrigation water right provided.

Therefore, the amount of annual surface can be calculated as follows:

$$9.2 \text{ MCM/year} + 8.2 \text{ MCM/year} = 17.4 \text{ MCM/year}$$

(3) Evapotranspiration

Observed annual pan-evaporation at KIA station and Lyamungu station, which was discussed in Section 1, are 2,194 mm and 1,220 mm, respectively. According to these records, and by applying a pan coefficient of 0.8, potential evapotranspiration is calculated as 960 mm at the Lyamungu station, and 1,680 mm at the KIA station, respectively. However, the evapotranspiration in this area does not occur much during the dry season, because annual rainfall is only 600 mm in KIA station and 1,600 mm in the Lyamungu station. In other words, annual evapotranspiration is considered to be 300-500 mm in the southern part and 400-600 mm in the northern part. Considering the distribution of the elevation, evapotranspiration in the area is estimated at 400 mm and calculated as follows:

$$400 \times 10^{-3} \times 975 \times 10^6 = 390 \times 10^6 \ (m^3/\text{year})$$

Accordingly, rough water balance is calculated as follows:

$$\begin{aligned} W &= P - O - E \\ &= 731.25 \times 10^6 - 17.4 \times 10^6 - 390 \times 10^6 \\ &= 3.24 \times 10^8 \ (m^3/\text{year}) \end{aligned}$$

5. DESIGN FLOOD

Flood pattern was analyzed in the Feasibility Study on the Lower Moshi Agricultural Development Project in 1980, using the actual flooding records which occurred in 1979. Basically, the same approach is applied for the analysis of design flood at the Boloti swamp dam site and the Lawati river intake weir site, since the flood characteristics in the Study area is almost the same as that in the lower Moshi area and little data are available in Lower Hai area. About the Sanya Chini intake weir site, the design flood is estimated by river hydraulic analyses based on the past flood experience.

5.1 Peak Flood Discharge of the Rawashi and Lawati Rivers

The peak flood discharges of the Rawashi and Lawati rivers are estimated by using the Rational formula as shown below. Flood discharges of the Rawashi and Lawati rivers were estimated using probable maximum daily rainfall data at Masama Sawe and Kibongoto stations, respectively. The Masama Sawe station is located at the mouth of Rawashi river, and the Kibongoto station near the confluence of the Lawati river with the Sanya river. Maximum daily rainfall was estimated by the Iwai method as shown in Section 2.2.4.

$$Qp = 1 / 3.6 \times r_e \times A$$

Where, Qp : peak flood discharge (m^3/sec)
r_e : effective rainfall intensity
A : catchment area (km^2)

Based on the analysis of the 1979 flood, the following equation was obtained and applied to the estimation of peak flood discharge.

$$Tp = 240 \times r_e^{-0.38} \times A^{0.22}$$

Where, Tp : time from start of rain to peak rate (min.)
r_e : effective rainfall intensity (mm/hr)
A : catchment area (km^2)

In this formula, rainfall intensity is calculated using the following formula for effective rainfall.

$$r_t = R_{24}/t \times (t/24)^{1/3}$$

Where, r_t : rainfall intensity duringt hours (mm/hr)
R_{24} : probable rainfall (mm)
t : time (hours)

$r_e = fp \times r_t$

Where, re : effective rainfall intensity
fp : peak runoff coefficient, = 0.25

The peak flood discharges of both the Rawashi and Lawati rivers are estimated as follows:

(Unit: m^3/sec)

River	Catchment area (km^2)	Return Period 5	10	20	50	100	200
Rawashi	14	18	22	26	32	36	41
Lawati	41	34	41	47	56	62	68

5.2 Peak Flood Discharge of Sanya River at Sanya Chini Intake

In order to estimate the flood water level at the Sanya Chini headworks, river cross sections were surveyed and flood water level was investigated by hearing from local inhabitants. According to local inhabitants, the Sanya Chini headworks was completely submerged in 1960 and 1984 and the overflow depth at the weir was estimated at about 2.0 m at those times. Applying the overflow equation at the weir, the flood discharge is estimated at 158 m^3/sec, on the. assumption that the overflow coefficient is 2.0. According to the results of non-uniform calculation from the railway-crossing point at the weir, and supposing that flood water level slightly exceeds both banks in the downstream reaches of the weir according to the experience of local inhabitants, and further assuming that the roughness coefficient is 0.045, maximum flood is estimated at 170 m^3/sec as shown in Table 5-1. Thus, design discharge of the Sanya Chini headworks is decided to be 170 m^3/sec.

Table 2-1 LIST OF THE RAINFALL STATIONS

No.	Registered Number	Name of Station	Location		
			Lat.	Long.	Altitude (m)
1	9337004	Moshi Meteorological Station	3 21'S	37°20'E	813
2	9337005	Kibosho Mission	3°13'S	37°20'E	1,478
3	9337006	Rombo Mkuu Mission	3°23'S	37°36'E	1,432
4	9337009	Old Moshi Schol	3°19'S	37°24'E	1,067
5	9337015	Kilema Nission	3°18'S	37°30'E	1,422
6	9337021	Lyamungu A.R.C.	3°14'S	37°15'E	1,268
7	9337024	Kikuletwa Railway Station	3°23'S	37°07'E	900
8	9337031	Himo Sisal Estate	3°23'S	37°33'E	810
9	9337046	Marangu School	3°17'S	37°31'E	1,433
10	9337064	Old Moshi Nursery	3°17'S	37°26'E	1,646
11	9337078	Kibongot Hospital	3°12'S	37°07'E	1,250
12	9337085	Lyakirimu Mwika	3°17'S	37°34'E	1,440
13	9337089	Nanjara Parish Station	3°18'S	37°35'E	1,676
14	9337119	Masama Lukani	3°11'S	37°09'E	1,615
15	9337120	Kilema Forest Office	3°15'S	37°27'E	1,830
16	9337123	Kilema Mava Seminary	3°16'S	37°19'E	1,660
17	9337134	Lerongo Forest Office	3°08'S	37°04'E	1,402
18	9337135	Masama Sawe	3°12'S	37°11'E	1,420
19	-	Kifufu Estate	3°10'S	37°05'E	1,341
20	-	Mt. Kilimanjaro 1E	3°13'S	37°31'E	2,200
21	-	Mt. Kilimanjaro 2E	3°10'S	37°31'E	2,870
22	-	Mt. Kilimanjaro 3E	3°08'S	37°26'E	3,810
23	-	Mt. Kilimanjaro 4E	3°06'S	37°26'E	4,270
24	-	Mr. Kilimanjaro 5E	3°05'S	37°23'E	4,800
25	9237006	Rongai Forest Office	2°57'S	37°29'E	1,981
26	9237033	West Kilimanjaro Forest Office	3°02'S	37°05'E	1,676
27	-	Kilimanjaro International Airport Station	3°27'S	37°01'E	897

