JAPAN INTERNATIONAL COOPERATION AGENCY

THE STUDY ON RESOURCE CONSERVATION AND
MANAGEMENT OF WATER, ENERGY AND MINERALS

FOR

THE

WATER SUPPLY DEVELOPMENT

IN

THE REPUBLIC OF YEMEN

FINAL REPORT

SUMMARY

(EXECUTIVE SUMMARY)

JUNE 1994

NIPPON KOEI CO., LTD.

PACIFIC CONSULTANTS INTERNATIONAL

JAPAN INTERNATIONAL COOPERATION AGENCY
THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF WATER , ENERGY AND MINERALS

STUDY ON WATER RESOURCES DEVELOPMENT IN THE RUVU RIVER BASIN

FINAL REPORT

VOLUME I

EXECUTIVE SUMMARY

JUNE 1994

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PREFACE

In response to a request from the Government of the United Republic of Tanzania, the Government of Japan decided to conduct a Master Plan Study on Water Resources Development in the Ruvu River Basin and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent to Tanzania a study team headed by Mr. Makoto Tsuda, Nippon Koei Co., Ltd., and composed of members from Nippon Koei Co., Ltd. and Pacific Consultants International, three times between February 1993 and June 1994.

The team held discussions with the officials concerned of the Government of the United Republic of Tanzania, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I with to express my sincere appreciation to the officials concerned of the Government of the United Republic of Tanzania for their close cooperation extended to the team.

June 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

June 1994

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

Letter of Transmittal

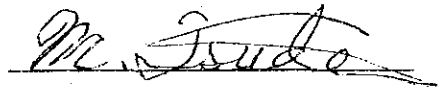
We are pleased to submit herewith the Final Report of the Study on Water Resources Development in the Ruvu River Basin in the United Republic of Tanzania.

The Report presents a master plan for water resources development comprising various projects for municipal water supply to Dar Es Salaam, agricultural development, electric power development and flood control, of which the municipal water supply is given the first priority in order to meet the water demand in Dar Es Salaam city by the year 2020. Based on the Study, two (2) development scenarios involving the provision of a few dams in the basin are proposed for not only municipal water supply, but also development in other sectors.

The Report consists of four (4) Volumes, the Executive Summary, Main Report, Supporting Report and Data Book. The Executive Summary presents main outputs of the Study. The Main Report covers all the study results including analysis of the respective disciplines. The Supporting Report gives additional and supporting information, and the Data Book provides data obtained from the field surveys and investigations.

We would like to express our heartfelt thanks to the personnel of your Agency, your Branch Office in Dar Es Salaam City, and the Embassy of Japan in Tanzania, and also to officials and individuals of the Government of Tanzania for the assistance and advice extended to the Study Team. We sincerely hope that the results of this Study will contribute to the national and regional development of the country.

Yours sincerely,



Makoto Tsuda
Team Leader
Water Resources Development in
the Ruvu River Basin

STUDY
ON
WATER RESOURCES DEVELOPMENT
IN
THE RUVU RIVER BASIN

OUTLINE OF STUDY

1. OBJECTIVE OF THE STUDY

The Study on Water Resources Development in the Ruvu River Basin was carried out by the Study Team of the Japan International Cooperation Agency (JICA) for the period from February 1993 to June 1994 in accordance with the Scope of Works concluded on 22 October 1992.

The Study Area covers the entire Ruvu River basin with a catchment area of about 17,900 km^2 and Dar Es Salaam city. The Study aims to establish the optimum master plan for water resources development in the Ruvu River basin taking into consideration the present and forecasted social, economic and financial conditions therein placing the first prioity on municipal water supply to Dar Es Salaam. The target year is 2020.

2. PRESENT WATER USE IN THE STUDY AREA

(1) The Study Area has enough rainfall in the rainy season for any water use but generally suffers from water shortage in the dry season. Often the small rivers in the lowermost areas dry up in the dry season.

(2) At present Dar Es Salaam, with a population of 1.3 million in 1988, badly suffers from water supply shortage due to outmoded pipe networks. Concerning the municipal water supply, it totally depends on the Ruvu River water with two intakes in the lowermost reach.

(3) Although there are many small-scale irrigation facilities scattered all over the basin, some of the existing facilities have deteriorated due to their poor structure and lack of maintenance and management.

3 WATER RESOURCES DEVELOPMENT PLAN

3.1 Future Water Demand

(1) Municipal water demand in Dar Es Salaam in the year 2020
The municipal water demand forecast for Dar Es Salaam, which was made by the Study Team at a master plan study level, reveals that the mean daily water demand in the service area of NUWA will increase from about 3.5 m^3/sec in 1990 to about 11.2 m^3/sec in the target year 2020.

The water demand of 11.2 m^3/sec in the year 2020 needs to be taken into consideration for future dam projects, because a mean daily discharge, with a 95% dependability, at the existing Upper Ruvu intake site is estimated at 9.1 m^3/sec based on the long-term streamflow data.

(2) Total water demand in the year 2020

To cope with the water demand in the target year 2020, a total of 16.3 m^3/sec will be required at the Upper Ruvu intake site throughout a year, taking into account not only water demand of Dar Es Salaam (11.2 m^3/sec), but also water required for downstream Irrigation water rights (0.8 m^3/sec) and the downstream river maintenance flow (4.3 m^3/sec).

3.2 Selection of Dam Projects

Of the 23 dam sites identified so far in the Ruvu River basin, the JICA Study Team selected the following three dam sites based on the results of review of all the previous data and information and the comparison concerning the topographic, geological, and hydrologic conditions, storage efficiency, provisional construction cost, and so on:

- Kidunda
- Ngerengere
- Mgeta

The main features of the three dams selected are listed below together with their present-day construction costs:

No.	Description	Promising Dam Project		
		Kidunda	Mgeta	Ngerengere
(1)	Dam height (m)	26	45	36
(2)	Reservoir area (km^2)	158.5	10.5	30.0
(3)	Yield of dependable discharge for water supply to DES/irrigation development (m^3/sec)	28.2	7.1	1.8
(4)	Possible hydropower development (kW)	3,900	2,300	400
(5)	Total construction cost (Mill. US$)	101.1	110.6	90.8
Construction cost per dependable discharge (Mill. US$/$m^3$/sec): (5)/(3)		3.6	15.6	50.4

As shown in the table above, it is obvious that the Kidunda Dam Project is capable of meeting the water demand in the year 2020 and that it is given the highest priority of development in terms of the lowest construction cost per dependable discharge.

3.3 Dam Development Scenarios for Municipal Water Supply

In order to satisfy the municipal water in the Dar Es Salaam by the target year 2020, the following two development scenarios were selected:

Development Scenario	Dam(s) to be developed
Scenario-1:	Kidunda Dam
Scenario-2:	Mgeta Dam and Ngerengere Dam

3.4 IRRIGATION DEVELOPMENT PLAN

The agricultural development projects are broadly categorized in the following two kinds:

(i) Dam-Related Projects: to be developed utilizing the streamflow in excess of the water demand in Dar Es Salaam in the year 2020 after construction of the planned dams.

(ii) Independent Projects: may be developed without use of water yielded by the planned dams.

(1) Dam-Related Project

The Development Scenario-1 and -2 would yield a discharge of about 12.3 and 0.2 m^3/sec respectively, available for new irrigation development projects. With the integrated use of the water exploited newly and that secured for existing small irrigation in the lower Ruvu, the new irrigation development projects were proposed by Development Scenario as follows:

Name of Irrigation Project	Irrigated Area under the Development Scenario (ha)	
	Scenario-1	Scenario-2
i) Kidunda Irrigation	10,500	-
ii) Bagamoyo Irrigation	1,100	980
iii) Low-lift pump irrigation	2,400	-
iv) Ruvu National Youth	200	-
v) Makurunge Irrigation	150	-
Total	14,350	980

All the above irrigation projects need to be provided with the flood protection works.

(2) Independent Project

The independent projects were identified in the relatively high land areas around the Uluguru Mountains. These are expected to be implemented independently of the dam development scenario. These are as follows:

Name of Agricultural Development Project	Area of Agricultural Development (ha)
- Mlali Irrigation	400
- Uluguru Mountain West	2,000
- Uluguru Mountain East	(16,000)
- Mgeta Plain Myuha Irrigation	(5,000)

Note : The area in the parentheses above shows the potential area.

4 EXPECTED EFFECTS OF THE KIDUNDA DAM

The Kidunda Dam Project (Development Scenario-1) is the most economical of the three (3) selected dam projects for the purpose of meeting the water demand in the Dar Es Salaam city by the year 2020 and would enable to realize a lot of irrigation projects as aforesaid and to encourage the rural development through the improvement of the local communication system now aggravated since it includes the improvement works of existing 100 km long rural road, connecting the dam site and the Morogoro road. In addition, the design flood for the irrigation projects (a 5-year probable flood) will decrease from 670 m^3/sec under the

present condition to about 360 m^3/sec in the case with the Kidunda dam owing to the flood control by surcharge volume of the reservoir.

5 RECOMMENDED POST-STUDY ACTION PLAN

5.1 Prefeasibility Study on the Kidunda Dam

(1) Environmental survey and geological issures
In addition, the Kidunda Dam Project has the following issues, which will have to be clarified in the next prefeasibility study stage:

- Geological issue: Existence of limestone at the downstream dam site and existence of clayey layer at the upstream dam site.

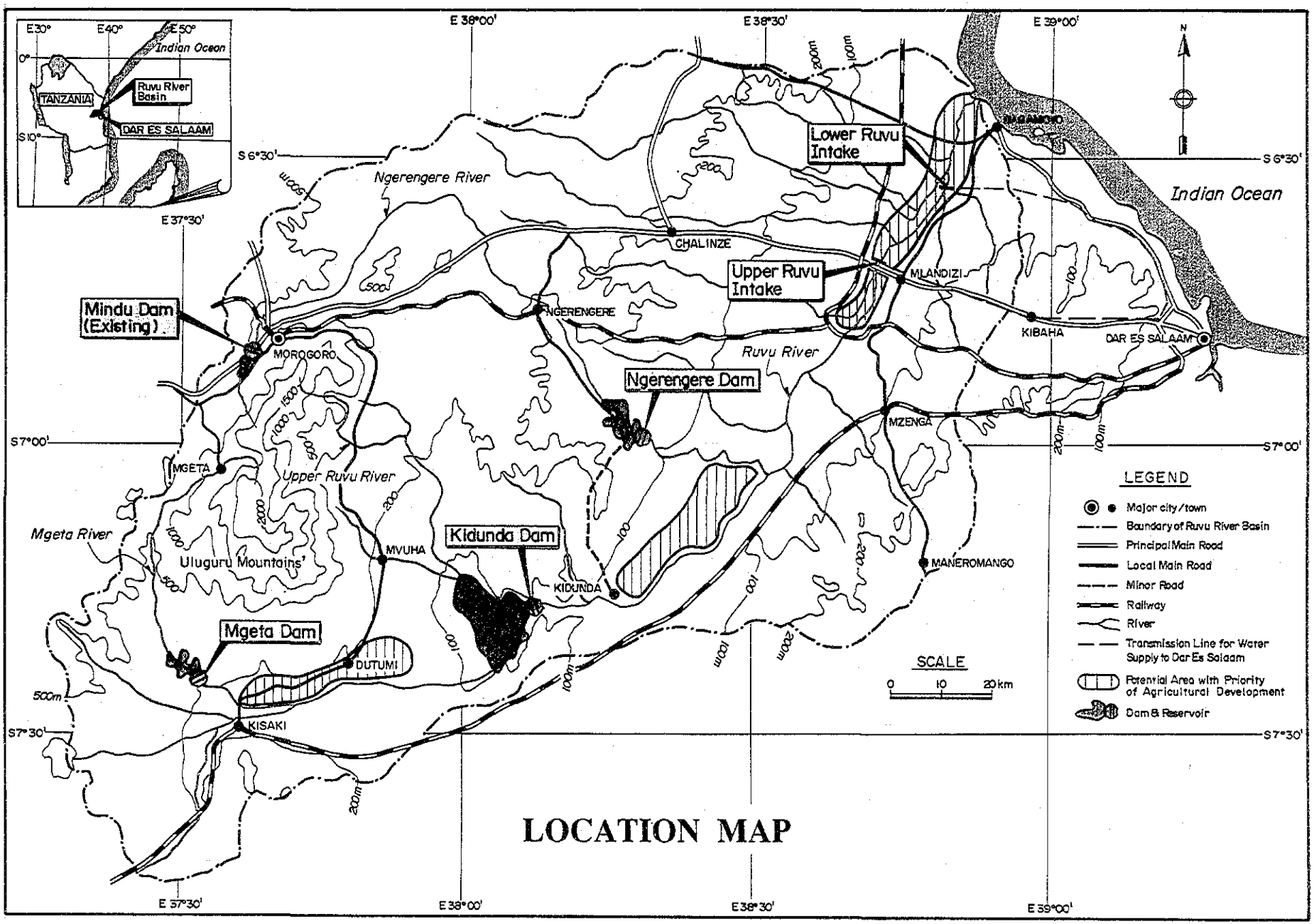
- Environmental issue: Adverse effect on the existing Selous Game Reserve with respect to conservation of wildlife

From the above, it is strongly recommended that the prefeasibility study on the Kidunda Dam Project be carried out in the subsequent stage focusing on the geological investigations at the alternative dam sites and the environmental impact assessment (EIA) study. In the prefeasibility study, the environmental study should be proceeded at an earlier stage. In particular, the EIA study in the next study stage needs to be carried out under good cooperation between the both ministries concerned, namely the Ministry of Water, Energy and Minerals and the Ministry of Tourism, National Resources and Environment.

(2) Resettlement of people in the reservoir area
The Study recommended that the people living in the Kidunda reservoir area should be resettled to the Kidunda Irrigation Project area where at present very few people are settled. The matters in relation to the resettlement need to be investigated and examined in more detail in the course of the EIA study of the next prefeasibility study .

5.2 Feasibility Study on the Mali Irrigation and Uluguru Mountain West Projects

It is recommended that a feasibility study on the Mali irrigation and Uluguru Mountain West Projects should proceed after completion of the Study. Both of these projects were selected as the high priority agricultural project in the Study Area, since the other high priority irrigation projects will have to await the completion of the planned dam project. The feasibility study on these two priority projects should be conducted at the same time in a single package taking into consideration the development scales of these projects, the vicinity of their locations and the problem inherently common to these two projects, namely soil erosion in the western area of the Uluguru Mountains and siltation at the Mlali intake site.



LOCATION MAP

EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

1. INTRODUCTION

The Ministry of Water, Energy and Minerals (MWEM) of the Government of Tanzania and the Japan International Cooperation Agency (JICA) agreed to carry out the necessary study works for the period from February 1993 to June 1994 in accordance with on the Scope of Work concluded on 22 October 1992. The detailed scope of works, time schedule and methodology were agreed on by both parties as mentioned in the Inception Report submitted to MWEM in early March 1993.