Table 2-2 ANALYSIS OF RAINFALL BY IWAI METHOD

Data : NON-EXCEEDING PROBABILITY (LYAMUNGU STATION)
Unit: mm

Year	Value	No	Year	Value	Return Period
1935	1,935.0000	1	1937	2,786.0000	***
1936	2,620.0000	2	1936	2,620.0000	***
1937	2,786.0000	3	1942	2,336.0000	***
1938	1,605.0000	4	1947	2,260.0000	***
1939	1,976.0000	5	1951	2,115.0000	***
1940	1,518.0000	6	1939	1,976.0000	***
1941	1,570.0000	7	1935	1,935.0000	***
1942	2,336.0000	8	1972	1,925.0000	***
1943	1,135.0000	9	1964	1,912.0000	***
1944	1,890.0000	10	1944	1,890.0000	***
1945	1,476.0000	11	1967	1,876.0000	***
1946	1,607.0000	12	1968	1,872.0000	***
1947	2,260.0000	13	1978	1,864.0000	***
1948	1,328.0000	14	1977	1,848.0000	***
1949	911.0000	15	1980	1,804.0000	***
1950	1,749.0000	16	1984	1,799.0000	***
1951	2,115.0000	17	1961	1,788.0000	***
1952	1,194.0000	18	1950	1,749.0000	***
1953	1,668.0000	19	1986	1,746.0000	***
1954	1,382.0000	20	1982	1,705.0000	***
1955	1,522.0000	21	1953	1,668.0000	***
1956	1,275.0000	22	1960	1,643.0000	***
1957	1,543.0000	23	1979	1,635.0000	***
1958	1,361.0000	24	1946	1,607.0000	***
1959	985.0000	25	1938	1,605.0000	***
1960	1,643.0000	26	1974	1,596.0000	***
1961	1,788.0000	27	1971	1,588.0000	***
1962	1,394.0000	28	1941	1,570.0000	2.1
1963	1,547.0000	29	1963	1,547.0000	2.2
1964	1,912.0000	30	1957	1,543.0000	2.2
1965	1,134.0000	31	1975	1,529.0000	2.3
1966	1,275.0000	32	1955	1,522.0000	2.4
1967	1,876.0000	33	1940	1,518.0000	2.4
1968	1,872.0000	34	1945	1,476.0000	2.7
1969	1,219.0000	35	1988	1,414.0000	3.1
1970	1,246.0000	36	1962	1,394.0000	3.4
1971	1,588.0000	37	1983	1,393.0000	3.4
1972	1,925.0000	38	1954	1,382.0000	3.5
1973	1,295.0000	39	1958	1,361.0000	3.7
1974	1,596.0000	40	1985	1,337.0000	4.0
1975	1,529.0000	41	1981	1,334.0000	4.1
1976	1,158.0000	42	1948	1,328.0000	4.2
1977	1,848.0000	43	1973	1,295.0000	4.8
1978	1,864.0000	44	1956	1,275.0000	5.2
1979	1,635.0000	45	1966	1,275.0000	5.2
1980	1,804.0000	46	1970	1,246.0000	5.8
1981	1,334.0000	47	1969	1,219.0000	6.6
1982	1,705.0000	48	1952	1,194.0000	7.5
1983	1,393.0000	49	1976	1,158.0000	9.0
1984	1,799.0000	50	1943	1,135.0000	10.1
1985	1,337.0000	51	1965	1,134.0000	10.2
1986	1,746.0000	52	1959	985.0000	26.1
1987	925.0000	53	1987	925.0000	41.1
1988	1,414.0000	54	1949	911.0000	46.0

Return Period	Probab. Consts.	Non-exceeding Probability
1000	2.1350	615.1940
500	2.0350	670.8730
400	1.9350	689.7410
300	1.9184	715.1210
250	1.8753	731.6960
200	1.8215	752.5510
150	1.7199	780.5980
100	1.6150	822.2980
80	1.5349	846.5180
60	1.5047	879.2190
50	1.4520	900.9440
40	1.3360	928.4220
30	1.2967	966.0830
25	1.2380	991.1450
20	1.1530	1023.5200
15	1.0614	1068.0400
10	0.9062	1137.5000
8	0.8134	1179.9000
5	0.5951	1282.2500
4	0.4769	1339.2300
3	0.3945	1424.3800
2	0.0000	1580.8700

Table 3-1 MONTHLY MEAN DISCHARGE OF EACH RIVER (1/3)

DISCHAGE KIKULETWA RIV. 1DD1
UNIT: M**3/SEC
C.A. 2400

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1955	-	-	-	-	-	-	-	-	-	-	9.82	11.26
1956	15.38	13.36	13.27	22.57	39.14	26.95	16.09	13.98	13.19	11.17	11.23	11.11
1957	13.69	14.09	10.52	30.08	91.82	34.04	22.07	16.47	12.88	11.89	21.37	30.96
1958	14.78	18.92	16.84	27.26	58.80	51.57	21.36	17.94	13.40	11.62	11.77	14.55
1959	12.08	11.88	12.41	28.63	36.27	16.68	18.39	16.24	13.55	12.73	12.06	15.07
1960	14.94	12.15	-	47.93	77.81	36.59	25.29	19.58	16.29	21.20	10.97	10.63
1961	9.89	10.04	9.90	15.56	13.72	10.10	13.86	11.54	11.13	18.33	-	-
1962	-	-	-	-	-	-	-	-	-	-	10.08	14.11
1963	12.88	10.84	13.26	49.56	69.89	32.53	27.17	16.34	12.91	10.79	27.90	27.90
1964	23.46	12.72	18.84	100.8	99.28	48.90	27.37	20.98	17.06	15.64	14.55	16.30
1965	19.97	13.21	12.90	42.20	35.04	19.58	13.31	12.34	10.89	12.66	19.47	14.12
1966	11.93	13.35	22.79	61.79	59.53	42.52	27.28	14.57	11.13	10.40	12.34	11.45
1967	10.42	10.61	10.64	21.64	64.58	39.97	30.01	24.78	24.49	19.77	29.46	22.20
1968	10.74	14.19	31.54	79.31	80.59	73.84	38.51	28.04	18.23	13.76	26.44	50.59
1969	20.10	25.59	24.00	20.41	38.34	28.88	21.41	19.76	14.13	15.07	15.19	13.09
1970	16.66	14.79	18.99	59.70	66.34	28.86	19.08	13.76	12.74	11.00	11.08	11.98
1971	14.10	-	-	-	-	46.21	31.98	27.30	17.59	13.76	13.17	17.40
1972	16.61	-	20.60	36.05	56.02	41.75	26.78	19.30	18.92	-	32.18	-
1973	28.37	19.48	13.74	44.64	69.16	34.55	29.09	20.08	12.84	12.35	14.09	13.05
1974	12.30	13.27	12.72	74.32	42.05	31.02	33.75	25.12	15.43	14.57	14.96	14.52
1975	15.59	17.19	14.84	36.80	45.26	32.22	30.53	20.31	15.56	14.37	14.63	15.52
1976	14.66	14.80	16.70	22.40	34.89	29.46	20.24	12.96	14.35	-	-	-
AV.	16.02	14.87	14.96	50.18	56.83	38.48	25.74	19.06	15.28	14.35	16.66	16.28

DISCHARGE KARANGA RIV. 1DD3
UNIT: M**3/SEC
C.A. 211 KM**2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1953	-	-	-	-	-	-	-	-	-	-	0.58	0.60
1954	0.44	0.48	0.26	6.55	8.94	6.31	1.70	0.70	0.06	0.05	0.21	0.19
1955	0.60	1.28	0.39	4.64	11.15	7.05	5.24	1.93	0.23	0.20	0.18	0.36
1956	0.92	0.72	0.56	4.48	11.65	8.58	2.48	1.44	0.49	0.33	0.33	0.25
1957	1.09	1.59	0.48	5.47	17.51	6.80	3.65	1.61	0.58	0.36	1.17	2.34
1958	0.49	1.32	0.86	2.42	10.90	8.99	3.72	1.86	0.58	0.35	0.28	0.58
1959	0.29	0.25	0.30	5.80	4.28	1.42	2.23	0.77	0.59	0.33	-	-
AV.	0.64	0.94	0.47	4.89	10.74	6.52	3.16	1.38	0.43	0.27	0.46	0.72

DISCHARGE WERU WERU 1DD5A
UNIT: M**3/SEC
C.A. 85 KM**2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1958	0.81	0.95	0.76	1.89	3.75	3.22	1.74	0.83	0.58	0.13	0.17	0.79
1959	0.27	0.30	0.23	3.02	2.57	0.72	0.69	0.43	0.25	0.14	0.12	-
AV.	0.55	0.63	0.50	2.48	3.20	1.99	1.23	0.64	0.42	0.14	0.17	0.80

Table 3-1 MONTHLY MEAN DISCHARGE OF EACH RIVER (2/3)

DISCHARGE WERUWERU RIV
FOREST BOUNDARY
1DD6A
UNIT: M**3/SEC
C.A. 68 KM**2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1969	-	-	2.71	2.49	4.09	2.55	1.96	2.16	1.69	2.08	3.28	1.92
1970	1.65	1.45	1.67	3.37	4.73	5.14	6.34	1.13	1.00	0.80	0.74	0.93
AV.	1.65	1.45	2.19	2.93	4.41	3.85	4.15	1.65	1.35	1.44	2.01	1.43

DISCHARGE NSERE
1DD7
UNIT: M**3/SEC
C.A. 54 KM**2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1957	-	-	-	-	-	-	-	-	-	-	0.38	0.28
1958	0.21	0.22	0.20	0.27	2.38	2.56	0.67	0.31	0.22	0.22	0.21	0.21
1959	0.18	0.17	0.18	0.95	0.38	0.09	0.18	0.12	0.09	0.09	-	-
AV.	0.20	0.20	0.19	0.61	1.38	1.33	0.42	0.21	0.15	0.16	0.29	0.24