The Study on Water Resources Development in the Ruvu River Basin aims to establish the optimum master plan for water resources development in the Ruvu River basin taking into consideration the present and forecasted social, economic and financial conditions therein. The target year is 2020.

The Study includes the following major works:

(1) Potential water resources assessment
(2) Clarification of present water use and the related problems
(3) Future water demand assessment up to the year 2020
(4) Preparation of a Master Plan up to 2020 for the most optimum water resources development including the initial environmental examination (IEE)

The Study period comprises three phases, each of which is divided into the field work period in Tanzania and the home office work in Japan. The Phase 1 Field Work was started in early March 1993 and was completed by the end of June 1993. All the results of the field survey and investigation were brought back to Tokyo and analyzed by the end of August 1993. The Interim Report was prepared by the Study Team in the Phase 1 Home Office Work and submitted to MWEM at the end of September 1993 to describe the results of the field survey and investigation, analyses, the major findings, and proposed the necessary works for the Phase 2 Field Work which was carried out between September 1993 and December 1993.

This Final Report describes the master plan on water resources development in the Ruvu River basin. The plan was established by combining all the results obtained in the course of the Study, placing the first priority on the municipal water supply to Dar Es Salaam.

This Final Report comprises the following four volumes.

- Volume I : Executive Summary
- Volume II : Main Report
- Volume III : Supporting Report
- Volume IV : Data Book

The Executive Summary briefs the Study results as well as the master plan for the water resources development in the Ruvu River basin, which was set up in the course of the Study. The Main Report describes the master plan in more detail in addition to the Study results on the respective disciplines related to the master plan. The Study results and field investigations performed are presented in detail in the Supporting Report. The Data Book provides the topographic survey data, meteo-hydrological data and the results of their analyses, data on flood damage survey and data on soil analysis.

2. PROJECT AREA

2.1 Topography

The Ruvu River with a catchment area of about 17,900 km^2 lies in the tropical zone between 6°-05' and 7°-45' South Latitude and 37°-15' and 39°-00' East Longitude. The Ruvu River originates in the Uluguru Mountains, with a highest peak of EL. 2,634 m, and flows into undulating highlands in the middle reaches. It finally pours into the Indian Ocean near the town of Bagamoyo located about 70 km northwest of Dar Es Salaam, the capital of Tanzania. The lower reaches have wide floodplains, most parts of which act as a wide natural retarding basin. This topographic characteristic makes the higher flood peaks in the uppermost reaches lower in the lowermost reaches by natural regulation on the one hand and high evaporation loss on the other hand.

2.2 Geology

The geology of the Study Area is categorized into the following five major divisions:

(i) Pre-Cambrian rocks: Acid gneisses, granulate, crystalline limestone extending over the Uluguru Mountains and the western part of the Ngerengere subbasin.

(ii) Karoo rocks: Sandstone and shale on the southeastern part of the Uluguru Mountains (Age: from Permian to Triassic).

(iii) Jurassic rocks: Coarse sandstone, mudstone, and oolitic limestone on the eastern margin of the Uluguru Mountains and the elevated rolling hills between the Ruvu and Wami Rivers.

(iv) Cretaceous rocks: Limestone, calcareous sandstone, mudstone, shale, and clay covering most of the rolling hills.

(v) Tertiary and Quaternary rocks:

a) Tertiary deposits : Sandy clay and clayey sand with minor lenses of pure sand or clay, gravel and calcareous fragments.

b) Quaternary deposits : Clay, silt and rarely gravel deposited in the fluvial and alluvial fan and swamps.

The Tertiary and Quaternary deposits lie over the subbasin of the Ngerengere River near Morogoro, the elevated rolling hills, the floodplains along the Ruvu River, and the coastal areas including Dar Es Salaam.

A careful review of the available geological maps and reports was made by the Geologist of the Study Team, through interpretation, to find the major fractures and active faults. The results are as follows:

i) Major fractures are clearly identified on the aerial photos: They run mainly in a NNE-SSW or E-W direction. The lineaments of fractures are classified as "major faults" in the existing geological maps. The fracture lineament running along the border between the mountains on the right bank and the alluvial plain of the Mgeta River is about 30 km long and 10 to 50 m deep.

ii) Other fracture's lineaments are 1 to 10 km in length mainly running in three directions, N-S, NNW-SSE, and ENE-WSW. The lineament running in an ENE-WSW direction branches from the major fracture running in an E-W direction. The lineament running in a NNW-SSE direction is parallel to the East African Rift System.

The geological assessment was carried out on each of the 23 dam sites identified by FAO. Firstly, the existence of a major fault at the dam sites was examined. Secondly, permeability of the dam foundations and reservoir areas was examined. In addition to

these, the bearing capacity of the dam foundations was also examined as discussed in Appendix-B of the Supporting Report. The assessment revealed the following facts:

The major faults run along the Mgeta River on the southern edge of the Uluguru Mountains. The faults penetrate between the Pre-Cambrian rocks and the Quaternary deposits. Of the 23 dam sites, the following five dam sites are located along or near the major faults:

No. 1 dam site (Mgeta)
No. 4 dam site (M/LB/R1)
No. 5 dam site (Mngazi)
No. 6 dam site (Bwakira)
No. 7 dam site (Dutumi)

In carrying out the feasibility study and implementing the above dam schemes, it is essential to clarify the detailed conditions of the major faults and geological movements through sufficient geological investigation such as physical exploration, core drillings, and observation by trench and adit excavation.

The following four dam sites and their reservoir areas may be composed of the limestone:

No. 9 dam site (Kidunda, the downstream alternative dam site)
No. 10 dam site (Mkulazi)
No. 12 dam site (LB/R1)
No. 13 dam site (Mbiki)

The geological conditions of these dam sites, in particular the permeability of dam foundations and reservoir areas should be clarified in detail through geological investigations including core drilling in the prefeasibility and/or feasibility study stage, since in this master planning stage geological data are not sufficiently available for planning proper foundation treatment measures and detailed estimation of the costs required therefor.

2.3 Meteorology

The Study Area situated in a tropical zone has a high average annual air temperature of 25.6°C. High temperature is common throughout the dry season from November to March and comparatively lower temperature prevails for the period from April to October.

Annual rainfall in the Study Area ranges between 800 and 2,700 mm. However, more than 1,500 mm of the annual rainfall occurs in the Uluguru Mountains occupying only about 10% of the total basin area. Therefore, the average annual basin rainfall amounts to 1,081 mm.

The average annual relative humidity is 62% with a monthly variation between 52% and 70%. The mountain area has about 10% lower humidity than the average and the middle reaches, having wide natural swamps in the wet season, has about 10% higher humidity.

The average annual sunshine duration is 7.0 hours/day with a monthly variation of 5.4 to 8.6 hours/day. Sufficient solar radiation in the tropical zone creates ideal conditions for plant growth.

The average monthly wind velocity is normally as moderate as 0.8 to 1.8 m/sec. The average annual pan evaporation is 1,814 mm with a monthly variation of 113 to 204 mm. The pan evaporation in the rainy season from April to August is less than 130 mm/month.

2.4 Hydrology

The Study Team collected all the available data for monthly rainfall at 66 rain gauge stations, daily rainfall at 19 stations, meteorological data at 4 stations, and stream gauging data at 11 stations. After reviewing those data, reliable data were selected, correlated, corrected and analyzed.

The average annual rainfall of the Ruvu River basin was calculated be about 1,080 mm by the Tiessen polygon method applied to the 19 representative rain gauge stations in the Study Area. It corresponds to 19.4 billion cubic meters in total volume.

Through the analysis, correlation, and correction of the discharge data at 11 gauging stations, the regional runoff characteristics were clarified as follows:

(1) The highest runoff coefficient of about 50% exists around the Uluguru Mountains area where annual rainfall exceeds 1,500 mm.
(2) The lowest runoff coefficient of about 5.0% is found in the Ngerengere River basin.
(3) In the Mgeta River basin, the runoff coefficient is derived to be about 20%.
(4) The runoff coefficient in the lowest reaches of the Ruvu River amounts to about 12% .

The above characteristics imply that the runoff coefficient is high in the uppermost Ruvu River basin and Mgeta River basin and that the runoff coefficient in the Ngerengere River

and the lowermost Ruvu basin is relatively small. However, the catchment area in the uppermost basin is very small and topographic conditions would not permit the large-scale water resources development. In addition, it would be possible to plan the large-scale development in the lower and middle basins where the streamflow is abundant, if a storage type dam which is capable of regulating the streamflow is economically implemented.

A preliminary estimate of sediment yield reveals about 200 and 400 m^3/km^2/year of specific sediment yield in the Ruvu River basin based on the limited suspended load data. It is considered essential to carry out the intensive water sampling for the suspended sediment load analysis on the selected dam projects in the next study stage.

2.5 Environmental Conditions

The water quality analysis was carried out on 18 river water samples and 2 well water samples which were collected in the Ruvu River basin in the dry and wet seasons of 1993. The results clarified that most of the river water samples exceed the standard quality for drinking water concerning the turbidity, color, permanganate value and iron. Most of the groundwater of shallow wells was affected by saline water or of poor quality. Therefore it is necessary to provide purification facilities for any domestic water supply project.

In general, the environmental conditions in the Study Area are good due to the hot climate with adequate rainfall on the one hand and very low population density of less than 20 people/km^2 on the other hand. However, the progressing deforestation by fuel wood supply and random animal grazing will gradually deteriorate the environment. Especially the areas near major towns such as Morogoro and Bagamoyo have the problem of water pollution due to sewage from domestic and small scale industrial wastes.

Deforestation on the mountain slopes for cultivation is accelerating erosion in the upstream reaches together with random over-grazing of livestock. Although these activities are far from the critical level at present, the reforestation and organized livestock breeding within settled areas need to be introduced for future maintenance of the natural environment in the Ruvu River basin.

2.6 On-going Selous Conservation Programme (SCP)

The Mikumi National Park with an area of about 3,200 km^2, the fifth largest park in Tanzania, is situated in the most western part of the Ruvu River basin. Besides, the Selous

Game Reserve lies in the southwest corner of the basin. The Reserve, which was established in 1922, occupies a total area of about 50,000 km^2.

There is an on-going project called the Selous Conservation Programme (SCP), which was created in 1988 under the Ministry of Tourism, National Resources and Environment with a finance of GTZ. The general objective of the project is to control the commercial poaching for ivory and rhino horn in the Reserve.

Recently, the SCP introduced a plan to demarcate the village areas bordering the Reserve. The areas demarcated by the SCP overlap with the reservoir areas of the planned Kidunda and Mgeta Dam Projects as shown in Figs. S.1 and S.2, respectively. In these two SCP's project areas, about 20% and 1% of the areas planned by the SCP would be submerged by the creation of dam in case of the Kidunda and Mgeta Dam Projects, respectively, as shown in Table S.1. The socio-economic data of the planned Kidunda reservoir area are listed in Table S. 2.

3. PRESENT WATER USE

The Study Area has enough rainfall in the rainy season for any use but generally suffers from water shortage in the dry season. Often the small rivers in the lowermost areas dry up in the dry season.

According to the survey carried out by the JICA Study Team, flood damage is minimal because almost all inhabitants live on higher ground than the flood water table due to the very low population density of the area. Agricultural damage affects mostly the paddy crop planted on the floodplain. However, most farmers grow maize on the floodplain after the flooding has subsided. This risk hedge method seems to compensate for the damage to the paddy. Therefore damage caused by low flow or drought is more serious, in this Study Area, than that caused by flooding.

Two major water uses are domestic/industrial water supply for major cities and irrigation. At present Dar Es Salaam, with a population of 1.3 million in 1988, badly suffers from water supply shortage due to outmoded pipe networks. It totally depends on the Ruvu River water with two intakes in the lowermost reach. A complete rehabilitation of the system is urgently needed. Less problems exist with the water supply for Morogoro and Bagamoyo.

There are many small-scale irrigation facilities scattered all over the Study Area. Some existing facilities have deteriorated due to their poor structure and lack of maintenance and

management. Due to low yield and income, the water charge is not sufficient to cover the maintenance and repair costs.

Concerning the Bagamoyo Irrigation Development Project, the regular construction works for a new irrigation area of 100 ha are about to be started. Therefore, the water right of about 0.1 m^3/sec required for the development of the new irrigation area should be applied by the Department of Irrigation as soon as possible.

4. POSSIBLE DEVELOPMENT

4.1 Future Municipal Water Demand

A detailed water demand forecast was not completed by the Tanzanian Government. In the Study, the water supply demand for Dar Es Salaam was estimated by the Study Team at the master plan study level. The demand forecast was made by dividing the service area of NUWA into two areas, namely the area covered by the distribution system of Dar Es Salaam and the area along the transmission mains of the existing water supply schemes. The results of the water demand forecast for Dar Es Salaam are summarized below:

Total demand in the service area of NUWA

Year	1990	1995	2000	2005	2010	2015	2020
I. Mean daily water demand							
(1) Area in the distribution network of DSM (m^3/day)	223,893	302,107	331,936	431,828	535,170	665,903	829,533
(2) Areas along transmission mains (m^3/day)	81,655	77,048	77,631	88,829	102,341	119,003	139,640
Total (in m^3/day)	305,548	379,155	409,567	520,658	637,511	784,905	969,173
Total (in m^3/sec)	3.45	4.39	4.74	6.03	7.38	9.08	11.22
II. Maximum daily water demand							
(1) Area in the distribution network of DSM (m^3/day)	279,867	377,634	414,919	539,785	668,963	832,378	1,036,917
(2) Areas along transmission mains (m^3/day)	102,069	96,310	97,039	111,037	127,926	148,753	174,550
Total (in m^3/day)	381,935	473,944	511,959	650,822	796,889	981,132	1,211,467
Total (in m^3/sec)	4.42	5.49	5.93	7.53	9.22	11.36	14.02

The above shows that the average daily demand in 2020 will amount to about 969,000 m^3/day (about 11 m^3/sec) and the daily peak demand to about 1,211,000 m^3/day (14.0 m^3/sec), compared with the present actual supply of 296,000 m^3/day (3.4 m^3/sec). This suggests the urgent need for not only the rehabilitation of the existing water supply system but also a vast enlargement of the water supply capacity.

The above raw water demand of 12.2 m^3/sec for 2020 needs to be taken into consideration for future dam projects, because a mean daily discharge, with a 95% dependability, at the existing Upper Ruvu intake site is estimated at 9.1 m^3/sec based on the long-term stream flow data.

In view of the basic human need for municipal water supply, the first priority of the water resources development plan gives the first priority to the municipal water supply to Dar Es Salaam where a more critical shortage of domestic water will take place in the near future.