DISCHARGE KIKAFU
1DD8
UNIT: M**3/SEC
C.A. 198 KM**2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1954	-	-	-	-	-	-	-	-	-	-	1.56	1.94
1955	1.03	-	1.78	8.15	13.63	9.06	6.75	3.16	1.41	0.97	1.16	1.58
1956	3.06	2.90	2.27	15.81	14.73	11.45	3.66	2.26	1.36	1.14	1.51	1.66
1957	1.28	2.23	2.45	29.22	53.77	8.87	5.57	2.57	1.76	1.18	5.72	7.72
1958	2.58	2.67	1.75	5.64	16.75	13.39	5.21	4.58	1.61	0.97	0.78	2.01
1959	0.93	0.80	1.11	11.42	8.18	2.91	3.47	2.12	1.15	0.74	0.52	-
AV.	1.85	2.17	1.88	13.91	21.63	9.14	4.94	2.56	1.45	1.00	2.15	2.99

DISCHARGE KWARE RIV.
1DD9
UNIT: M**3/SEC
C.A. 76 KM**2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1954	-	-	-	-	-	-	-	-	-	-	0.01	0.03
1955	0.01	0.03	0.06	0.17	0.48	0.31	0.18	0.04	0.00	0.01	0.01	0.04
1956	0.17	0.54	0.02	0.13	0.24	0.11	0.01	0.00	0.00	0.01	0.01	0.01
1957	0.01	0.02	0.01	1.87	5.72	1.01	0.27	0.07	0.02	0.02	0.07	0.56
1958	0.03	0.07	0.08	0.68	3.59	1.10	0.82	0.47	0.23	0.08	0.03	0.02
1959	0.01	0.01	0.03	1.02	0.53	0.03	0.03	0.02	0.01	0.01	-	-
AV.	0.05	0.13	0.04	0.77	2.11	0.51	0.26	0.12	0.06	0.02	0.02	0.13

Table 3-1 MONTHLY MEAN DISCHARGE OF EACH RIVER (3/3)

DISCHARGE KWARE RIV.

1DD10
UNIT: M**3/SEC
C.A. 34 KM**2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1954	-	-	-	-	-	-	-	-	-	-	0.07	0.05
1955	0.02	0.02	0.05	0.13	0.34	0.37	0.23	0.09	0.03	0.04	0.04	0.06
1956	0.12	0.10	0.09	0.26	0.33	0.15	0.05	0.06	0.04	0.04	0.05	0.04
1957	0.03	0.04	0.04	0.49	4.95	3.23	0.75	0.09	0.04	0.04	0.15	0.41
1958	0.10	0.16	0.19	0.26	1.76	1.36	0.75	0.21	0.09	0.05	0.03	0.03
1959	0.02	0.04	-	-	-	-	-	-	-	-	-	-
AV.	0.06	0.07	0.09	0.29	1.84	1.28	0.45	0.11	0.05	0.04	0.07	0.12

DISCHARGE SANYA

1DD13
UNIT: M**3/SEC
C.A. 138 KM**2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1954	-	-	-	-	-	-	-	-	-	-	-	0.16
1955	0.08	0.05	0.02	1.00	0.82	0.14	0.05	0.01	0.00	0.00	0.00	0.01
1956	0.05	0.13	0.20	0.52	0.50	0.08	0.01	0.01	0.00	0.00	0.02	0.00
1957	0.00	0.00	0.01	0.55	1.74	0.67	0.09	0.01	0.00	0.00	0.86	1.70
1958	0.44	0.21	0.33	0.78	1.91	0.45	0.08	0.02	0.00	0.00	-	-
AV.	0.14	0.10	0.14	0.71	1.24	0.33	0.06	0.01	0.00	0.00	0.29	0.47

DISCHARGE TANESCO P/S

1DD54
UNIT: M**3/SEC
C.A. 2220 KM**2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1967	-	10.41	10.43	10.97	13.79	12.20	10.66	10.65	10.80	10.65	11.94	12.35
1968	11.43	11.75	13.84	-	-	-	14.82	12.61	11.25	11.43	14.43	17.54
1969	12.15	13.42	13.21	12.57	13.90	12.37	12.28	11.91	11.91	11.33	12.23	12.11
1970	12.58	12.51	12.96	19.63	19.31	12.66	11.53	11.29	10.60	11.44	10.56	11.20
AV.	12.05	12.02	12.61	14.39	15.67	12.41	12.32	11.62	11.14	11.21	12.29	13.30

Table 3-2 WATER RIGHTS REGISTERED AT MOSHI WATER OFFICE

APPL. NO.	ZONE	NAME OF APPLICANT	TYPE OF WATER RIGHT PROVISIONAL/FINAL	DATE OF APPROVAL	QUANTITY	m3/sec	SOURCE	REMARKS
1. LOWER HAI AREA								
1.1 WERU WERU RIVER								
4679	IDDA	NATIONAL DEV.COPORATION	PROV.	21/4/80	1.5 cusec	0.042	WERU WERU	
3759	-DO-	DISTRICT DEV. DIRECT. HAI	FINAL	12/6/80	2 cusec	0.057	WERU WERU	
3071		MACHAME NORTH CO-OP.SOCIETY	FINAL	8/3/76	2.5 cusec	0.071	WERU WERU	
3065		MACHAME UROKI CO-OP.SOCIETY	FINAL	-DO-	33750 g.p.d	0.002	WERU WERU	
3040		IYAMUNGO CO-OP. SOCIETY	FINAL		3 cusec	0.085	WERU WERU	
3354		KIBOSHO MWEKA SUNGU CO-OP.	FINAL			0.000	WERU WERU	3/42 of Makeresho furrow
3329		TANGANYIKA PLANTING CO.LTD.	FINAL	23/5/75	100 *cusec	2.832	WERU WERU	
2566		MR.SWAI	PROVISIONAL	21/5/69	3000 g.p.d	0.000	WERU WERU	
2388	IDD	MESSRS TWO BRIDGE ESTATE	PROVISIONAL	7/3/66	12000 g.p.d	0.001	WERU WERU	
2365	IDDA	MR.MOELJI NAZARALI	PROVISIONAL	10/3/65	2 cusec	0.057	WERU WERU	
2162	IDDA	MUSA MWINJANGA	FINAL	5/10/62	0.5 cusec	0.014	WERU WERU	
1999	IDDA	N.U.NGOMBEZI	FINAL	6/7/62	1.5 cusec	0.042	WERU WERU	
1901	IDDA	KILIMAN.NATIVE CO-OP. UNION	FINAL	24/5/62	20000 g.p.d	0.001	WERU WERU	
1832	IDDA	N.V.C.N.NGOMBEZI	FINAL	25/4/61	0.75 cusec	0.021	WERU WERU	
1773	IDDA	C.E.BLEASDALE	FINAL	8/3/61		0.000	WERU WERU	
1698	IDDA	G.EMANUEL ESTATE	FINAL	3/11/60	3 cusec	0.085	WERU WERU	
1650	IDDA	J.S.DAVIS	FINAL	30/6/60	500 g.p.d	0.000	WERU WERU	
1538	IDDA	DR.PHONES	FINAL	1/2/62	0.75 cusec	0.021	WERU WERU	
1347	IDDA	P.KARANGEORGELIS	FINAL	22/12/59	1 cusec	0.028	WERU WERU	
1243	IDDA	MANGI MKUU			500000 g.p.d	0.026	WERU WERU	
937	IDD	COL.T.S.CONNER	PROVISIONAL	1/3/56	54000 g.p.d	0.003	WERU WERU	
922	IDD	N.V.C.M.NGOMBEZI	PROVISIONAL	10/1/58	2 cusec	0.057	WERU WERU	
921	IDD	N.C.M.NGOMBEZI	PROVISIONAL	10/1/58	1 cusec	0.028	WERU WERU	
919	IDD	N.V.C.M.NGOMBEZI	PROVISIONAL	28/10/58	3.5 cusec	0.099	WERU WERU	
917	IDD	C.N.C.KOCH	PROVISIONAL	7/6/58	1.5 cusec	0.042	WERU WERU	
689	IDD	COFFEE BOARD OF TANGANYIKA	FINAL	22/10/59	5 **cusec	0.142	WERU WERU	
688	IDD	JOHN DICKSON	FINAL	22/10/59	20500 g.p.d.	0.001	WERU WERU	