4.2 Agriculture

Regarding agricultural development, the Study Team carried out a review of the past studies, reconnaissance survey, soil analysis, and selection of potential areas. The criteria for selection were:

(1) Assuming the main crop to be paddy, the area should be within the floodplain of the Ruvu River.
(2) Soils should be suitable for crop production.
(3) The areas should not lie near national parks and game reserves, so as not to affect wildlife and the natural environment, and to avoid crop damage by wild animals.
(4) The area should be within the limits of the available water, not affecting the downstream requirement of water supply.

As a result of the soil survey including chemical laboratory tests on soils sampled in the lower Ruvu and Mgeta plain areas, the floodplains can be developed as agricultural land, except for some 1,700 ha in the Mgeta plain where sodium adsorption is over 12. The area and locations of potential irrigable areas preliminarily selected are tabulated below and illustrated in Fig. S.3

Potential area identified (Gross area in ha)			
Lower Ruvu	Middle Ruvu	Mgeta Plain	Total(ha)
24,000	30,000	30,000	84,000

The Study clarified that there are about 84,000 ha of potential land in the Study Area, in which 11 agricultural development were identified as shown in Table S.3.

The priority of the eleven (11) agricultural projects identified were assessed based on the following four (4) main aspects:

(i) Conformity with the Government policy
(ii) Socio-economic aspect (population served, accessibility)
(iii) Technical aspect (water resources, soil condition, water quality, easiness for implementation)
(iv) Economic aspect (construction cost, benefit, ratio of total benefit to total cost)

The procedures adopted for the priority ranking are explained in Chapter V of the Main Report and Appendix-G of the Supporting Report. The agricultural projects are categorized into the following three classes based on the results of the priority ranking study;

Class A : High Priority
Class B : Priority
Class C : Low Priority

The results of the priority ranking study are shown in Table S.4 and summarized below;

	Project	Class
1.	Bagamoyo Irrigation Development	A
2.	Low-lift Pump Irrigation	A
3.	Makurunge Irrigation	B
4.	Ruvu National Youth	C
5.	Kidunda Irrigation	B
6.	Ngerengere Irrigation	B
7.	Uluguru Mountain East	B
8.	Mlali Irrigation	A
9.	Mgeta Plain Irrigation	C
10.	Mgeta Plain Mvuha Irrigation	C
11.	Uluguru Mountain West	A

4.3 Hydropower

The Ruvu River basin is located relatively close to Dar Es Salaam, the largest electricity-consuming area in Tanzania, as compared with other river basins with the hydropower potential around the city. However, the large head to generate power is exploitable only in the upstream mountainous areas of the Ruvu basin because of the topographic condition, but the available discharge therein is less because of the small catchment area. Thus, it is envisaged that large scale of hydropower potential is much lower in the Ruvu River basin. In

principle, therefore, the hydropower development was planned utilizing the head to be created by the construction of the dam for the purpose of municipal and irrigation water supply.

5. WATER RESOURCES DEVELOPMENT PLAN

5.1 Basic Concept

The technical review of the present water uses and the future water demand in the Study Area shows that a water shortage exists in the municipal water supply for Dar Es Salaam. Domestic water supply is an indispensable factor for human existence, regardless of its economic value, compared with other water uses. Therefore, priority should be given to solving this water shortage problem. However, the present water supply shortage in Dar Es Salaam is not due to the shortage of raw water at the two Ruvu River intakes, but is due mainly to very high leakage along the aged pipe networks and the inadequate distribution system. Therefore, the complete rehabilitation and provision of flow meters are urgently required.

According to the survey and hydrological study, the increase in irrigation water use in the dry season in the upstream basin directly affects the decrease of dry season discharge at the existing intakes for the Dar Es Salaam water supply. If some irrigation projects are developed in the upstream reaches, it would be impossible to prohibit the taking of water in the dry months. Therefore in order to ensure a 95% dependable water supply to Dar Es Salaam, there should be a reasonable limit on irrigation development in the upstream basin, unless effective regulations on the use of irrigation water in the dry season are introduced in the form of legal measures and practical actions.

Hydrological estimation shows the limit of irrigation development in the upstream basin which depends on exploitations of water in the dry season through the construction of the storage type dam (s).

The hydropower potential of the Ruvu River basin will be dependent on the dam height to be optimized in view of the municipal water supply.

The flood risk map is given in Fig. S.4 which shows the inundation area in the event of a 100-year probable flood in the Ruvu River basin. On the other hand, the flood survey clarified that there would be none or only insignificant flood damage to society. Therefore, reservoir planning should not include large-scale flood control precautions except in the case of

abnormal flooding, for instance once every 100 or 200 years. However, if the plan aims at large-scale flood control, such dam construction might be not only uneconomical but also might cause social and environmental problems by submergence of a wide area of land for the reservoir.

On the other hand, the promising irrigation areas identified are located in the low-lying floodplains of the lower Ruvu where the bank-full flow capacity is estimated to be less than 300 m^3/sec, while, a 5-year probable flood in the lower Ruvu which is adopted as the flood protection level for irrigation development amounts to about 670 m^3/sec. Hence, some flood control works are required to protect the planned irrigation areas from the same scale of flood. In principle, the flood control plan consisting of the provision of dikes along the river as well as sluices for the internal drainage was selected for each of the irrigation areas, while that combined with flood storage space in the reservoir of dam was proposed in case the irrigation project is developed in association with such a dam development with sufficient capacity therefor as the Kidunda dam.

From the above, the Study has formulated the Master Plan on water resources development to cope with the future imbalance between water demand and supply in Dar Es Salaam, for irrigation, and likewise for the flood control in case of the Kidunda dam.

5.2 Water Required for Future Municipal Water Demand

As mentioned in the respective Chapters of the Main Report, to cope with water demand in the final target year of 2020 the following quantities will be necessary at the Upper Ruvu intake site:

(1)	Water demand for Dar Es Salaam	11.2 m^3/sec
(2)	Downstream irrigation water rights (considering of the return flow)	0.8 m^3/sec
(3)	Downstream river maintenance flow	4.3 m^3/sec
	Total	16.3 m^3/sec

In order to meet the above demands in 2020, one or two reservoir type dams are required to be constructed in the basin. Therefore a comparison study was carried out to find the optimum dam site(s) in the upstream reaches as explained below.

5.3 Selection of Dam Projects

Out of the 23 dam sites identified by FAO Study Team in 1961, whose locations are shown in Fig. S.5, four (4) dam sites were recommended by the French Government Study Team in 1962, namely Mkombezi, Mgeta, Ngerengere, and Kidunda. The Kidunda Dam Project was recommended as the top priority project. Then an additional study, including core drilling, was carried out in 1964, and its results were reported in the "Report on Selection of the Kidunda Dam Site", Ministry of Agriculture, Tanzania.

The JICA Study Team reviewed all the previous data and information and made comparisons concerning the topographical, geologic, and hydrologic conditions, storage efficiency, provisional construction cost, and so on. The comparison of the 23 dam sites is shown in Table S.5. As a result, the following three dam sites are preliminarily recommended.

- Kidunda
- Ngerengere
- Mgeta

In addition, it was recognized that the Kidunda Dam has the highest storage efficiency and the greatest effect on downstream discharge increase. However, the past geological investigation was deemed unclear on the possible existence of limestone caves. Accordingly, it is recommended that detailed geological investigations be carried out in the future prefeasibility study. This recommendation shall also be applied to the Mgeta Dam site, not with regard to the limestone problem, but to the major fault problems.

The main features of the three dams selected are listed below with their present-day construction costs:

No.	Description	Promising Dam Project		
		Kidunda	Mgeta	Ngerengere
(1)	Dam height (m)	26	45	36
(2)	Reservoir area (km^2)	158.5	10.5	30.0
(3)	Yield of dependable discharge for water supply to DES/irrigation development (m^3/sec)	28.2	7.1	1.8
(4)	Possible hydropower development (kW)	3,900	2,300	400
(5)	Total construction cost (Mill. US$)	101.1	110.6	90.8
Construction cost per dependable discharge (Mill. US$/$m^3$/sec): (5)/(3)		3.6	15.6	50.4

As shown in the table above, the Kidunda Dam Project is obviously the most economically advantageous as compared with other two dam projects.

5.4 DAM Development Scenarios for Municipal Water Supply

In order to satisfy the municipal water supply in the Dar Es Salaam by the target year 2020, the following two development scenarios were selected:

Development Scenario	Dam(s) to be developed
Scenario-1:	Kidunda Dam
Scenario-2:	Mgeta Dam and Ngerengere Dam

The water balance of demand and supply for the Dar Es Salaam water supply system in each of these two Development Scenarios is summarized in Table S.6. They are illustrated in Figs. S.6 and S.7, respectively.

6. IRRIGATION DEVELOPMENT PLAN

The agricultural development projects are broadly categorized into the following two kinds;

(i) Dam-Related Projects: to be developed utilizing the streamflow in excess of the water demand in Dar Es Salaam in the year 2020 after construction of the planned dams.

(ii) Independent Projects: may be developed without the use of water yielded by the planned dams.

6.1 Dam-Related Project

As seen in Figs. S.6 and S.7, the Development Scenario-1 and -2 would yield a discharge of about 12.3 and 0.2 m^3/sec, respectively, available for new irrigation development projects. With the integrated use of the water exploited newly and that secured for existing small irrigation in the lower Ruvu, the new irrigation development projects were proposed by the Development Scenario as follows:

Name of Irrigation Project		Irrigated Area under the Development Scenario (ha)	
		Scenario-1	Scenario-2
i)	Kidunda Irrigation	10,500	-
ii)	Bagamoyo Irrigation	1,100	980
iii)	Low-lift pump irrigation	2,400	-
iv)	Ruvu National Youth	200	-
v)	Makurunge Irrigation	150	-
Total		14,350	980

All the above irrigation projects need to be provided with flood protection works. In the Scenario-1, the design flood for the irrigation projects (a 5-year probable flood) will decrease from 670 m^3/sec under the present condition to about 360 m^3/sec in the case with the Kidunda dam owing to the flood control by surcharge volume of the reservoir. The general layout plans of these dam-related irrigation projects are illustrated in Figs. S.8 to S.11. In case of the Development Scenario-1, it is recommended that the people living in the Kidunda reservoir area should be resettled to the Kidunda irrigation area where at present very few people are settled.

6.2 Independent Project

The independent projects were identified in the relatively high land areas around the Uluguru Mountains, and these are expected to be implemented independently of the dam development scenario. The independent projects identified in the course of the Study are as follows:

Name of Agricultural Development Project	Area of Agricultural Development (ha)
- Mlali Irrigation	400
- Uluguru Mountain West	2,000
- Uluguru Mountain East	(16,000)
- Mgeta Plain Myuha Irrigation	(5,000)

Note : The area in the parentheses above shows the potential area.

Of the above four irrigation projects, the Uluguru Mountain West and East Project involve the watershed management in the Uluguru Mountains as explained in Appendix-G of the Supporting Report. It is recommended that the Mlari Irrigation and Uluguru Mountain West Projects are to be implemented together. The layout plans of these two independent irrigation projects are shown in Figs. S.12 and S.13.

7. OVERALL IMPLEMENTATION PLAN FOR WATER RESOURCES DEVELOPMENT

7.1 Implementation Plan of Dam-Related Projects

Concerning the projects related to the dam development, their implementation plans were established by the Development Scenario in accordance with the following policies;

(i) Concerning each of the Kidunda, Mgeta and Ngerengere dam projects, it will take at least nine (9) years after commencement of the next study until the start of operation of the water supply system to Dar Es Salaam, which includes two (2) years for prefeasibility/feasibility studies or feasibility study, two (2) years for the detailed design, four (4) years for the main construction works and presumably one year for impounding the reservoir depending on rainfall amount after the completion of the construction.

(ii) In case of the Development Scenario-1, the Bagamoyo Irrigation Development Project and Kidunda Irrigation Project will be implemented at an earlier stage owing to the high economic viability for the former and the necessity for solving the resettlement issues concerning the people living in the Kidunda reservoir area.

Under the Development Scenario-2, the Bagamoyo Irrigation Development Project will be implemented at a more limited scale as compared with that in the Development Scenario-1. The overall implementation plan was established by development scenario taking into account the aforesaid aspects as shown in Fig. S.14.

7.2 Implementation Plan of Independent irrigation Projects

Of the four irrigation projects identified as the independent projects, the Mlali Irrigation Project and the Uluguru Mountain West Project were proposed to be implemented together. The overall implementation plan of these independent projects is shown in Fig. S.15.

8. PRELIMINARY DESIGN, COST ESTIMATE AND ASSESSMENT FOR WATER RESOURCES DEVELOPMENT PLAN

8.1 Preliminary Design and Cost Estimate

The preliminary design for the Kidunda, Mgeta and Ngerengere Dam Projects was carried out at a master plan study level. Their layout plans are shown in Figs. S.16 to S.18.

On the basis of the prelliminary design, the preliminary cost estimate was made for the projects involved in the two development scenarios with reference to the cost data in similar current projects. The estimated present-day project costs for the three dam projects are shown in Tables S.7 to S.9, respectively, while those for the dam related irrigation projects are summarized in Table S.10. The general construction schedule of the Kidunda dam project, which is almost common to that of the Mgeta and Ngerengere Dam Projects, is given in Fig. S.19.

8.2 Economic Evaluation of the Development Scenario-1

As explained in Appendix-L of the Supporting Report, the unit construction cost of dam project for the purpose of the municipal water supply ranges between 20 and 100 million US$/m^3/sec in other countries. Hence, the unit construction cost of 3.6 million US$/m^3/sec in the Kidunda Dam Project reveals the extremely economical water resource development. Moreover, even the unit construction cost of 50.4 million US$/m^3/sec in case of the Ngerengere Dam Project falls within the normal range.

From the above comparison of unit construction costs for the selected three dam projects. It is obvious that, the post-Study action should be taken towards the realization of the Development Scenario-1 (Kidunda Dam Project). The economic evaluation of the Development Scenario-1 is discussed in Appendix-L of the Supporting Report. Based on the cash flow of economic benefit and cost, the economic viability was assessed for each of the following components of water resource development involved in the Development Scenario-1.

(i) Water resource development for the municipal water supply by means of the construction of the Kidunda Dam

(ii) 5 Dam-related irrigation projects

(iii) Total water resources development ((i) + (ii))

As a result, an economic internal rate of return (EIRR) for the municipal water supply was estimated to be 14.3% and a ratio of benefit to cost (B/C) at about 2.3. While, an economic internal rate of return for the whole of the 5 dam-related irrigation projects was estimated to be as low as 4.2%. However, an EIRR for the whole water resources development comprising the municipal water supply, hydropower and irrigation development comes to about 10.2%. Therefore, the water resources development by the Kidunda Dam Project (Development Scenario-1) is judged to be economically sound as a whole.

8.3 Initial Environmental Examination

The Initial Environmental Examination (IEE) is a preliminary environmental review, and it is carried out to assess whether or not Environmental Impact Assessment (EIA) is necessary for the development plan in the next study stage. The environmental elements for IEE were confirmed through the screening by the preparatory study carried out in October 1992 concerning the following items:

i) Resettlement of inhabitants
ii) Public health and hygienic conditions
iii) Geographical and geological conditions
iv) Soil erosion
v) Surface water and water quality
vi) Ground water
vii) Animals and vegetation

Of the above items, the ground water would not constitute the major element in the water resources development plan formulated in this Master Plan. In the implementation stage of the water resource development plan, an assessment of the possible impacts on the environment of the surrounding areas of the proposed project and a more detailed environmental investigation, namely the Environmental Impact Assessment (EIA), are necessary for the following projects as a result of the environmental screening shown in Table S. 11.

i) Kidunda Dam Project
ii) Mgeta Dam Project
iii) Ngerengere Dam Project
iv) Kidunda Irrigation Project

9. EXPANSION PLAN OF WATER SUPPLY FACILITY FOR DAR ES SALAAM

In order to meet the water demand in the Dar Es Salaam water supply system, the existing water supply facility with a total capacity of 3.16 m^3/sec will have to be expanded through the provision of new projects as well as the aforesaid water resource development.

Since the water conveyance facilities are required to be designed for the maximum daily demand, those facilities for conveying treated water of about 9.8 m^3/sec need to be newly constructed even in case the capacity of the existing Lower Ruvu scheme is expanded under the current study before the implementation of the Kidunda Dam Project.

The following three (3) water conveyance projects, each with a conveyance capacity of about 3.3 m^3/sec, were planned to be newly installed in accordance with the increase in the water demand. To cope with the municipal water demand in Dar Es Salaam, the following three (3) new water conveyance projects will have to be implemented:

No.	Name of New Water Supply Project	Water Conveyance Capacity (m^3/sec)
1.	New Lower Ruvu Scheme-1	3.27
2.	New Lower Ruvu Scheme-2	3.27
3.	New Upper Ruvu Scheme	3.28
	Total	9.82

The three (3) new water conveyance projects for the Dar Es Salaam water supply system, namely the New Lower Ruvu-1, New Lower Ruvu-2 and New Upper Ruvu projects, will be implemented to meet the daily maximum water demand in the Dar Es Salaam water supply system as shown in Fig. S.20. Their implementation plan is shown in Fig. S. 21.

The general alignment of the three new water conveyance projects is illustrated in Fig. S. 22. However, the further study needs to be carried out in order to find the optimum route of the pipeline from various alternatives, one of which is suggested in the Figure.

The total construction cost for the 3 new water conveyance projects was preliminarily estimated at about 460 million US$ as summarized in Table S.12.

10 RECOMMENDED POST-STUDY ACTION PLAN

10.1 Prefeasibility Study on the Kidunda Dam

It is obvious that the Kidunda Dam Project (Development Scenario-1) is the most economical of the three selected dam projects for the purpose of meeting the water demand in the Dar Es Salaam city by the year 2020. Moreover, the implementation of the Kidunda Dam Project would enable to realize a lot of irrigation projects as aforesaid and to encourage the rural development through the improvement of the local communication system now aggravated since it includes the improvement works of existing 100 km long rural road, connecting the dam site and the Morogoro road.

However, the Kidunda Dam Project has issues mentioned below, which will have to be clarified in the next study stage. Therefore, the Development Scenario-2 should be retained as an alternative to the Development Scenario-1.

The main issues in relation to the Kidunda Dam are as follows;

- Geological issue: Existence of limestone at the downstream dam site and existence of a clayey layer at the upstream dam site.

- Environmental issue: Adverse effect on the existing Selous Game Reserve with respect to conservation of wildlife

From the above, it is strongly recommended that the prefeasibility study on the Kidunda Dam Project be carried out in the subsequent stage focusing on the geological investigations at the alternative dam sites and the environmental impact assessment (EIA) study. It is foreseen that the aggravated situation concerning water supply to Dar Es Salaam is accelerated from now on unless the water resources project is implemented at an earlier stage. In particular, the EIA study in the next study stage needs to be carried out under good cooperation between the both ministries concerned, namely the Ministry of Water, Energy and Minerals and the Ministry of Tourism, National Resources and Environment.

It is expected that a feasibility study on the project be commenced after the above issues have thoroughly been solved through the prefeasibility study. In that case, the basin management issue will appear in the Terms of Reference (TOR) for the regular feasibility study.

10.2 Feasibility Study on the Mlari Irrigation and Uluguru Mountain West Projects

As the independent project of the dam development, it is recommended to proceed with a feasibility study on the Mlari irrigation and Uluguru Mountain West Projects soon after completion of the Study. Both of these projects were selected as the high priority agricultural projects in the Study Area, since the other high priority irrigation projects will have to await the completion of the planned dam project.

The feasibility study on these two priority projects should be conducted at the same time in a single package taking into consideration the development scales of these projects, the vicinity of their locations and the problem inherently common to these two projects, namely soil erosion in the western area of the Uluguru Mountains and siltation at the Mlali intake site.

TABLES

Table S.1 AREA TO BE SUBMERGED BY THE KIDUNDA AND MGETA RESERVOIR

The SCP's planning area likely to be submerged by the Kidunda Dam-Reservoir

No.	Land Use Planned by the SCP	Kidunda Dam		
		Total Planning Area by the SCP: Ta	Area to be Submerged by the Reservoir	
		(km^2)	(km^2)*	Ratio to Ta (%)
1	Residential area	10	6.6	66
2	Area for agriculture	39	28.3	73
3	Communal wildlife utilization area	162	13.9	9
4	Area for fuel wood	49	7.2	15
5	Area for future expansion	41	2.8	7
	Total	301	58.8	20

The SCP's planning area likely to be submerged by the Mgeta Dam-Reservoir

No.	Land Use Planned by the SCP	Mgeta Dam		
		Total Planning Area by the SCP: Ta	Area to be Submerged by the Reservoir	
		(km^2)	(km^2)*	Ratio to Ta (%)
1	Residential area	35	0.0	0.0
2	Area for agriculture	250	0.2	0.1
3	Communal wildlife utilization area	310	5.8	1.9
4	Area for fuel wood	60	0.2	0.3
5	Area for future expansion	95	1.2	1.3
6	Miombo wood land	120	1.0	0.8
	Total	870	8.4	1.0

Note: *; Area at the dam crest level

Table S.2 LAND USE AND AGRICULTURAL ACTIVITY IN THE PLANNED RESERVOIR AREA OF KIDUNDA DAM

		Name of Village				Total	Remark (Data Source)	
		Mggni	Kgnla	Bwila-J	Bwila-C			
Location (Bank side of the Ruvu River)		Right	Left	Left	Right/Left	-		
Population		929	979	806	1,962	4,676	CENSUS'88	
Population		na	1,016	na	2,700	na	WARD '93	
Population		na	2,128	881	2,961	5,970	SCP '91	+2.6pa
Population		1,420	1,170	1,104	1,014	4,708	DAO '92	
Workforce		696	573	541	497	2,307	DAO '92	
Household		237	195	184	169	785	DAO '92	
Household		na	266	220	370	856	SCP '91	
House No.		na	300	350	352	1,002	WARD '93	A.
(of burnt brick)			10	9	0	19	WARD '93	
Church+Pastor, School			5	1	0	6	WARD '93	
with gcs roof			na	20	45	65	WARD '93	
Housing Area (ha)		na	310	153	203	666	SCP '91	B.
Crop Land (ha)		na	837	310	641	1,788	SCP '91	C.
Maize	(max ha)	278	229	216	199	922	DAO '92	
	(act. ha)	252	179	196	159	786	DAO '92	
Paddy	(max ha)	40	115	24	38	217	DAO '92	
	(act. ha)	40	86	24	38	188	DAO '92	
Sorghum	(max ha)	278	229	128	199	834	DAO '92	
	(act. ha)	238	213	118	136	705	DAO '92	
Cotton	(max ha)	278	229	216	199	922	DAO '92	
	(act. ha)	78	89	65	39	271	DAO '92	
Total	(max ha)	874	802	584	635	2,895	DAO '92	
	(act. ha)	608	567	403	372	1,950	DAO '92	
Banana		na	900	1,050	1,056	3,006	WARD '93	Ax3
Coconut		na	450	525	528	1,503	WARD '93	Ax1.5
Mango		na	600	700	704	2,004	WARD '93	Ax2
Goat		256	420	135	150	961	DAO '92	
Poultry		3,680	4,027	2,116	2,312	12,135	DAO '92	
Duck		1,020	156	600	465	2,241	DAO '92	
Forest	(ha)		3,053	3,386	2,429	8,868	SCP '91	D.
Total	(ha)		4,200	3,849	3,273	11,322	SCP '91	B+C+D

SOURCE : WARD '93; from village chairmen
SCP '91; Selous Conservation Programme, DGTZ 1991
DAO '92; District Agriculture Office, 1992/93

NOTE : MGGNI=Magogoni, KGNLA=Kiganila, J=juu, C=chini
A big discrepancy in population of Bwila-chini is due to the fact if they count that of newly created Kiburma or not.

Table S.3 SUMMARY TABLE OF AGRICULTURAL PROJECT

Project Title	Location	Project Type	Potential Area (ha)	Project Area (ha)	Project Description
Bagamoyo Irrigation Development Project	Lower Ruvu	Extension	1,100	1,100	The project area comprises Bagamoyo Irrigation Development Project (BIDP) area of 1,000 ha and a private farm area of 100 ha BIDP is under phased development as follows; - Phase 1 Experimental Farm of 8ha (existing) - Phase 2 Pilot Farm of 100ha (under construction) - Phase 3 Full development of 1,000 ha by gravity irrigation (proposed) As the irrigation water resources, construction of large scale reservoir(s) is required for dry season.
Low-lift Pump Irrigation Project	Lower Ruvu	New Development	2,400	50 Pilot Farm	The project is requested by farmers. Irrigation will be done by small scale and removable type pumps utilizing existing ponds as a water resource. Equipment will be managed by farmers' group. As a trial, pilot farm of 50 ha will be a proper size of the project.
Makurunge Irrigation Project	Lower Ruvu	Rehabilitation	150	150	Reconstruction of the abandoned pump irrigation scheme. At present the area is cultivated by farmers from Makurunge village under rainfed condition.
Ruvu National Youth Irrigation Project	Lower Ruvu	Rehabilitation	800	200	Rehabilitation of the existing pump irrigation scheme of 24 ha and construction of remaining area of 176 ha The project is operated by National Youth Service.
Kidunda Irrigation Project	Middle Ruvu	New Development	26,500	15,600	Proposed project area is located in the floodplain of the Ruvu river. At present almost no agricultural activities in the area. Construction of Kidunda dam is necessary for this project.
Ngerengere Irrigation Project	Middle Ruvu	New Development	3,500	3,500	Proposed project area is located in the floodplain of the Ruvu river. At present no agricultural activities in the area. Construction of Ngerengere dam is necessary for this project.
Uluguru Mountains East Project	Upper Ruvu Uluguru Mountains	Rehabilitation and Development	16,000	16,000	Project component - Watershed management - Rehabilitation of trunk rural road (Morogoro-Kisaki) - Construction of agricultural marketing facilities especially for fruits
Mgeta Plain Irrigation Project	Mgeta Plain	New Development	25,000	7,000	Both banks of the Mgeta River are the potential area. However, existence of Selous Game Reserve limits the development of the right bank. Construction of Mgeta dam is necessary for this Project.
Mgeta Plain Mvuha Irrigation Project	Mgeta Plain	New Development	5,000	5,000	The potential area is estimated on the basis of the information from farmers. Basic data for development are not available. Farmers have a strong intention of irrigating for their field under rainfed condition.
Mlali Irrigation Project	Vicinity of Morogoro Uluguru Mountains	Rehabilitation	800	400	This project has a high priority in the FAO's study and in the Regional office. The project has suffered from serious sedimentation at the weir site. Irrigation facilities are also deteriorated . In addition to the existing area of 150 ha, an area of 250 ha is proposed to be extended.
Uluguru Mountains West Project	Uluguru Mountains West side slope	Rehabilitation and Development	2,000	2,000	Project component - Watershed management; Afforestation - Rehabilitation and improvement of existing traditional irrigation system for erosion control - Improvement of trunk rural road (approx. 42 km) *The area is the Vegetable Zone for Dar Es Salaam* and Morogoro city.