74	IDO	FRANK GREEN		31/1/56	300 g.p.d.	0.000	WERU WERU
4697	IDDA	J.B.MMARI+4 OTHERS	PROVISIONAL	3/10/80	0.5 cusec	0.014	NSERE S.
3372	IDDA	NSERE COFFEE ESTATE	FINAL	8/3/1976	1.5 cusec	0.042	NSERE R.
		MOOLJI NAMARALI			100000	0.005	SERE
1247	IDDA	N.V.C.M.MGOMBEZI	FINAL	19/6/63	40000 g.p.d.	0.002	NSERE R.
1246		N.V.C.M.MGOMBEZI		13/4/59	15000 g.p.d.	0.001	NSERE R.
1245	IDDA	N.V.C.M.MGOMBEZI	PLOVISIONAL	13/4/59	1000 g.p.d.	0.000	NSERE S.
934	IDD	P.W.D.M		9/12/57	1.5 cusec	0.042	NSERE S.
920	IDD	N.V.C.M.MGOMBEZI	PROVISIONAL	10/1/58	1 cusec	0.028	SERI
						---------- 3.893	

1.2 KIKAFU RIVER

4663	IDDA	NATIONAL DEV.CORPORATION			108480 lpd	0.001	KIKAFU
2998	IDDa	KILIMANJARO DISTRICT COUNCIL	FINAL	20/2/74	20 cusec	0.566	KIKAFU
2826	IDDA	KILIMANJARO DISTRICT COUNCIL	FINAL	19/3/74	1.5 cusec	0.042	KIKAFU
2206		LEBULU MMANDO			700000 g.p.d.	0.037	KIKAFU
4610	IDD	DISTRICT DEV.DIRECTOR HAI	PROVISIONAL	17/12/76	19 cusec	0.538	NAMWI
4125	IDDA	DISTRICT DEV. DIRECTOR HAI	FINAL	28/5/73	540000 gpd	0.028	NAMWE
3039	IDDA	MANAGER MACHAME SOUTH CO.SOC.	FINAL	8/3/76	1000 gpd	0.000	MAKOA
3038	IDDA	MANAGER MACHAME SOUTH CO.SOC.	FINAL	8/3/76	2 cusec	0.057	MAKOA
3031	IDDA	MASAMA SIHA COOP SOCIETY	FINAL	8/3/76	50% OF F		KIDENGE
3029	IDDA	MASAMA SIHA COOP SOCIETY	FINAL	8/3/76	0.25 cusec	0.007	NAMWE
3022	IDDA	MASAMA SIHA COOP SOCIETY	FINAL	8/3/76	0.5 50% OF F	0.014	KIDENGE
3021	IDDA	MASAMA SIHA COOP SOCIETY	FINAL	8/3/76	25% OF F	0.000	NAMWE
3141	IDDA	MASAMA MILA CO-OP.SOCIETY	FINAL	8/3/1976	73% OF F	0.000	NAMWE
2359	IDD	MASAMA MXILO ROO CO-OPARATIVE SOCIETY LTD.	FINAL	6/4/65	50000 g.p.d.	0.003	NAMWI
2120	IDDA	MR.ANINADAM SOLOMON MACHAME	PROVISIONAL	6/7/62	300 g.p.d.	0.000	MAKOA
1699		G.EMANUEL ESTATES LTD.		20/5/60	1000 g.p.d.	0.000	MAKOA
1126	IDD	KIDO ESTATE NAMWE RIVER	PROVISIONAL	19/1/59	2.5 cusecs	0.071	NAMWE
1125	IDD	KIDO ESTATE F.	PROVISIONAL	19/1/59	1000 g.p.d.	0.000	NAMWE
1115	IDD	NAT. COUNCIL	PROVISIONAL	28/10/58	8 cusecs	0.227	SEMIRA
968	IDD	P.C.VIONNIHOS	FINAL	14/2/58	0.5 cusec	0.014	NAMWE
936		9 HOCHI NATIV COFFEE BOARD	PROVISIONAL	14/4/58	0.1 cusec	0.003	MAKOA

797	IDD	H/S GAORGE ISSAISS &CO.LTD.			?	0.000	NAMWE	
598		GEORGE ISSAINDS & CO.LTD.	PROVISIONAL	25/4/57	2.5 p.d	0.071	NAMWE	

						1.679		
1.3 SANYA RIVER								
4611	IDDA	DISTRICT DEV.DIRECTOR HAI	FINAL	14/2/81	5 cusec	0.142	SANYA	JOHARI F.
4612	IDDA	DISTRICT DEV.DIRECTOR HAI	FINAL	14/2/81	5 cusec	0.142	SANYA	NGOMENI F.
1334	IDDA	MRS.L.I.HAURAN	PROVISIONAL	8/6/60	4000 g.p.d.	0.000	SANYA	
1205		G.MERALI JIWA			2 cusecs	0.057	SANYA	
1198	IDD	IAN PETRPSON	PROVISIONAL		5000 gallons	0.000	SANYA	
1117	IDD	M.V.TRUTARCHLER		11/2/59	2710 g.p.d.	0.000	SANYA	
658		KIKULETWN RAILWAY STATION E.A.R. & H.			8000 g.p.d.	0.000	SANYA	
294		SANYA JUU MINA SETTLEMENT	PROVISIONAL		12000 g.p.d.	0.001	SANYA	
107		IDVESTOCK SUPT.VETY.DEPT.			6000 g.p.m	0.000	SANYA	
106		IDVESTOCK SUPT.VETY.DEPT.			10000 g.p.w	0.001	SANYA	
3121		MANAGER MEMBA CO-OP.SOCIETY	FINAL	8/3/76	1.5 cusec	0.042	SAGANA	
3294	IDDA	GENERAL MANAGER K.N.C.H.	FINAL	8/3/1988	0.5 of flow	0.014	SAGANA	
					up to 0.5cusec		SAGANA	
2062	IDDA	CHAGGA COUNCIL	FINAL	3/8/65	150000 g.p.d.	0.008	LAWATI	
1935		PYRITA LIMITED		27/3/62	1.5 cusecs	0.042	FUKA	
1022	IDD	PYRITN LTD.	PROVISIONAL	21/10/58	0.125 cusec	0.004	FUKA	

						0.453		
1.4 KARANGA RIVER								
3313	IDDA	KAHAWA ESTATE	FINAL	28/10/196	2 cusec	0.057	KARANGA	IF AVAILABLE
3295	IDDA	MANAGER,KIBOSHI KIRIMA CO-OP SOCIETY	FINAL	8/3/1988	0.5	0.014	KARANGA	
2930					1	0.028	KARANGA	
2767	IDDA	KINCU LTD	FINAL	28/7/77	20000 Gpd	0.001	KARANGA	
2369	IDDA	KIBO MATCH CORPORATION LTD.	FINAL	30/10/58	0.25 cusecs	0.007	KARANGA	
2169	IDDA	MISS SOPIA BILALI		1/8/62	0.5 cusec	0.014	KARANGA	
2114	IDDA	PENFORD CO. LTD	FINAL	6/7/62	5000 g.p.nonsa	0.000	KARANGA	
1878	IDDA	HARI SINGH SONGS	FINAL	5/4/61	500 g.p.d.	0.000	KARANGA	
1696	IDDA	KARAM SINGH	FINAL	4/10/60	500 g.p.d.	0.000	KARANGA	

1648				30000	0.002	KARANGA
914 IDD	G.PAPODOPOULOS	PROVISIONAL	12/9/58	1 cusec	0.028	KARANGA
240 IDD	R.S.B. WELLE-KIGUNGI SISAL ESTATE			2.56 cusecs p.d.	0.072	KARANGA
4584 IDDA	KIFUNI/ONANA VILLAGE	PROVISIONAL	3/10/77	1 cusec	0.028	UMBWE
3350 IDDA	MANAGER,KIBOSHO SENTRAL CO-OP. SOCIETY	FINAL	8/3/1976	50%OF F	0.000	UMBWE
3123	MANAGER HAMBA CO-OP SOCIETY	FINAL	8/3/76	1 cusec	0.028	UMBWE
1780 IDDA	HILLCREST ESTATES LTD.	FINAL	29/7/65	2 cusecs	0.057	GOMBERI
1762 IDDA	UMBEE SOC.MISSION SCHOOL	FINAL	8/3/61	30000 g.p.d.	0.002	UMBWE
1050	S.T.PATRICKS SCHOOL SHINGA	FINAL	28/10/58	5000 g.p.d.	0.000	MSO
915 IDD	G.PAPODOPOULOS	PLOVISIONAL	12/9/58	1 cusec	0.028	MSO
913 IDD	G.PAPODOPOULOS	PLOVISIONAL	12/9/58	750 g.p.d.	0.000	MSO
362 IDD	N.H.VICARO-HARRIE	PLOVISIONAL		7000 g.p.d.	0.000	SP
					0.368	