Table S.4 PRIORITY OF AGRICULTURAL PROJECT IN THE RUVU BASIN

	Item \ Project Title	1. Bagamoyo Irrigation Development Project	2. Pilot Farm Low-lift of Pump Irrigation Project	3. Existing Pump Irrigation Schemes Rehabilitation Project		4. Middle Ruvu Irrigation Project		5. Uluguru Mountain East Project	6. Mlali Irrigation Project	7. Mgeta Plain Irrigation Development Project		8. Uluguru Mountain West Project
		Lower Ruvu Valley				Middle Ruvu Valley		Upper Ruvu Valley				
			Low-lift Pump Irrigation Project	Makurunge Irrigation Project	Ruvu National Youth Irrigation Project	Kidunda Irrigation Project	Ngerengere Irrigation Project			Mgeta Plain Irrigation Project	Mgeta Plain Mvuha Irrigation Project	(Mgeta traditional irrigation)
General Feature of the Project	**Project Description**											
	Potential Area in Gross (ha)	1,000	2,400	150	800	26,500	3,500	16,000	800	25,000	5,000	2,000
	Proposed Project Size in Net (ha)	1,100 including area of private farm	50 5 nos. of pilot schemes	150	200	15,600	2,450	Potential area for the Area is estimated based on cultivation and production records	400	7,000	Potential area is estimated based on villager's information	2,000 Data from district office
	Present Status	Pilot farm of 100ha is under Construction	Small-scale irrigation by manpower	Abandoned	Farm exists but no irrigation since 1978	African Cultivation	African Cultivation	Existing "Fruit (Orange) Zone" Existing Area = 2,624 ha	Existing but no irrigation area because of siltation at weir site	Rainfed farming	Rainfed farming	Existing "Vegetable Zone" for Morogoro and DSM
	Prospective Project Component	Irrigation and Drainage system - Main Irrigation : 12 km - Secondary : 10 km - Drainage : 12 km Heightening of Lower Ruvu NUWA intake will be required for gravity irrigation.	Pilot farm construction : 100ha - 5 canals (0.5 km each) - Supply of Low-lift pumps - Construction of workshops - Training programmes to farmers	- Reconstruction of Pumping house - Re-excavation of canals Irrigation canal : 2 km	- 2 pumping stations - Rehabilitation of existing canal system for 24 ha - Construction of new canal system for 176 ha - Supply of machinery - Rehabilitation of Godown	Irrigation & Drainage Canals Main Irrigation : 51 km Secondary : 122 km Drainage : 124 km	Irrigation and Drainage canals - Main Irrigation : 11 km - Secondary : 17 km - Drainage : 14 km Construction of basic social infrastructures	Soil conservation : 16,000 ha Improvement of trunk rural road Bigwa - Mkuyuni : 37 km Storage godowns : 1 Sorting and packing facilities : 1	Irrigation and Drainage canals - Main Irrigation : 2 km - Secondary : 10 km - Drainage : 9 km - Intake Weir : L=50 m - Intake Facility	Irrigation and Drainage canals - Main Irrigation : 40 km - Secondary : 65 km - Drainage : 50 km Rehabilitation of rural road - Morogoro - Kisaki : 140 km	Irrigation and Drainage canals - Irrigation canals Main & Secondary : 53km - Drainage canals : 28km Intake Weir : 1 no. Rehabilitation of rural road - Mvuha - site : 15 km	Soil erosion control : 2,000 ha Rehabilitation of rural road Mlali - Langali : 15 km Langali - Nyandira : 5 km Improvement of irrigation canals 68 systems : 170 km Domestic piped water supply
Conformity with Government Policy	**Long Term National Plan**											
	1. Attaining self-sufficiency	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
	2. Increasing agricultural diversification	○	○	○	○	○	○	◎	○	○	○	◎
	3. Providing raw materials for industry	×	×	×	×	○	○	◎	○	○	○	○
	4. Production for Export	×	×	×	×	○	○	◎	×	×	×	◎
	5. Deriving from livestock resources	×	×	×	×	○	○	×	×	×	×	×
	National Irrigation Policy											
	1. Economic viability											
	2. State farm considered ending	-	-	-	-	-	-	-	-	-	-	-
	3. State farm to investor or smallholder's organization	-	-	-	-	-	-	-	-	-	-	-
	4. New project to private sector	×	×	×	×	◎	◎	×	○	○	×	×
	5. Support to smallholder	◎	◎	◎	×	○	×	◎	◎	○	◎	◎
	6. Strong request by farmer's group	◎	◎	○	×	×	×	○	◎	○	◎	◎
	7. Independency from Gov. interventions	○	○	○	×	◎	◎	○	○	○	○	○
	Project Ranking by ISID	No.1 out of 9 projects in Coast Region	Newly Identified Not yet included in the ranking	No.5 out of 9 projects	No.9 out of 9 projects	Newly Identified	Newly Identified	Newly Identified	No.5 out of 16 projects in Morogoro Region	Newly Identified	Newly Identified	No.3 out of 16 projects in Morogoro Region
	Weighted Sub-Total Score	18	12	13	5	15	14	16	18	12	13	20
Socio-economic Aspect	**Population Served**											
	Estimated population in the area	22,900	25,000	1,700	National Youth Service	5,200	5,200	45,000	12,200	29,500	8,100	32,600
	Estimated population density (no./km2)	280	150	30		15	15	140	150	70	100	100
	Accessibility											
	Distance from national trunk road (km)	9.5	10	10 (from Bagamoyo)	0.1	90	70	40	8 (3km form old trunk)	110	95	30
	Road condition in the Area	Accessibility is hard in the low-lying area for 2.5 km in flood season.	Access road is hardly passable in rainy season.	Road from BIDP to site is not passable in rainy season. The Ruvu river crossing by a ferry is required.	The project area is located besides the Morogoro - DSM Highway	Secondary rural roads connect the project area to a trunk road. Condition is seriously bad in rainy season	Secondary rural roads connect the project area to a trunk road. Condition is seriously bad in rainy season.	Major rural road "Morogoro - Kisaki" passes through the area. However, bad road condition is a serious constraint of the area.	Accessibility of this project is rather good.	Condition of the "Mkuyuni - Mvuha" section is serious in rainy season. Mngazi to Kisaki is not passable in rainy season.	Access road from Mvuha to the project area is not passable in rainy season.	Road in mountainous section of "Mlali - Nyandira" is seriously damaged. Section from Langali to Nyandira is not passable by a jeep.
	Weighted Sub-Total Score	18	17	10	10	5	5	12	15	9	7	12
Technical Aspect	**Water Resources**	**The Ruvu river** on following conditions - Construction of Dam(s) - Improvement of Lower NUWA intake weir or construction of new weir	**The Ruvu river** on following condition - Construction of Dam(s) for the whole potential area	**The Ruvu river** on following condition - Construction of Dam(s) for the whole potential area	**The Ruvu river** on following condition - Construction of Dam(s) for the whole potential area	**The Ruvu river** on following condition - Construction of Kidunda Dam	**The Ruvu river** on following condition - Construction of Ngerengere Dam	Mainly depend on Rainfall	**The Mlali river**	**The Mgeta river** on following condition - Construction of Mgeta Dam	**The Mvuha river** Hydrological data on the river is not available. Further study will be inevitable.	**The Mgeta river and small seasonal rivers and streams**
	Water Quality	Suitable for Irrigation	Water quality of the Mkombezi river is not suitable.	Suitable for Irrigation	Suitable for Irrigation	Suitable for Irrigation	Suitable for Irrigation	Suitable for Irrigation	Suitable for Irrigation	Suitable for Irrigation	Suitable for Irrigation	Suitable for Irrigation
	Soil Condition	Suitable for Paddy	Suitable for Paddy	Suitable for Paddy	Suitable for Paddy	No data on suitability for cultivation	No data on suitability for cultivation	Suitable for most crops	Suitable for most crops	Suitable for most crops except north part of Gombo	Suitable for most crops	Suitable for most crops
	Easiness of project implementation	On-going	Preliminary plan	Abandoned	Abandoned (no farming)	Preliminary plan	Preliminary plan	Existing	Existing	Preliminary plan	Preliminary plan	Existing
	Weighted Sub-Total Score	16	15	15	15	15	15	13	17	16	14	15
Economic Aspect	**Estimated Cost and Benefit**											
	Total construction cost (million Tshs)	1,768	72	265	540	25,949	3,829	6,192	752	11,725	5,534	4,120
	Cost per hectares (1,000 Tshs/ha)	1,630	1,442	1,771	2,702	1,658	1,563	2,360	1,881	1,675	1,581	2,060
	Benefit per hectares (Tshs/ha)	6,854	5,518	6,048	6,770	5,740	5,743	6,000	5,069	3,073	3,073	17,841
	B/C Ratio	4.20	3.83	3.42	2.51	3.46	3.67	2.54	2.69	1.83	1.94	8.66
	Weighted Sub-Total Score	19	21	21	12	17	17	12	14	12	14	26
Evaluation	**Total Score**	71	65	59	42	52	51	53	64	49	48	73
	Comments											
	Priority	A*	A	B	C	B	B	B	A	C	C	A

Note ; ◎ Fitted ○ Partly Fitted × Unfitted Priority A : Top Priority , A* : Top Priority with conditions , B : Priority , C : Low Priority

Table S.5 MAIN FEATURES OF 23 DAM SITES IDENTIFIED BY THE PREVIOUS STUDY

No.	Name of Dam Site	Catchment Area	Dam Height	Hydrological Feature			Storage Efficiency of Reservoir				Requirement of New Access road		
				Annual rainfall	Runoff Coefficient	Inflow Rate	Annual Inflow Volume	Reservoir Storage Capacity	Dam Embank. Volume	Storage Efficiency	Improve. of Existing road	New road Construct.	Total
		(km2)	(m)	(mm)	(%)	(mm/year/km2)	(Mill. m3/year)	(Mill. m3)	(Thous. m3)		(km)	(km)	
		(1)		(2)	(3)	(2)x(3)/100	(4)x(1)/1000	(6)	(7)	(6)/(7)	(9)	(10)	(9)+(10)
1	Mgeta	914	21	1,220	35	427	390	57	405	0.14	121	10	131
2	Rudete	249	20	1,150	33	383	95	13	421	0.03	121	12	133
3	Msoro	899	5	1,080	19	205	184	13	230	0.06	125	8	133
4	M/LB/R1	54	20	1,110	55	611	33	5	380	0.01	116	6	122
5	Mngazi	223	20	1,110	50	555	124	13	278	0.04	110	4	114
6	Bwakira	75	20	1,110	55	611	46	9	278	0.03	102	2	104
7	Dutumi	114	20	1,110	45	500	57	4	464	0.01	95	3	98
8	Ngerengere	2,701	17	970	5	49	131	84	340	0.25	59	3	62
9	Ruvu-Mgeta	3,672	21	1,340	20	268	984	1,665	1,542	1.08	85	4	89
10	Mkulazi	352	16	1,050	10	105	37	62	221	0.28	85	17	102
11	LB/R1	47	9	940	6	56	3	6	192	0.03	40	2	42
12	Msus	526	15	930	6	56	29	37	439	0.08	0	12	12
13	Mbiki (Major)	492	15	940	6	56	28	26	508	0.05	6	1	7
14	Mbiki (Minor)	91	14	940	6	56	5	11	351	0.03	13	1	14
15	Mkombezi	588	18	1,030	6	62	36	47	257	0.18	26	3	29
16	Msigwe	205	17	1,020	6	61	13	39	802	0.05	31	0	31
17	RB/R1	210	14	890	5	45	9	19	141	0.14	54	18	72
18	RB/R2	129	10	890	5	45	6	7	256	0.03	43	9	52
19	RB/R3	67	8	890	5	45	3	6	112	0.05	54	5	59
20	Banda	311	12	920	5	46	14	13	134	0.09	25	3	28
21	Mlandisi	78	17	950	5	48	4	9	229	0.04	7	1	8
22	Mbwawa	184	27	1,090	5	55	10	46	496	0.09	11	4	15
23	Chombe	189	15	1,090	5	55	10	12	164	0.07	30	2	32

Note

4 dam sites, the Mgeta (No.1), Negerengere (No.8), Ruvu-Mgeta (NO.9) and Mkombezi (No.15) are selected by the French study as the promising dam sites in the Ruvu river basin.

Table S.6 WATER BALANCE BY DEVELOPMENT SCENARIO

(Unit : m3/sec)

	Component of Water Balance	Scenario-1 Dam Name	Scenario-1 Outflow	Scenario-2 Dam Name	Scenario-2 Outflow
1	Regulated Outflow from upstream dam(s)	(1)Kidunda	28.16	(1)Ngerengere	1.81
				(2)Mgeta	7.11
		Total-1	28.16	Total-1	8.92
2	95 % Dependable Discharge Yielded in Area not Covered by Upstream Dam(s)	(1)U.R.I.S.	9.06	(1)U.R.I.S.	9.06
		(2)Kidunda	-8.60	(2)Ngerengere	-0.02
				(3)Mgeta	-1.38
		Total-2	0.46	Total-2	7.66
3	River Maintenance Flow for Downstream Reach of U.R.I.S.	(1)River flow*	4.12	(1)River flow*	4.12
		(2)Irrigation	1.00	(2)Irrigation	1.00
		Total-3	5.12	Total-3	5.12
4	Water Demand in Year 2020		11.23		11.23
5	Water Balance (Available (Discharge for New Irrigation Development)		12.27		0.23

Note

1. U.R.I.S. means existing upper Ruvu intake site.
2. The water balance is made on the basis of annual mean discharge data.
3. *; the required minimum river maintenance flow is the minimum mean monthly discharge at the existing gauging station 1H8.
4. Development Scenarios
   Senario-1 : (Kidunda dam)
   Senario-2 : (Mgeta dam) + (Ngerengere dam)

Table S.7 BREAKDOWN OF CONSTRUCTION COST FOR KIDUNDA DAM (1/2)

Item No.	Work	Unit	Quantity	Foreign Currency (US$)		Local Currency (US$)		Total (US$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
I	Direct Construction Cost								
1.	Preparatory Works (General)	L.S.			5,451,000		1,450,000		6,901,000
2.	Permanent Access Road								
	2.1 Improvement of existing rural road	km	90	70000.00	6,300,000	30000.00	2,700,000	100,000.00	9,000,000
	2.2 Construction of new access road	km	10	105000.00	1,050,000	45000.00	450,000	150,000.00	1,500,000
	(Subtotal-2)				7,350,000		3,150,000		10,500,000
3.	Diversion Tunnel and Intake Tunnel								
	3.1 Excavation at tunnel portals,common	m3	70,000	3.40	238,000	0.90	63,000	4.30	301,000
	3.2 Excavation at tunnel portals,rock	m3	210,000	11.50	2,415,000	2.70	567,000	14.20	2,982,000
	3.3 Tunnel excavation	m3	16,000	59.50	952,000	20.00	320,000	79.50	1,272,000
	3.4 Steel support	ton	62	1173.00	72,726	117.00	7,254	1,290.00	79,980
	3.5 Concrete for tunnel lining	m3	4,100	111.20	455,920	55.90	229,190	167.10	685,110
	3.6 Plug concrete	m3	4,000	85.60	342,400	43.00	172,000	128.60	514,400
	3.7 Reinforcement bar	ton	120	528.90	63,468	137.70	16,524	666.60	79,992
	3.8 Backfill grouting	m3	550	90.60	49,830	23.20	12,760	113.80	62,590
	3.9 Others(5 %)	L.S.			229,467		69,386		298,854
	(Subtotal-3)				4,818,811		1,457,114		6,275,926
4.	Main Dam								
	4.1 Excavation,common	m3	22,000	3.40	74,800	0.90	19,800	4.30	94,600
	4.2 Excavation,rock	m3	67,000	11.50	770,500	2.70	180,900	14.20	951,400
	4.3 Embankment,core	m3	240,000	7.10	1,704,000	1.80	432,000	8.90	2,136,000
	4.4 Embankment,filter	m3	110,000	34.80	3,828,000	16.10	1,771,000	50.90	5,599,000
	4.5 Embankment,rock	m3	420,000	12.60	5,292,000	3.00	1,260,000	15.60	6,552,000
	4.6 Blanket grouting	m	8,900	76.50	680,850	23.00	204,700	99.50	885,550
	4.7 Curtain grouting	m	38,000	96.50	3,667,000	27.00	1,026,000	123.50	4,693,000
	4.8 Crest road	m	4,400	70.00	308,000	30.00	132,000	100.00	440,000
	4.9 1 Measuring apparatus(1%)	L.S.			163,252		50,264		213,516
	4.10 Others(5 %)	L.S.			824,420		253,833		1,078,253
	(Subtotal-4)				17,312,822		5,330,497		22,643,319
5.	Spillway								
	5.1 Excavation,common	m3	65,000	3.40	221,000	0.90	58,500	4.30	279,500
	5.2 Excavation,rock	m3	195,000	11.50	2,242,500	0.70	136,500	12.20	2,379,000
	5.3 Concrete,gravity dam	m3	19,000	107.00	2,033,000	52.00	988,000	159.00	3,021,000
	5.4 Reinforcement bar	ton	790	503.80	398,002	137.70	108,783	641.50	506,785
	5.5 Anchor bar	m	670	11.40	7,638	1.90	1,273	13.30	8,911
	5.6 Spillway bridge	m	52	12600.00	655,200	5400.00	280,800	18,000.00	936,000
	5.7 Others(5 %)	L.S.			277,867		78,693		356,560
	(Subtotal-5)				5,835,207		1,652,549		7,487,756

(Continued)