2. LOWER ROMBO AREA

3310 IDDA	KIKULETWA FARM LTD.	FINAL	21/10/196	2 cusec	0.057	RUNDUGAI
2475 IDDA	TANESCO			34500 FT		KIKULETWA

* To abstruct 100 cusecs or such less quantity as mat be available, plus 50 % of the flow at the intake in excess of 100 cusecs upto a maximum of 600 cusecs

** 2 cusec of secondary abstruction and 3 cusec of hydropower generation. In addition, 85,000 g.p.d of tertiary abstruction

Table 3-3 RESULT OF WATER QUALITY FIELD TEST

Point	pH		EC (µmho/cm^2)		T (°C)		Class
	(a)	(b)	(a)	(b)	(a)	(b)	
Kikafu River	8.7	-	63	-	20.9	-	C1
Sanya River (1)	8.1	-	576	-	26.7	-	C2
Sanya River (2)	7.5	-	235	-	23.6	-	C1
Fuka River	7.7	-	174	-	21.2	-	C1
Liwati River	8.3	-	193	-	22.6	-	C1
Biriri River	8.0	-	3,450	-	21.5	-	C4
Kikuletwa River	7.0	6.8	1,565	1,530	28.1	27.2	C3
Kware River	7.1	7.2	850	650	24.6	23.4	C2-C3
Rundugai Spring (1)	7.7	6.4	457	485	23.1	23.3	C2
Rundugai Spring (2)	-	7.5	-	486	-	22.7	C2
Rundugai Spring (3)	-	7.7	-	409	-	22.4	C2
Rundugai Spring (4)	-	7.6	-	440	-	24.7	C2
Rundugai Spring (5)	7.6	-	850	-	24.6	-	C2
Rundugai Spring (6)	6.9	6.5	1,693	1,320	26.9	26.6	C3
Rundugai Spring (7)	6.8	5.3	1,660	1,670	28.9	28.5	C3
Rundugai Spring (8)	6.7	-	1,767	-	28.4	-	C3
Rundugai Spring (9)	6.9	-	1,603	-	28.3	-	C3
Lume River	-	7.6	-	33	-	23.9	C1
Kitaha River	5.9	-	58	-	21.3	-	C1
Lake Chala	8.7	-	350	-	26.9	-	C2

Table 3-4 RESULT OF WATER QUALITY TEST

Sampling Point	Field Test			Laboratory Test							
	Temp (°C)	pH	EC (µmho/cm^2)	pH	EC (µmho/cm^2)	Na^+ (mg/l)	K^+ (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Total (mg/l)	TDS (mg/l)
1	15.5	7.2	455	7.2	60	5.86	1.34	0.80	1.0	trace	80
2	18.8	8.7	1,999	9.1	5,640	823.8	173.2	1.6	6.6	trace	4,080
3	16.2	7.4	731	7.0	90	3.74	0.66	1.07	6.80	trace	80
4	23.0	7.1	424	8.1	440	32.0	4.66	2.66	33.40	trace	340
5	22.8	7.4	399	8.3	420	64.0	5.32	2.13	32.0	trace	320
6	22.9	7.3	334	8.2	360	33.34	4.66	2.13	31.0	trace	220
7	28.6	6.4	1,466	7.5	1,280	112.0	24.0	5.07	66.0	trace	920
8	23.1	7.3	295	8.0	340	17.6	5.32	1.60	36.0	trace	240
9	-	-	-	-	1,060	112.0	35.32	0.27	2.40	trace	820

**Sampling Point

1. Weruweru River/Kimashuku Intake
2. Biriri River/Confluence with Sanya River
3. Lawati River/Moshi-Sanya Juu Bridge
4. Rundugai Spring/Left Spring
5. Rundugai Spring/Middle Spring
6. Rundugai Spring/Right Spring

Table 3-5 ESTIMATED DISCHARGE BY TANK MODEL METHOD (1/4)

(1) WERU WERU RIVER

Unit : m³/s

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1969	0.10	1.10	0.83	0.57	8.80	5.22	2.15	2.37	0.75	1.07	0.85	0.41
1970	1.82	0.98	1.44	6.87	7.78	3.34	1.58	0.46	0.28	0.23	0.17	0.13
1971	0.11	0.42	0.58	6.75	10.92	6.75	4.23	1.92	0.59	0.29	0.22	1.21
1972	0.39	1.97	2.13	3.94	11.81	6.42	3.04	1.51	1.64	5.29	8.68	4.01
1973	5.24	4.92	2.68	3.47	10.86	5.12	3.04	1.27	0.63	0.36	0.30	0.40
1974	0.17	0.12	0.10	9.71	8.79	6.91	5.02	1.73	0.51	0.29	0.23	0.47
1975	0.32	0.15	5.33	9.46	8.20	4.98	3.82	1.99	1.80	0.46	0.26	0.19
1976	0.13	2.78	0.58	1.52	7.72	7.10	2.67	1.09	0.30	0.23	0.19	0.48
1977	0.30	0.51	1.55	9.23	8.86	3.83	1.69	1.94	0.64	1.27	3.04	2.73
1978	2.71	1.57	3.11	4.97	9.62	9.12	5.31	2.51	1.15	0.58	2.38	9.14
1979	3.87	5.13	2.63	4.67	12.62	11.53	4.56	2.93	2.15	1.26	0.74	0.42
1980	0.48	0.33	0.88	2.25	18.87	7.00	3.52	2.57	1.28	1.27	2.07	6.59
1981	2.07	0.44	0.83	2.96	14.97	6.77	2.66	1.41	0.76	0.95	0.31	0.79
1982	0.22	0.37	0.15	2.62	12.20	8.05	5.21	2.81	1.19	2.41	2.89	3.69
1983	0.63	0.31	1.05	2.82	11.06	13.06	4.72	2.64	1.22	0.75	0.42	0.58
1984	0.39	0.35	0.93	7.95	10.76	7.57	4.90	2.12	0.90	0.49	2.22	2.95
1985	0.54	7.44	2.42	5.78	7.58	3.82	2.38	0.97	0.40	0.34	0.34	1.16
1986	3.10	0.49	0.19	6.29	11.75	9.14	4.44	1.51	0.59	0.97	0.66	4.92
1987	1.78	0.36	0.38	0.52	5.44	3.21	1.84	3.18	1.01	0.26	0.26	0.17
1988	0.22	0.12	0.83	7.80	6.28	5.71	2.75	0.78	0.28	0.23	0.33	1.02
Ave.	1.23	1.49	1.43	5.01	10.24	6.73	3.48	1.89	0.90	0.95	1.33	2.07

(2) KWARE RIVER

Unit : m³/s

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1969	0.02	0.26	0.11	0.08	0.35	0.29	0.09	0.08	0.03	0.04	0.11	0.06
1970	0.10	0.06	0.09	1.17	0.96	0.42	0.14	0.05	0.03	0.02	0.01	0.01
1971	0.00	0.03	0.02	1.19	1.39	0.66	0.33	0.12	0.04	0.02	0.01	0.42
1972	0.01	0.36	0.19	0.67	1.12	0.71	0.27	0.09	0.06	0.37	1.54	0.70
1973	0.63	0.37	0.58	0.67	1.39	0.61	0.34	0.19	0.14	0.08	0.04	0.03
1974	0.02	0.01	0.01	1.37	1.35	0.63	0.38	0.13	0.06	0.03	0.02	0.01
1975	0.01	0.01	0.57	1.58	1.02	0.55	0.28	0.12	0.08	0.03	0.02	0.01
1976	0.00	0.56	0.08	0.22	0.72	0.37	0.11	0.02	0.02	0.01	0.01	0.01
1977	0.00	0.02	0.10	1.74	1.28	0.54	0.19	0.12	0.04	0.05	0.39	0.26
1978	0.24	0.19	0.35	0.85	1.16	0.67	0.40	0.20	0.12	0.06	0.39	1.13
1979	0.50	0.87	0.46	0.88	1.26	1.06	0.49	0.30	0.22	0.16	0.11	0.07
1980	0.03	0.02	0.09	0.34	1.84	0.84	0.36	0.21	0.12	0.08	0.26	0.69
1981	0.24	0.05	0.06	0.50	1.47	0.62	0.26	0.10	0.07	0.05	0.02	0.03
1982	0.02	0.03	0.01	0.40	1.23	0.57	0.30	0.14	0.03	0.11	0.35	0.49
1983	0.06	0.02	0.06	0.41	1.15	0.70	0.31	0.13	0.05	0.03	0.02	0.02
1984	0.01	0.02	0.05	1.52	1.57	0.65	0.36	0.14	0.06	0.02	0.34	0.28
1985	0.05	1.51	0.47	1.06	0.94	0.51	0.24	0.12	0.07	0.03	0.04	0.06
1986	0.25	0.04	0.02	1.24	1.19	0.76	0.33	0.11	0.05	0.04	0.06	0.44
1987	0.15	0.03	0.02	0.05	0.42	0.23	0.04	0.11	0.03	0.02	0.01	0.01
1988	0.00	0.00	0.03	1.37	0.91	0.42	0.16	0.02	0.02	0.01	0.02	0.03
Ave.	0.12	0.25	0.17	0.39	1.16	0.59	0.27	0.13	0.07	0.06	0.19	0.22