Table S.7 BREAKDOWN OF CONSTRUCTION COST FOR KIDUNDA DAM (2/2)

Item No.	Work	Unit	Quantity	Foreign Currency (US$)		Local Currency (US$)		Total (US$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
6.	Architectural Buildings								
	6.1 Control house	m2	200	540.00	108,000	360.00	72,000	900.00	180,000
	6.2 Valve house	m2	50	540.00	27,000	360.00	18,000	900.00	45,000
	6.3 Gate house	m2	30	540.00	16,200	360.00	10,800	900.00	27,000
	(Subtotal-6)				151,200		100,800		252,000
7.	Metal Work								
	7.1 Diversion gates	ton	52	5830.00	303,160	650.00	33,800	6,480.00	336,960
	7.2 Spillway gate(radial)	ton	300	8330.00	2,499,000	930.00	279,000	9,260.00	2,778,000
	7.3 Intake gate	ton	9	7500.00	67,500	830.00	7,470	8,330.00	74,970
	7.4 Outlet facilities	ton	50	15750.00	787,500	1750.00	87,500	17,500.00	875,000
	7.5 Steel pipes(inc. penstock for hydropower)	ton	146	3300.00	481,800	370.00	54,020	3,670.00	535,820
	(Subtotal-7)				4,138,960		461,790		4,600,750
8.	Powerhouse and Generating Equipment	L.S.			14,908,000		2,352,000		17,260,000
	Total of Direct Construction Cost (I)				59,966,000		15,954,750		75,920,750
II	Land Aquisition and Compensation	L.S.			0		2,120,000		2,120,000
III	Administration Expenses	L.S.			0		759,000		759,000
IV	Engineering Services (Detailed design and supervision)	L.S.			7,744,000		1,367,000		9,111,000
	Total(I to IV)				67,710,000		20,200,750		87,910,750
V	Physical Contengency (15%)	L.S.			10,156,000		3,030,000		13,186,000
	Grand Total				77,866,000		23,230,750		101,096,750

Table S.8 BREAKDOWN OF CONSTRUCTION COST FOR MGETA DAM (1/2)

Item No.	Work	Unit	Quantity	Foreign Currency (US$)		Local Currency (US$)		Total (US$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
I	Direct Construction Cost								
1.	Preparatory Works (General)	L.S.			5,959,000		1,775,000		7,734,000
2.	Permanent Access Road								
	2.1 Improvement of existing rural road	km	130	70000.00	9,100,000	30000.00	3,900,000	100000.00	13,000,000
	2.2 Construction of new access road	km	12	105000.00	1,260,000	45000.00	540,000	150000.00	1,800,000
	(Subtotal-2)				10,360,000		4,440,000		14,800,000
3.	Diversion Tunnel and Intake Tunnel								
	3.1 Excavation at tunnel portals,common	m3	11,000	3.40	37,400	0.90	9,900	4.30	47,300
	3.2 Excavation at tunnel portals,rock	m3	32,000	11.50	368,000	2.70	86,400	14.20	454,400
	3.3 Tunnel excavation	m3	15,000	59.50	892,500	20.00	300,000	79.50	1,192,500
	3.4 Steel support	ton	78	1173.00	91,494	117.00	9,126	1290.00	100,620
	3.5 Concrete for tunnel lining	m3	4,600	111.20	511,520	55.90	257,140	167.10	768,660
	3.6 Plug concrete	m3	4,900	85.60	419,440	43.00	210,700	128.60	630,140
	3.7 Reinforcement bar	ton	140	528.90	74,046	137.70	19,278	666.60	93,324
	3.8 Backfill grouting	m3	620	90.60	56,172	23.20	14,384	113.80	70,556
	3.9 Others(5 %)	L.S.			122,529		45,346		167,875
	(Subtotal-3)				2,573,101		952,274		3,525,375
4.	Main Dam								
	4.1 Excavation,common	m3	28,000	3.40	95,200	0.90	25,200	4.30	120,400
	4.2 Excavation,rock	m3	82,000	11.50	943,000	2.70	221,400	14.20	1,164,400
	4.3 Embankment,core	m3	420,000	7.10	2,982,000	1.80	756,000	8.90	3,738,000
	4.4 Embankment,filter	m3	180,000	34.80	6,264,000	16.10	2,898,000	50.90	9,162,000
	4.5 Embankment,rock	m3	1,500,000	12.60	18,900,000	3.00	4,500,000	15.60	23,400,000
	4.6 Blanket grouting	m	4,800	76.50	367,200	23.00	110,400	99.50	477,600
	4.7 Curtain grouting	m	12,000	96.50	1,158,000	27.00	324,000	123.50	1,482,000
	4.8 Crest road	m	800	70.00	56,000	30.00	24,000	100.00	80,000
	4.9 Measuring apparatus(1%)	L.S.			307,654		88,590		396,244
	4.10 Others(5 %)	L.S.			1,553,653		447,380		2,001,032
	(Subtotal-4)				32,626,707		9,394,970		42,021,676
5.	Spillway								
	5.1 Excavation,common	m3	50,000	3.40	170,000	0.90	45,000	4.30	215,000
	5.2 Excavation,rock	m3	150,000	11.50	1,725,000	2.70	405,000	14.20	2,130,000
	5.3 Concrete	m3	10,000	98.50	985,000	49.80	498,000	148.30	1,483,000
	5.4 Reinforcement bar	ton	435	503.80	219,153	137.70	59,900	641.50	279,053
	5.5 Anchor bar	m	400	11.40	4,560	1.90	760	13.30	5,320
	5.6 Spillway bridge	m	20	12600.00	252,000	5400.00	108,000	18000.00	360,000
	5.7 Others(5 %)	L.S.			167,786		55,833		223,619
	(Subtotal-5)				3,523,499		1,172,492		4,695,991

(Continued)

Table S.8 BREAKDOWN OF CONSTRUCTION COST FOR MGETA DAM (2/2)

Item No.	Work	Unit	Quantity	Foreign Currency (US$)		Local Currency (US$)		Total (US$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
6.	Architectural Buildings								
	6.1 Control house	m2	200	540.00	108,000	360.00	72,000	900.00	180,000
	6.2 Valve house	m2	50	540.00	27,000	360.00	18,000	900.00	45,000
	6.3 Gate house	m2	30	540.00	16,200	360.00	10,800	900.00	27,000
	(Subtotal-6)				151,200		100,800		252,000
7.	Metal Work								
	7.1 Diversion gates	ton	32	8330.00	266,560	930.00	29,760	9260.00	296,320
	7.2 Spillway gate(radial)	ton	112	7500.00	840,000	830.00	92,960	8330.00	932,960
	7.3 Intake gate	ton	10	8330.00	83,300	930.00	9,300	9260.00	92,600
	7.4 Outlet facilities	ton	19	15750.00	299,250	1750.00	33,250	17500.00	332,500
	7.5 Steel pipes(inc. penstock for hydropower)	ton	87	5830.00	507,210	650.00	56,550	6480.00	563,760
	(Subtotal-7)				1,996,320		221,820		2,218,140
8.	Powerhouse and Generating Equipment	L.S.			8,356,000		1,464,000		9,820,000
	Total of Direct Construction Cost (I)				65,545,826		19,521,356		85,067,182
II	Land Aquisition and Compensation	L.S.			0		50,000		50,000
III	Administration Expenses	L.S.			0		851,000		851,000
IV	Engineering Services (Detailed design and supervision)	L.S.			8,677,000		1,531,000		10,208,000
	Total(I to IV)				74,222,826		21,953,356		96,176,182
V	Physical Contengency (15%)	L.S.			11,133,000		3,293,000		14,426,000
	Grand Total				85,355,826		25,246,356		110,602,182

Table S.9 BREAKDOWN OF CONSTRUCTION COST FOR NGERENGERE DAM (1/2)

Item No.	Work	Unit	Quantity	Foreign Currency (US$)		Local Currency (US$)		Total (US$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
I	Direct Construction Cost								
1.	Preparatory Works (General)	L.S.			4,837,000		1,467,000		6,304,000
2.	Permanent Access Road								
	2.1 Improvement of existing rural road	km	60	70000.00	4,200,000	30000.00	1,800,000	100000.00	6,000,000
	2.2 Construction of new access road	km	3	105000.00	315,000	45000.00	135,000	150000.00	450,000
	(Subtotal-2)				4,515,000		1,935,000		6,450,000
3.	Diversion Tunnel and Intake Tunnel								
	3.1 Excavation at tunnel portals,common	m3	5,000	3.40	17,000	0.90	4,500	4.30	21,500
	3.2 Excavation at tunnel portals,rock	m3	14,000	11.50	161,000	2.70	37,800	14.20	198,800
	3.3 Tunnel excavation	m3	6,400	59.50	380,800	20.00	128,000	79.50	508,800
	3.4 Steel support	ton	45	1173.00	52,785	117.00	5,265	1290.00	58,050
	3.5 Concrete for tunnel lining	m3	2,800	111.20	311,360	55.90	156,520	167.10	467,880
	3.6 Plug concrete	m3	1,300	85.60	111,280	43.00	55,900	128.60	167,180
	3.7 Reinforcement bar	ton	80	528.90	42,312	137.70	11,016	666.60	53,328
	3.8 Backfill grouting	m3	390	90.60	35,334	23.20	9,048	113.80	44,382
	3.9 Others(5 %)	L.S.			55,594		20,402		75,996
	(Subtotal-3)				1,167,465		428,451		1,595,916
4.	Main Dam								
	4.1 Excavation,common	m3	58,000	3.40	197,200	0.90	52,200	4.30	249,400
	4.2 Excavation,rock	m3	172,000	11.50	1,978,000	2.70	464,400	14.20	2,442,400
	4.3 Embankment,core	m3	510,000	7.10	3,621,000	1.80	918,000	8.90	4,539,000
	4.4 Embankment,filter	m3	220,000	34.80	7,656,000	16.10	3,542,000	50.90	11,198,000
	4.5 Embankment,rock	m3	1,500,000	12.60	18,900,000	3.00	4,500,000	15.60	23,400,000
	4.6 Blanket grouting	m	8,400	76.50	642,600	23.00	193,200	99.50	835,800
	4.7 Curtain grouting	m	24,000	96.50	2,316,000	27.00	648,000	123.50	2,964,000
	4.8 Crest road	m	2,000	70.00	140,000	30.00	60,000	100.00	200,000
	4.9 Measuring apparatus(1%)	L.S.			354,508		103,778		458,286
	4.10 Others(5 %)	L.S.			1,790,265		524,079		2,314,344
	(Subtotal-4)				37,595,573		11,005,657		48,601,230
5.	Spillway								
	5.1 Excavation,common	m3	13,000	3.40	44,200	0.90	11,700	4.30	55,900
	5.2 Excavation,rock	m3	38,000	11.50	437,000	2.70	102,600	14.20	539,600
	5.3 Concrete	m3	11,000	98.50	1,083,500	49.80	547,800	148.30	1,631,300
	5.4 Reinforcement bar	ton	430	503.80	216,634	137.70	59,211	641.50	275,845
	5.5 Anchor bar	m	670	11.40	7,638	1.90	1,273	13.30	8,911
	5.6 Spillway bridge	m	5	12600.00	63,000	5400.00	27,000	18000.00	90,000
	5.7 Others(5 %)	L.S.			92,599		37,479		130,078
	(Subtotal-5)				1,944,571		787,063		2,731,634

(Continued)

Table S.9 BREAKDOWN OF CONSTRUCTION COST FOR NGERENGERE DAM (2/2)

Item No.	Work	Unit	Quantity	Foreign Currency (US$)		Local Currency (US$)		Total (US$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
6.	Architectural Buildings								
	6.1 Control house	m2	200	540.00	108,000	360.00	72,000	900.00	180,000
	6.2 Valve house	m2	50	540.00	27,000	360.00	18,000	900.00	45,000
	6.3 Gate house	m2	30	540.00	16,200	360.00	10,800	900.00	27,000
	(Subtotal-6)				151,200		100,800		252,000
7.	Metal Work								
	7.1 Diversion gates	ton	6	5830.00	34,980	650.00	3,900	6480.00	38,880
	7.2 Spillway gate(radial)	ton	28	8330.00	233,240	930.00	26,040	9260.00	259,280
	7.3 Intake gate	ton	6	7500.00	45,000	830.00	4,980	8330.00	49,980
	7.4 Outlet facilities	ton	13	15750.00	204,750	1750.00	22,750	17500.00	227,500
	7.5 Steel pipes(inc. penstock for hydropower)	ton	26	3300.00	85,800	370.00	9,620	3670.00	95,420
	(Subtotal-7)				603,770		67,290		671,060
8.	Powerhouse and Generating Equipment	L.S.			2,392,000		348,000		2,740,000
	Total of Direct Construction Cost (I)				53,206,579		16,139,262		69,345,840
II	Land Aquisition and Compensation	L.S.			0		600,000		600,000
III	Administration Expenses	L.S.			0		693,000		693,000
IV	Engineering Services (Detailed design and supervision)	L.S.			7,073,000		1,248,000		8,321,000
	Total(I to IV)				60,279,579		18,680,262		78,959,840
V	Physical Contengency (15%)	L.S.			9,042,000		2,802,000		11,844,000
	Grand Total				69,321,579		21,482,262		90,803,840

Table S.10 PRESENT-DAY CONSTRUCTION COST BY DEVELOPMENT SCENARIO

Scenario - 1		Scenario - 2	
Name of Project	Total Present-day Construction Cost (Million US$)	Name of Project	Total Present-day Construction Cost (Million US$)
I. Dam project			
(1-1) Kidunda Dam	101.1	(1-1) Mgeta Dam	110.6
		(1-2) Ngerengere Dam	90.8
II. Irrigation project*			
- Kidunda Irrigation	65.2	- Bagamoyo Irrigation Development	9.4
- Bagamoyo Irrigation Development	10.6		
- Low-lift Pump Irrigation	20.3		
- Ruvu National Youth Irrigation	2.8		
- Makurunge Irrigation	2.0		
Total	202.0	Total	210.8

Note: *; include the construction costs for the necessary flood control works

Table S.11 RESULT OF ENVIRONMENTAL SCREENING

Project Name	Environmental Element							
	a	b	c	d	e	f	g	EIA
(1) Kidunda Dam Project	+	+	+	+	+	-	+	Y
(2) Mgeta Dam Project	-	+	+	+	+	-	+	Y
(3) Ngerengere Dam Project	+	+	+	+	+	-	+	Y
(3) Lower Ruvu Schemes-1 and -2	-	-	-	-	+	-	-	N
(4) Upper Ruvu Scheme	-	-	-	-	+	-	-	N
(6) Bagamoyo Irrigation Development	-	+	+	-	+	-	-	N
(7) Low-lift Pump Irrigation Project	-	+	+	-	+	-	-	N
(8) Makurunge Irrigation Project	-	+	+	-	+	-	-	N
(9) Ruvu National Youth Irrigation Project	-	+	+	-	+	-	-	N
(10) Kidunda Irrigation Project	+	+	+	-	+	-	+	Y
(11) Ngerengere Irrigation Project	+	+	-	-	+	-	+	Y
(12) Uluguru Mountain East Project	-	-	-	+	-	-	-	N
(13) Mgeta Plain Mvuha Irrigation Project	+	+	-	-	+	-	+	Y
(14) Mgeta Plain Irrigation Project	+	+	+	+	+	-	+	Y
(15) Mlali Irrigation Project	-	+	-	-	+	-	-	N
(16) Uluguru Mountain West Project	-	-	-	+	-	-	-	N