Table 3-5 ESTIMATED DISCHARGE BY TANK MODEL METHOD (2/4)

(3) SANYA RIVER

Unit : m³/s

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1969	0.00	0.00	0.02	0.00	0.21	0.04	0.00	0.00	0.00	0.00	0.04	0.03
1970	0.08	0.07	0.16	1.33	0.91	0.18	0.08	0.06	0.03	0.00	0.00	0.00
1971	0.00	0.00	0.01	1.16	1.67	0.47	0.13	0.08	0.05	0.02	0.00	0.03
1972	0.02	0.01	0.17	0.37	0.63	0.37	0.09	0.06	0.04	0.23	2.91	1.49
1973	1.60	0.82	0.44	0.39	1.57	0.42	0.15	0.12	0.09	0.05	0.02	0.01
1974	0.00	0.00	0.00	1.64	1.61	0.35	0.13	0.08	0.05	0.01	0.00	0.00
1975	0.00	0.00	2.02	2.79	1.38	0.42	0.13	0.09	0.07	0.04	0.01	0.00
1976	0.00	0.08	0.01	0.03	0.15	0.09	0.03	0.01	0.00	0.00	0.00	0.00
1977	0.01	0.00	0.14	1.62	1.63	0.31	0.10	0.08	0.06	0.03	0.16	0.25
1978	0.37	0.16	0.47	1.13	1.41	0.59	0.18	0.13	0.09	0.06	0.70	3.14
1979	1.38	1.04	0.31	0.84	1.38	1.23	0.25	0.15	0.14	0.10	0.07	0.05
1980	0.02	0.01	0.02	0.08	1.55	0.58	0.11	0.08	0.06	0.03	0.08	1.64
1981	0.22	0.07	0.05	0.20	1.24	0.35	0.10	0.07	0.05	0.03	0.01	0.16
1982	0.00	0.00	0.00	0.12	0.64	0.16	0.08	0.04	0.03	0.03	0.27	0.66
1983	0.07	0.03	0.02	0.12	0.72	0.21	0.09	0.06	0.04	0.01	0.00	0.00
1984	0.00	0.00	0.08	1.55	2.14	0.41	0.13	0.08	0.05	0.02	0.13	0.37
1985	0.07	0.48	0.18	0.85	0.67	0.21	0.10	0.07	0.05	0.02	0.00	0.09
1986	0.42	0.06	0.01	0.91	0.86	0.44	0.12	0.07	0.04	0.01	0.01	0.79
1987	0.14	0.05	0.03	0.02	0.08	0.06	0.02	0.03	0.01	0.00	0.00	0.00
1988	0.00	0.00	0.04	1.40	0.96	0.19	0.09	0.05	0.03	0.00	0.00	0.02
Ave.	0.22	0.14	0.21	0.83	1.07	0.35	0.10	0.07	0.05	0.03	0.22	0.43

(4) RAWASHI RIVER

UNIT:m3/sec

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1969	0.01	0.11	0.05	0.03	0.34	0.12	0.04	0.03	0.01	0.02	0.05	0.03
1970	0.04	0.03	0.04	0.47	0.39	0.17	0.06	0.02	0.01	0.01	0.01	0.01
1971	0.00	0.02	0.01	0.48	0.56	0.27	0.13	0.05	0.02	0.01	0.01	0.02
1972	0.01	0.15	0.08	0.27	0.45	0.29	0.11	0.04	0.03	0.15	0.62	0.28
1973	0.25	0.35	0.24	0.27	0.56	0.25	0.14	0.08	0.06	0.03	0.02	0.01
1974	0.01	0.01	0.01	0.75	0.54	0.25	0.15	0.06	0.03	0.01	0.01	0.01
1975	0.01	0.01	0.23	0.63	0.41	0.22	0.11	0.05	0.04	0.01	0.01	0.01
1976	0.00	0.23	0.04	0.09	0.29	0.15	0.05	0.01	0.01	0.01	0.01	0.00
1977	0.00	0.01	0.04	0.70	0.52	0.22	0.08	0.05	0.02	0.02	0.16	0.11
1978	0.10	0.08	0.14	0.34	0.47	0.27	0.16	0.08	0.05	0.03	0.16	0.46
1979	0.20	0.35	0.19	0.36	0.51	0.43	0.20	0.12	0.09	0.07	0.05	0.03
1980	0.02	0.01	0.04	0.14	0.74	0.34	0.15	0.09	0.05	0.04	0.11	0.28
1981	0.10	0.02	0.03	0.20	0.59	0.25	0.10	0.04	0.03	0.02	0.01	0.01
1982	0.01	0.01	0.01	0.16	0.49	0.23	0.12	0.06	0.01	0.05	0.14	0.20
1983	0.03	0.01	0.03	0.17	0.46	0.28	0.13	0.05	0.02	0.01	0.01	0.01
1984	0.01	0.01	0.02	0.61	0.63	0.26	0.15	0.06	0.03	0.01	0.14	0.12
1985	0.02	0.61	0.19	0.43	0.38	0.21	0.10	0.05	0.03	0.01	0.02	0.03
1986	0.10	0.02	0.01	0.50	0.48	0.30	0.13	0.05	0.02	0.02	0.02	0.18
1987	0.06	0.01	0.01	0.02	0.17	0.10	0.02	0.05	0.01	0.01	0.01	0.01
1988	0.00	0.00	0.01	0.55	0.37	0.17	0.07	0.01	0.01	0.01	0.01	0.01
AV.	0.05	0.10	0.07	0.36	0.47	0.24	0.11	0.05	0.03	0.03	0.08	0.09

Table 3-5 ESTIMATED DISCHARGE BY TANK MODEL METHOD (3/4)

(5) LAWATI RIVER

UNIT:m3/sec

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1969	0.03	0.33	0.14	0.11	1.07	0.37	0.12	0.10	0.05	0.05	0.15	0.08
1970	0.13	0.08	0.12	1.46	1.20	0.53	0.19	0.07	0.04	0.03	0.02	0.02
1971	0.01	0.05	0.03	1.49	1.75	0.83	0.42	0.16	0.05	0.03	0.02	0.05
1972	0.02	0.45	0.25	0.84	1.41	0.90	0.35	0.12	0.09	0.46	1.93	0.89
1973	0.79	1.10	0.73	0.84	1.74	0.77	0.43	0.24	0.18	0.11	0.05	0.04
1974	0.03	0.02	0.02	2.35	1.69	0.79	0.48	0.17	0.08	0.04	0.03	0.02
1975	0.02	0.02	0.71	1.98	1.28	0.69	0.35	0.16	0.11	0.04	0.03	0.02
1976	0.01	0.70	0.11	0.28	0.90	0.47	0.14	0.04	0.03	0.02	0.02	0.01
1977	0.01	0.03	0.14	2.18	1.61	0.68	0.24	0.16	0.06	0.07	0.49	0.33
1978	0.30	0.24	0.45	1.07	1.45	0.85	0.51	0.25	0.15	0.08	0.49	1.43
1979	0.64	1.09	0.58	1.11	1.58	1.33	0.62	0.38	0.28	0.21	0.15	0.09
1980	0.05	0.04	0.12	0.43	2.31	1.06	0.46	0.26	0.16	0.11	0.33	0.87
1981	0.31	0.07	0.08	0.63	1.84	0.79	0.33	0.13	0.10	0.06	0.04	0.04
1982	0.03	0.04	0.02	0.51	1.54	0.72	0.38	0.18	0.05	0.14	0.45	0.62
1983	0.09	0.03	0.09	0.52	1.45	0.88	0.39	0.17	0.07	0.04	0.03	0.03
1984	0.02	0.03	0.07	1.90	1.97	0.81	0.46	0.18	0.08	0.04	0.43	0.36
1985	0.06	1.90	0.59	1.33	1.18	0.65	0.31	0.15	0.10	0.05	0.05	0.09
1986	0.32	0.05	0.03	1.55	1.50	0.95	0.41	0.14	0.07	0.05	0.08	0.56
1987	0.19	0.04	0.03	0.07	0.54	0.30	0.05	0.15	0.04	0.03	0.02	0.02
1988	0.01	0.01	0.04	1.72	1.14	0.53	0.21	0.04	0.03	0.02	0.03	0.05
AV.	0.15	0.32	0.22	1.12	1.46	0.74	0.34	0.16	0.09	0.08	0.24	0.28