Notes
- + : Negative impact
- - : No or very small influence
- Y : EIA is necessary
- N : EIA is unnecessary

Environmental Element
- a. : Resettlement of Inhabitants
- b. : Public Health and Hygienic Conditions
- c. : Geographic and Geological Conditions
- d. : Soil Erosion
- e. : Surface Water
- f. : Ground Water
- g. : Animals and Vegetation
- EIA : Environmental Impact Assessment

Table S.12 PRESENT-DAY CONSTRUCTION COST FOR NEW WATER CONVEYANCE PROJECT

Name of Project	Total Present-day Construction cost (Million US$)
- New Lower Ruvu Project - 1	208.5
- New Lower Ruvu Project - 2	91.4
- New Upper Ruvu Project	160.0
Total	459.9

FIGURE

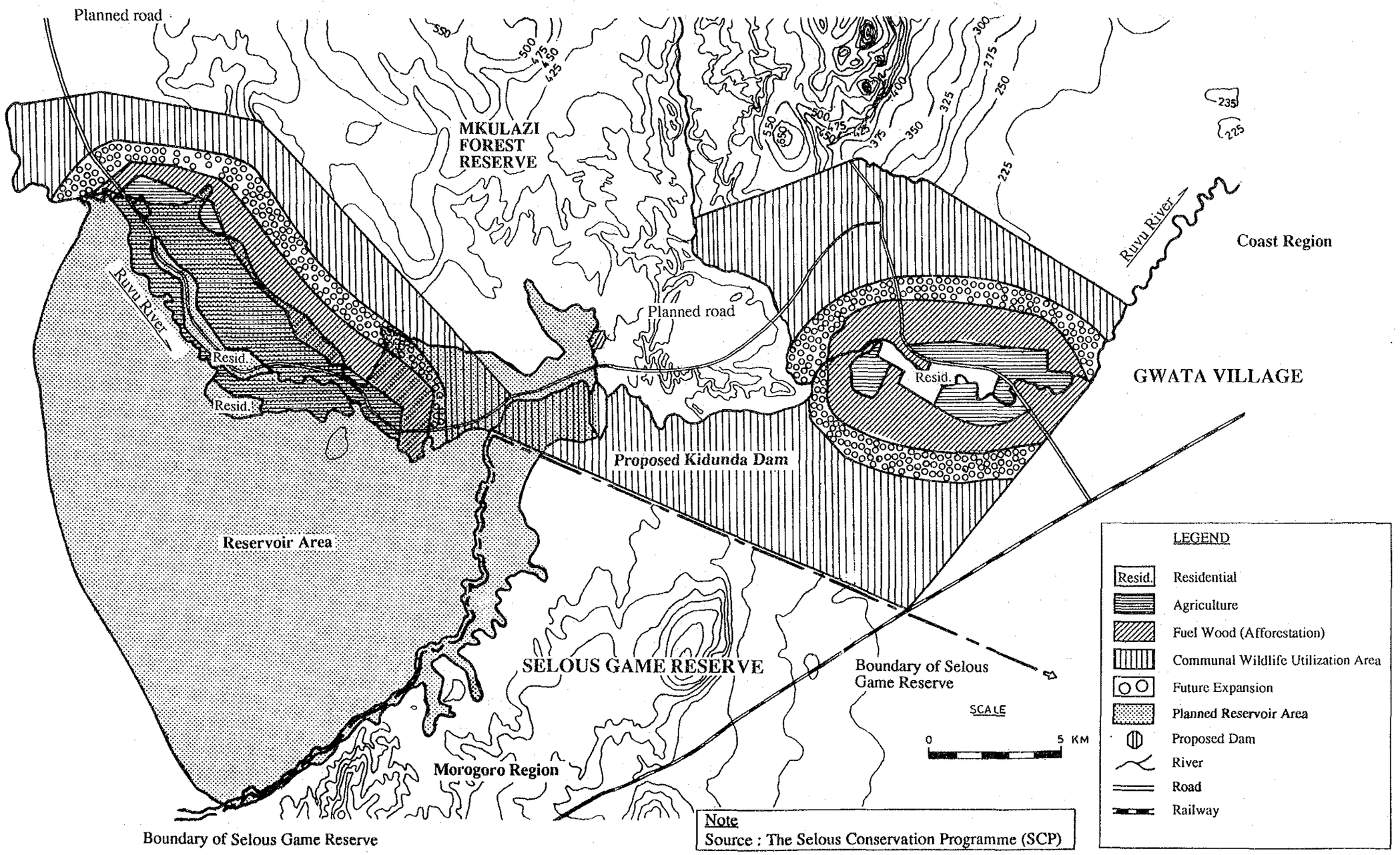

Fig. S.1 VILLAGE PLANNING AREA IN AND AROUND THE KIDUNDA DAM/RESERVOIR

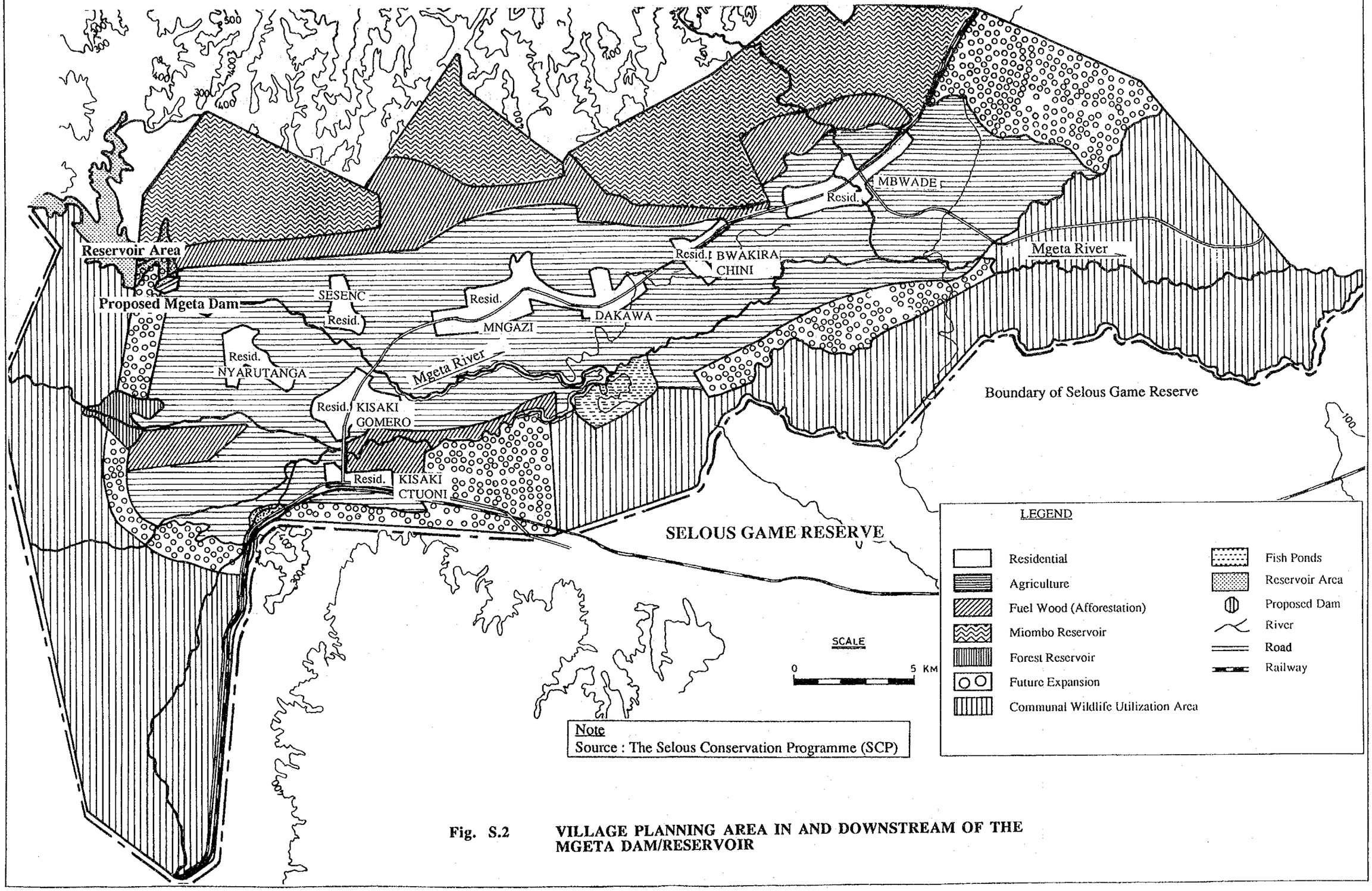

Fig. S.2 VILLAGE PLANNING AREA IN AND DOWNSTREAM OF THE MGETA DAM/RESERVOIR

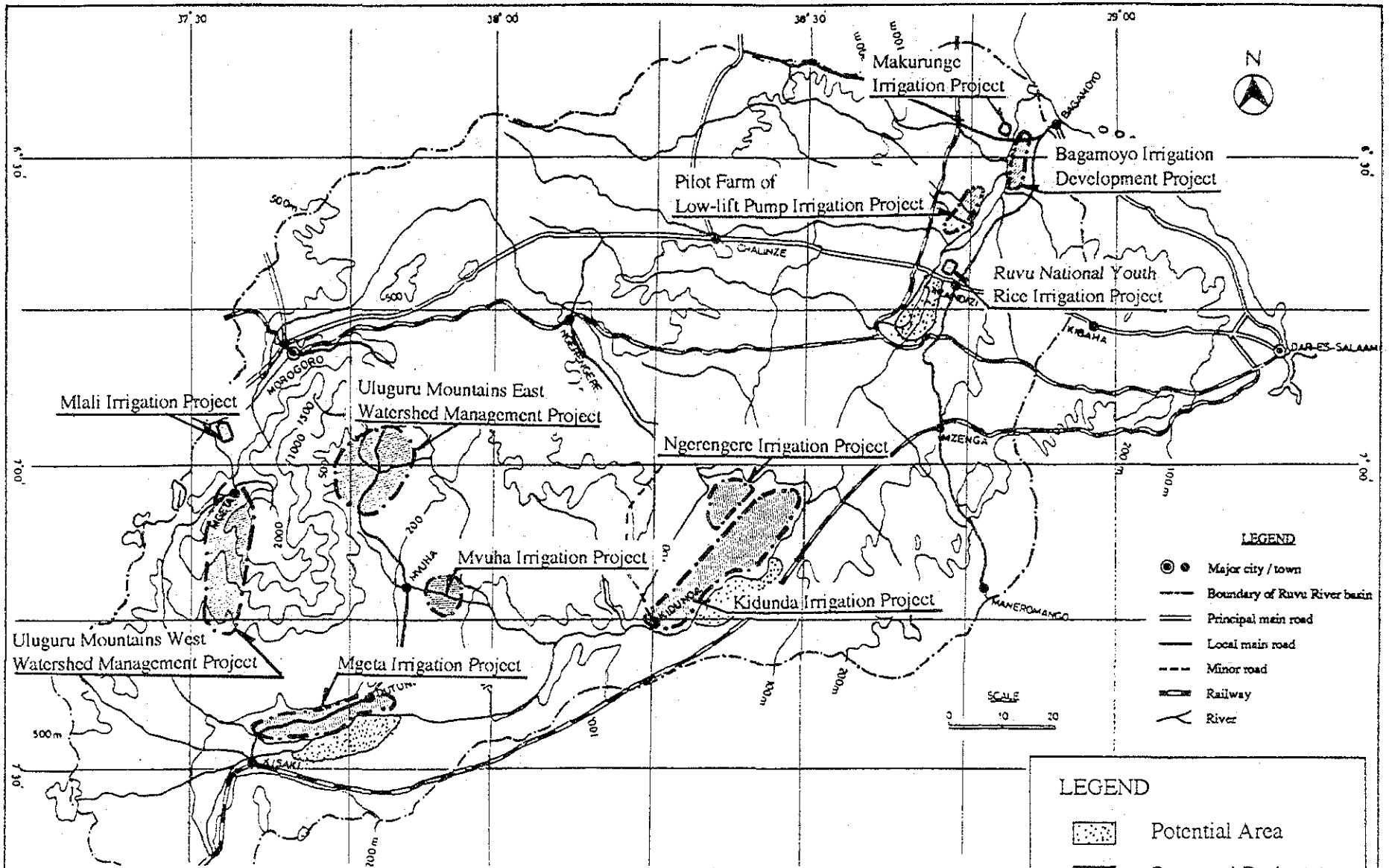

Fig. S.3 LOCATION MAP OF POTENTIAL AREA FOR AGRICULTURAL DEVELOPMENT AND PROPOSED PROJECT AREA

INDIAN OCEAN
(ZANZIBAR CHANNEL)

RUVU NORTH FOREST RESERVE

Pande
Mbegani
Kiromo
Buma
Chambe River
Dar es Salaam
Visiga
Saeni River
Mafaya
Matinbwa
Kombo
Chasimde
Logera River
Chalota River
Kizota River
Landizi River
Mbwawa
Miswe
Vikuruti
Mlandizi
BAGAMOYO
Dam
Kikongoni Forest
No.3
Kongo
No.4
Lower River
No.5
No.6
No.7
No.8
No.2
No.1
Nunge Salt Works
BIDP Farm
Ferry
Ruvu
Maumbiji River
Hoe River
Kidogoweni
Kiwangwa
Reservoir Makurunge Ranch
Ubena River
to Tanga/Moshi
Usigwa River
Mkombezi River
Mbiki River
to Morogoro
Kiwoko River