(6) FUKA RIVER

UNIT:m3/sec

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1969	0.02	0.17	0.07	0.06	0.56	0.19	0.06	0.05	0.02	0.03	0.08	0.04
1970	0.07	0.04	0.06	0.76	0.63	0.27	0.10	0.04	0.02	0.02	0.01	0.01
1971	0.01	0.02	0.01	0.78	0.91	0.43	0.22	0.08	0.03	0.02	0.01	0.03
1972	0.01	0.24	0.13	0.44	0.73	0.47	0.18	0.06	0.05	0.24	1.01	0.46
1973	0.41	0.57	0.38	0.44	0.90	0.40	0.22	0.13	0.09	0.06	0.03	0.02
1974	0.02	0.01	0.01	1.22	0.88	0.41	0.25	0.09	0.04	0.02	0.02	0.01
1975	0.01	0.01	0.37	1.03	0.67	0.36	0.18	0.08	0.06	0.02	0.02	0.01
1976	0.01	0.37	0.06	0.14	0.47	0.24	0.07	0.02	0.01	0.01	0.01	0.01
1977	0.01	0.02	0.07	1.13	0.84	0.35	0.13	0.08	0.03	0.04	0.26	0.17
1978	0.16	0.13	0.23	0.56	0.76	0.44	0.27	0.13	0.08	0.04	0.26	0.74
1979	0.33	0.57	0.30	0.58	0.82	0.69	0.32	0.20	0.15	0.11	0.08	0.05
1980	0.02	0.02	0.06	0.23	1.20	0.55	0.24	0.14	0.08	0.06	0.17	0.45
1981	0.16	0.04	0.04	0.33	0.96	0.41	0.17	0.07	0.05	0.03	0.02	0.02
1982	0.02	0.02	0.01	0.26	0.80	0.38	0.20	0.09	0.02	0.07	0.23	0.32
1983	0.04	0.02	0.05	0.27	0.75	0.46	0.20	0.09	0.04	0.02	0.02	0.02
1984	0.01	0.02	0.04	0.99	1.03	0.42	0.24	0.09	0.04	0.02	0.22	0.19
1985	0.03	0.99	0.31	0.69	0.61	0.34	0.16	0.08	0.05	0.02	0.03	0.04
1986	0.17	0.03	0.01	0.81	0.78	0.50	0.22	0.07	0.04	0.03	0.04	0.29
1987	0.10	0.02	0.02	0.04	0.28	0.15	0.03	0.08	0.02	0.01	0.01	0.01
1988	0.01	0.01	0.02	0.89	0.59	0.28	0.11	0.02	0.02	0.01	0.02	0.02
AV.	0.08	0.17	0.11	0.58	0.76	0.39	0.18	0.08	0.05	0.04	0.13	0.15

Table 3-5 ESTIMATED DISCHARGE BY TANK MODEL METHOD (4/4)

(7) BOLOTI SWAMP

UNIT:m3/sec

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1969	0.04	0.44	0.19	0.14	1.42	0.48	0.16	0.14	0.06	0.07	0.20	0.11
1970	0.17	0.11	0.15	1.93	1.59	0.69	0.25	0.10	0.05	0.04	0.03	0.02
1971	0.01	0.06	0.03	1.97	2.31	1.10	0.55	0.21	0.07	0.04	0.03	0.07
1972	0.03	0.60	0.33	1.11	1.86	1.19	0.46	0.16	0.12	0.61	2.55	1.17
1973	1.05	1.45	0.97	1.11	2.30	1.01	0.56	0.32	0.24	0.14	0.07	0.05
1974	0.04	0.03	0.02	3.10	2.23	1.04	0.63	0.23	0.11	0.05	0.04	0.03
1975	0.03	0.02	0.94	2.62	1.69	0.92	0.46	0.21	0.15	0.06	0.04	0.03
1976	0.02	0.93	0.14	0.37	1.19	0.62	0.19	0.05	0.03	0.03	0.02	0.02
1977	0.02	0.04	0.18	2.88	2.13	0.89	0.32	0.21	0.08	0.10	0.65	0.44
1978	0.40	0.32	0.59	1.41	1.92	1.12	0.67	0.33	0.20	0.11	0.65	1.88
1979	0.84	1.44	0.77	1.47	2.09	1.76	0.82	0.51	0.37	0.28	0.20	0.12
1980	0.06	0.05	0.15	0.57	3.05	1.40	0.61	0.35	0.21	0.15	0.44	1.15
1981	0.40	0.09	0.10	0.83	2.43	1.04	0.43	0.18	0.13	0.09	0.05	0.06
1982	0.04	0.06	0.03	0.67	2.03	0.95	0.51	0.24	0.06	0.19	0.59	0.82
1983	0.11	0.04	0.11	0.69	1.91	1.16	0.52	0.22	0.10	0.05	0.04	0.04
1984	0.03	0.04	0.10	2.51	2.61	1.08	0.61	0.24	0.11	0.05	0.56	0.48
1985	0.08	2.50	0.78	1.75	1.56	0.86	0.40	0.20	0.13	0.06	0.07	0.11
1986	0.42	0.07	0.03	2.05	1.98	1.26	0.55	0.19	0.09	0.07	0.10	0.74
1987	0.26	0.05	0.04	0.09	0.71	0.39	0.07	0.20	0.05	0.03	0.03	0.02
1988	0.02	0.01	0.06	2.27	1.50	0.70	0.28	0.05	0.04	0.03	0.04	0.06
AV.	0.20	0.42	0.29	1.48	1.92	0.98	0.45	0.22	0.12	0.11	0.32	0.37

Table 5-1 NON-UNIFORM FLOW CALCULATION IN SANYA RIVER FROM FROM CROSSING POINT OF RAILWAY TO SANYA CHINI HEAD WORKS

***** NON-UNIFORM FLOW CALCULATION *****

RIVER NAME=SANYA
TITLE=Q=170

DISCHARGE --- 170 (M^3/S) INITIAL W.L.--- 907.3 (M)

I	N-VALUE	A(M^2)	R(M)	HC(M)
1	0.045	44.842	1.408	906.577
2	0.045	48.086	1.256	906.565
3	0.045	49.270	1.188	908.271
4	0.045	42.891	1.515	908.971
5	0.045	52.949	1.023	910.059
6	0.045	45.195	1.398	910.790

NOTE
I:SECTION NO.
N-VALUE:COEFFICIENT OF ROUGHNESS
A:AREA OF CROSS SECTION
R:HYDRAULIC RADIOUS
HC:CRITICAL WATER LEVEL

***** CALCULATIONN OF SUB CRITICAL DEPTH *****

I	ET	EC	H(M)	A(M^2)	V(M/S)
1	907.871	0.000	907.300	88.160	1.928
2	908.180	906.045	907.909	135.164	1.258
3	909.982	906.962	908.860	80.805	2.104
4	910.814	907.944	910.278	111.574	1.524
5	911.398	908.560	910.972	107.459	1.582
6	0.000	909.614	911.668	79.125	2.148

NOTE
I:SECTION NO.
ET:TOTAL ENERGY(RIGHT)
EC:CRITICAL ENERGY(LEFT)
H:SUB-CRITICAL WATER LEVEL
A:AREA OF CROSS SECTION
V:VELOCITY

DISTANCE NO. OF HYDRAULIC JUMP ---------- 0

NOTHING HYDRAULIC JUMP.

SUMMARY OF THE METEOROLOGICAL DATA
STATION: MOSHI

ITEM		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
TEMPARATURE	(C)	25.2	25.8	26.1	24.8	22.6	21.3	20.8	21.2	22.5	24.3	24.8	24.5
RELATIVE HUMIDITY	(%)	44.3	41.8	45.4	59.1	66.1	00	56.8	53.6	48.5	47.9	48.3	53.3
PAN EVAPORATION	(MM/DAY)	7.7	8.9	8.8	5.8	4.2	3.4	3.5	4.7	6.2	8.3	7.4	5.7
MEAN WIND SPEED	(M/SEC)	2.05	2.05	2.59	1.84	1.18	0.87	0.9	1.2	2.09	2.03	2.15	1.84
SUNSHINE HOURS	(HRS/DAY)	9.1	9.1	7.9	6.4	4.5	4.5	4.5	5.1	7.7	7.7	8	8.2
MONTHLY RAINFALL	(MM/MONTH)	41.3	25.4	123.3	324.6	183.4	33.1	31.8	18.3	7.2	29	85.1	65.1
DUEY POINT		15.8	13.8	13.8	25.6	25.3	23.1	21.3	20.7	20.1	20.3	13.9	22.5

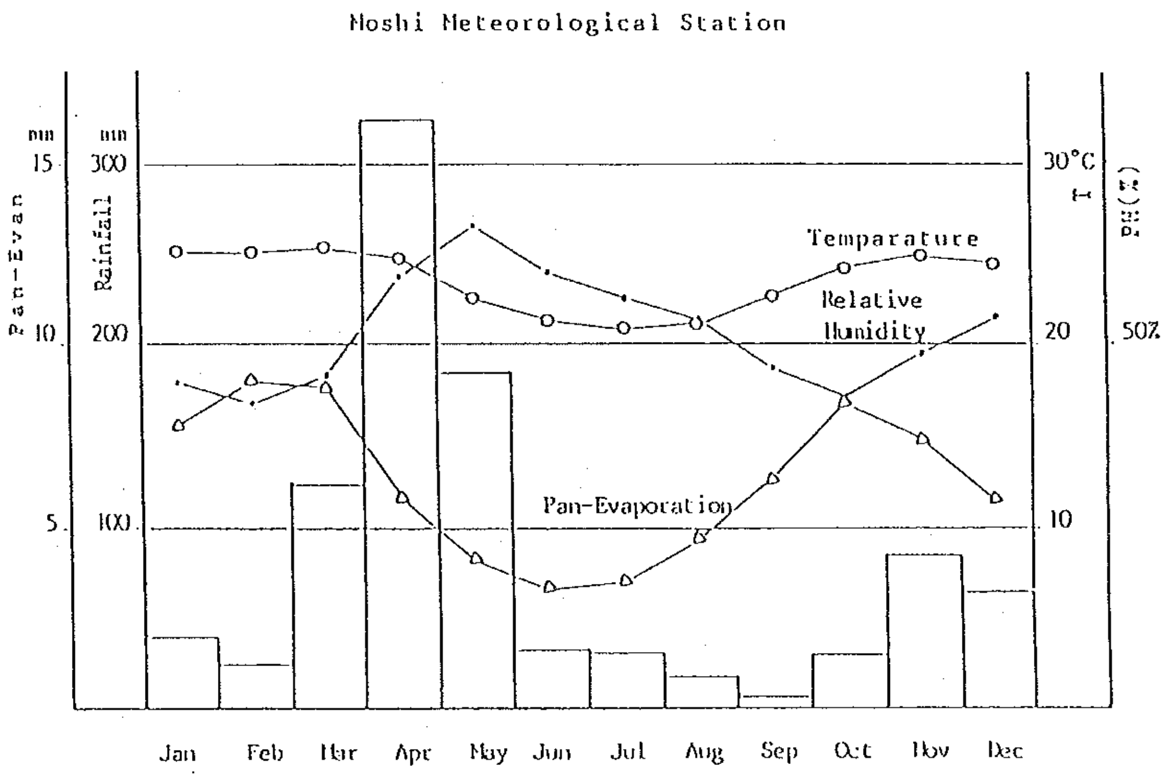

Fig. 2-1 METEOROLOGICAL DATA OF MOSHI STATION

SUMMARY OF THE METEOROLOGICAL DATA
STATION: KILIMANJARO INTERNATIONAL AIRPORT

ITEM		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
TEMPARATURE	(C)	24.0	25.3	25.8	24.4	22.3	20.4	20	18.6	22.1	23.9	24.8	24.8
RELATIVE HUMIDITY	(%)	54	55.3	57.2	68.8	73	68.8	64.9	62.1	55.5	53.4	58.9	59.1
PAN EVAPORATION	(MM/DAY)	7.6	8.3	7.7	5.8	3.7	3.7	3.6	4.6	6.4	7.1	7	6.8
MEAN WIND SPEED	(M/SEC)	2.36	2.45	2.31	1.51	1.09	1.24	1.17	2.39	1.98	4.87	2.4	2.29
SUNSHINE HOURS	(HRS/DAY)	9	8.5	7.6	6.2	4.5	4.8	4.3	5	7	8	7.4	7.8
RADIATION	(CAL/CM**2/DAY)	19.1	21	18.5	15.7	12.6	11.2	11.3	35.4	17.5	17.7	17.7	18.8
MONTHLY RAINFALL	(MM/MONTH)	60.8	36.6	73.7	140.2	115.6	12.7	6.4	10.4	2.7	3.5	62.6	54.9
DEW POINT		18.5	18.5	17.3	18.8	18	15.3	14.1	14	14.1	14.8	18.5	18.9

Kilimanjaro International Airport Station

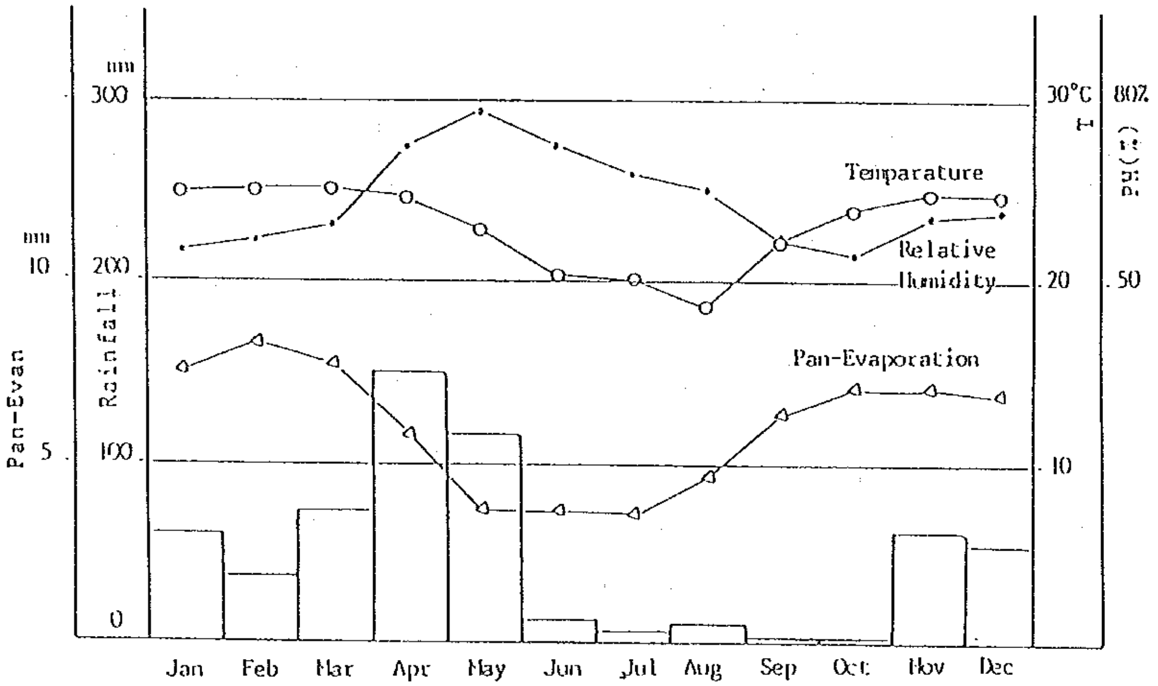

Fig. 2-2 METEOROLOGICAL DATA OF KILIMANJARO INTERNATIONAL AIRPORT