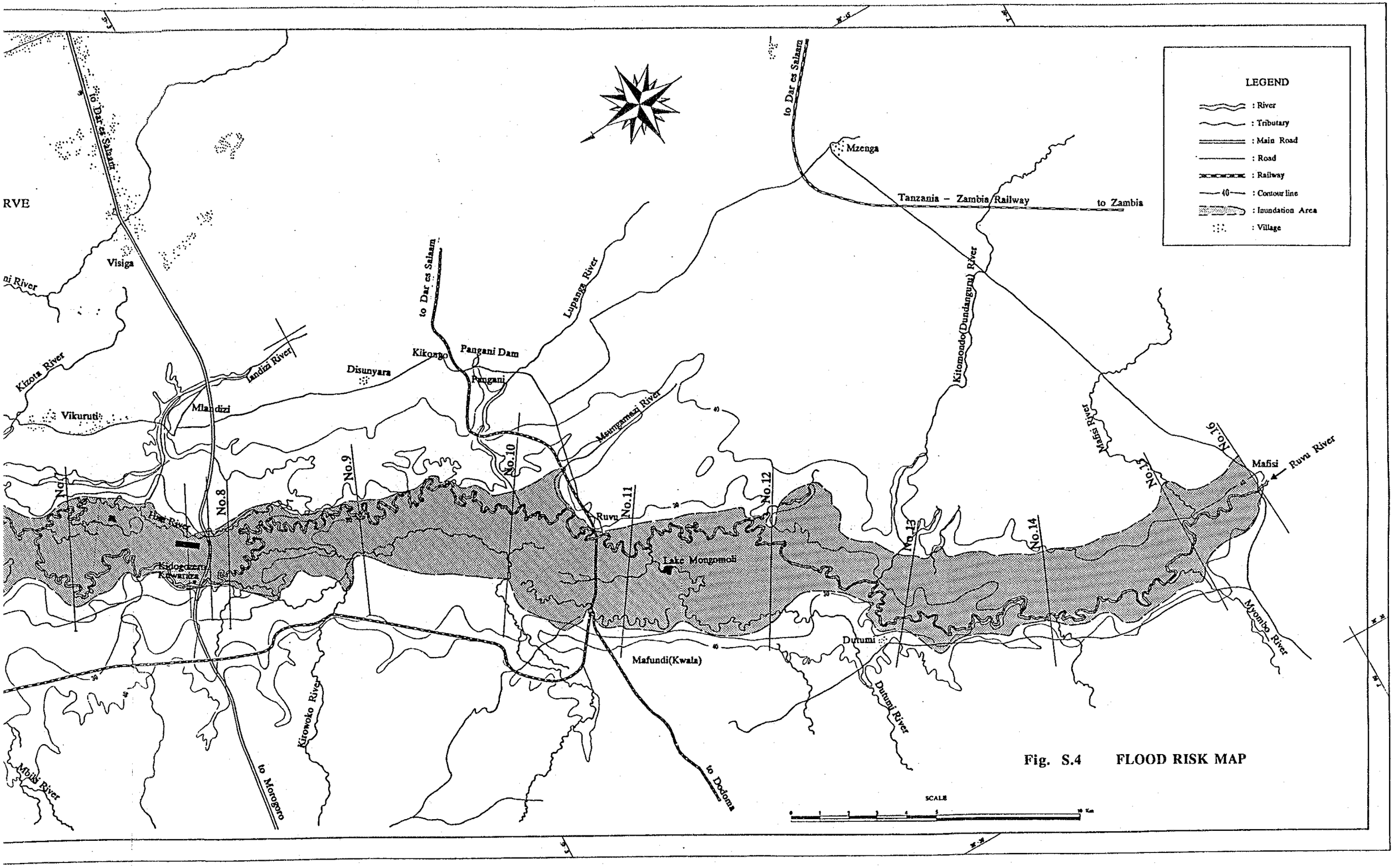

Fig. S.4 FLOOD RISK MAP

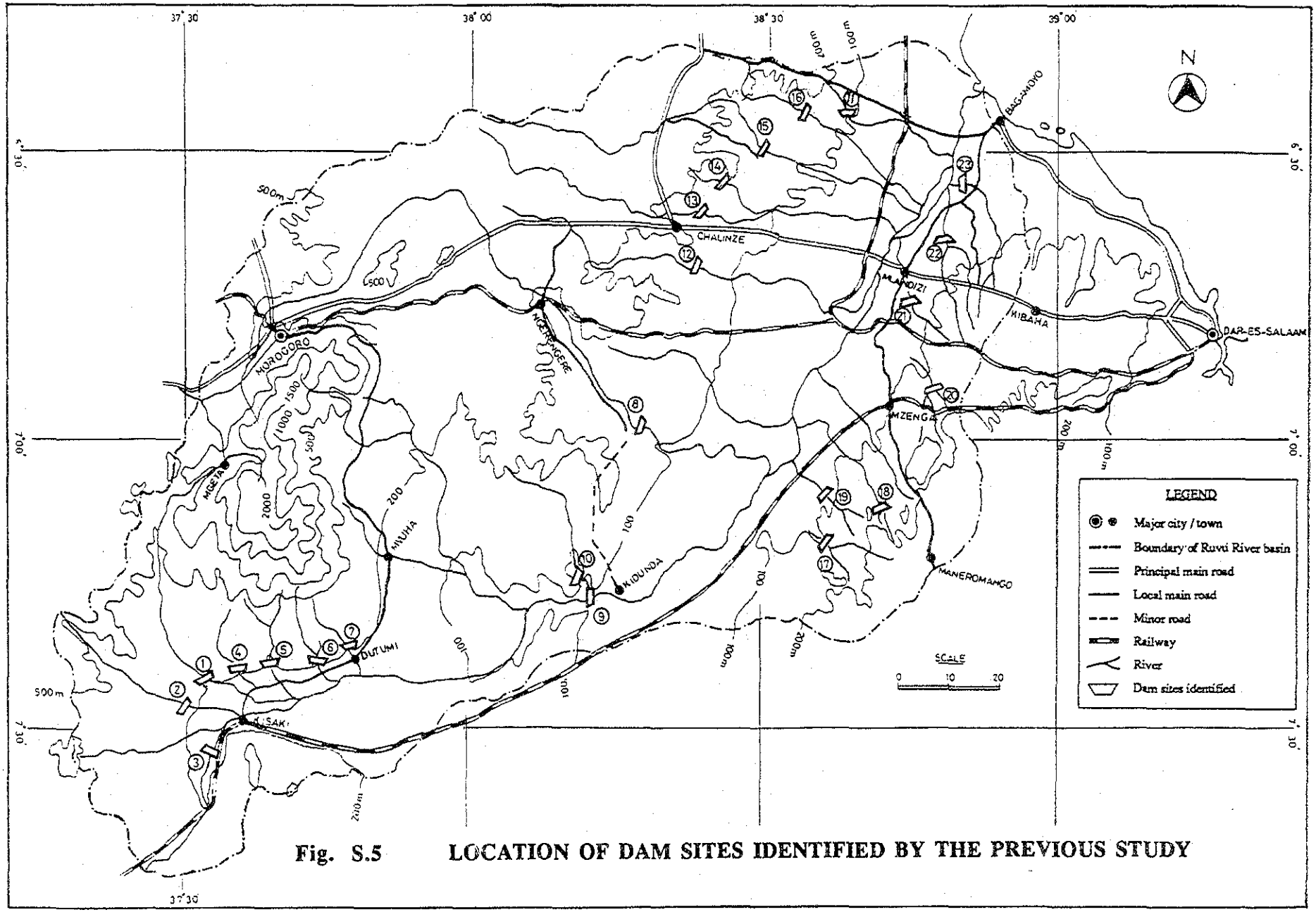

Fig. S.5 LOCATION OF DAM SITES IDENTIFIED BY THE PREVIOUS STUDY

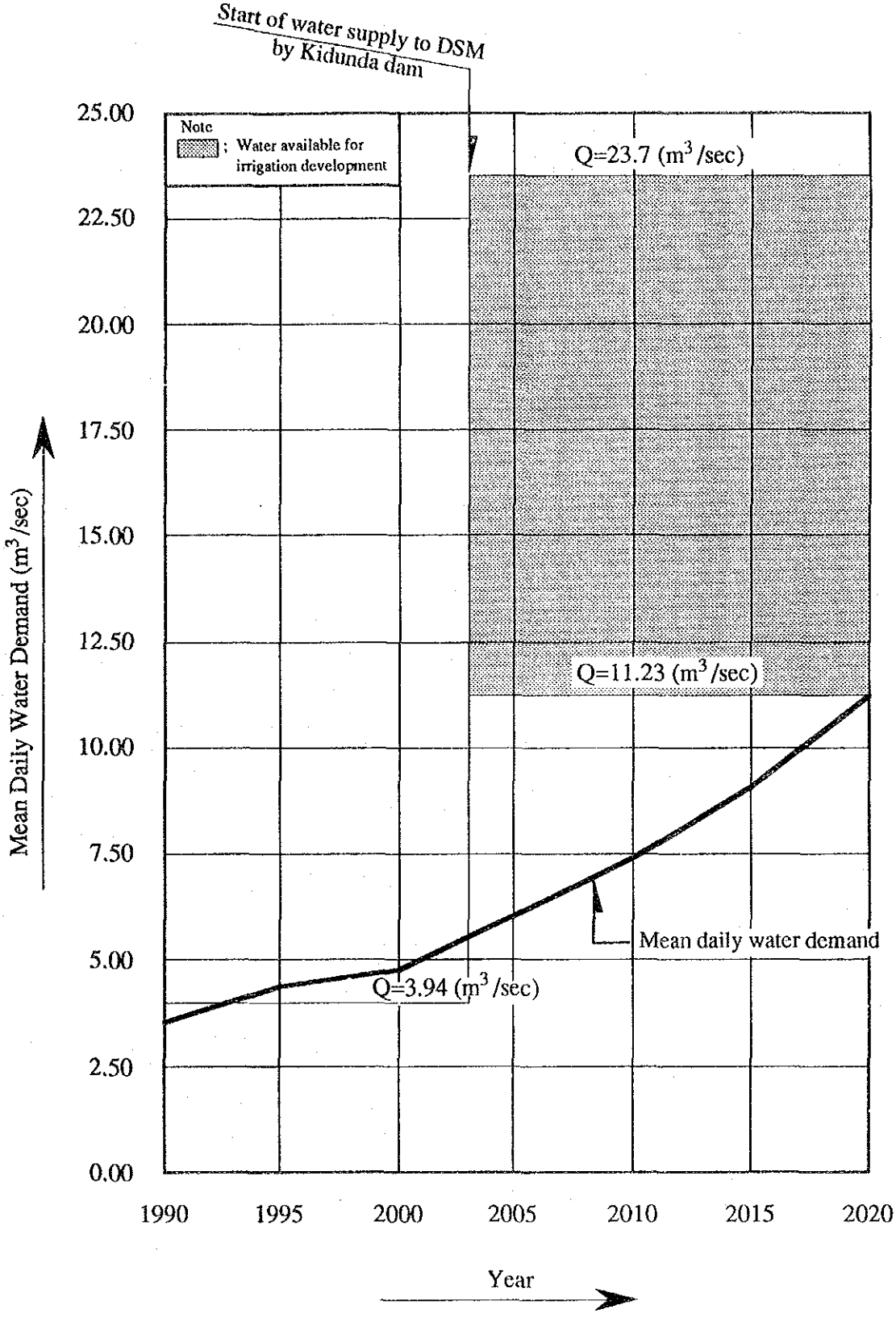

Fig. S.6 MUNICIPAL WATER DEMAND AND WATER SUPPLY FOR DAR ES SALAAM IN CASE OF DEVELOPMENT SCENARIO-1

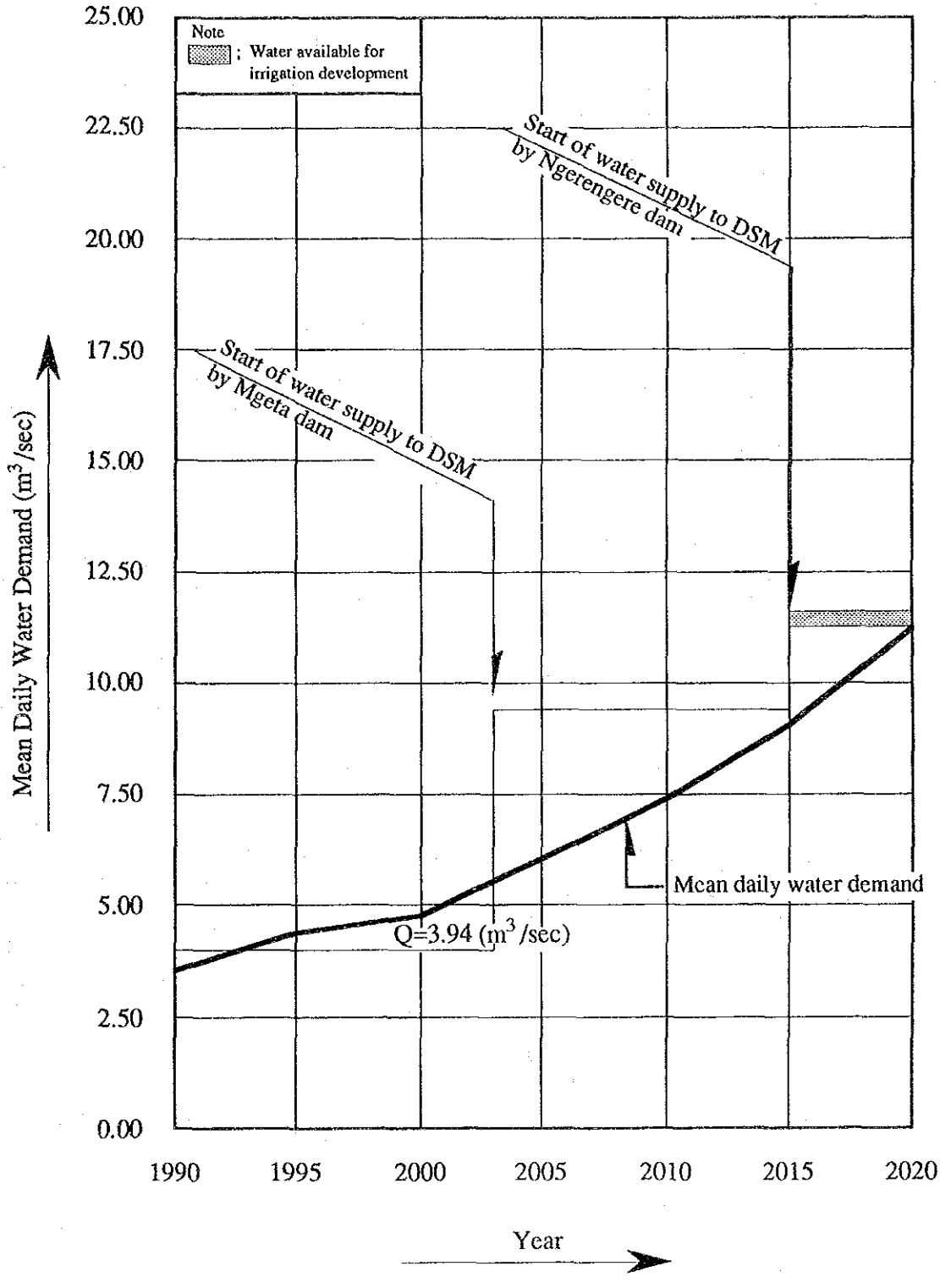

Fig. S.7 MUNICIPAL WATER DEMAND AND WATER SUPPLY FOR DAR ES SALAAM IN CASE OF DEVELOPMENT SCENARIO-2

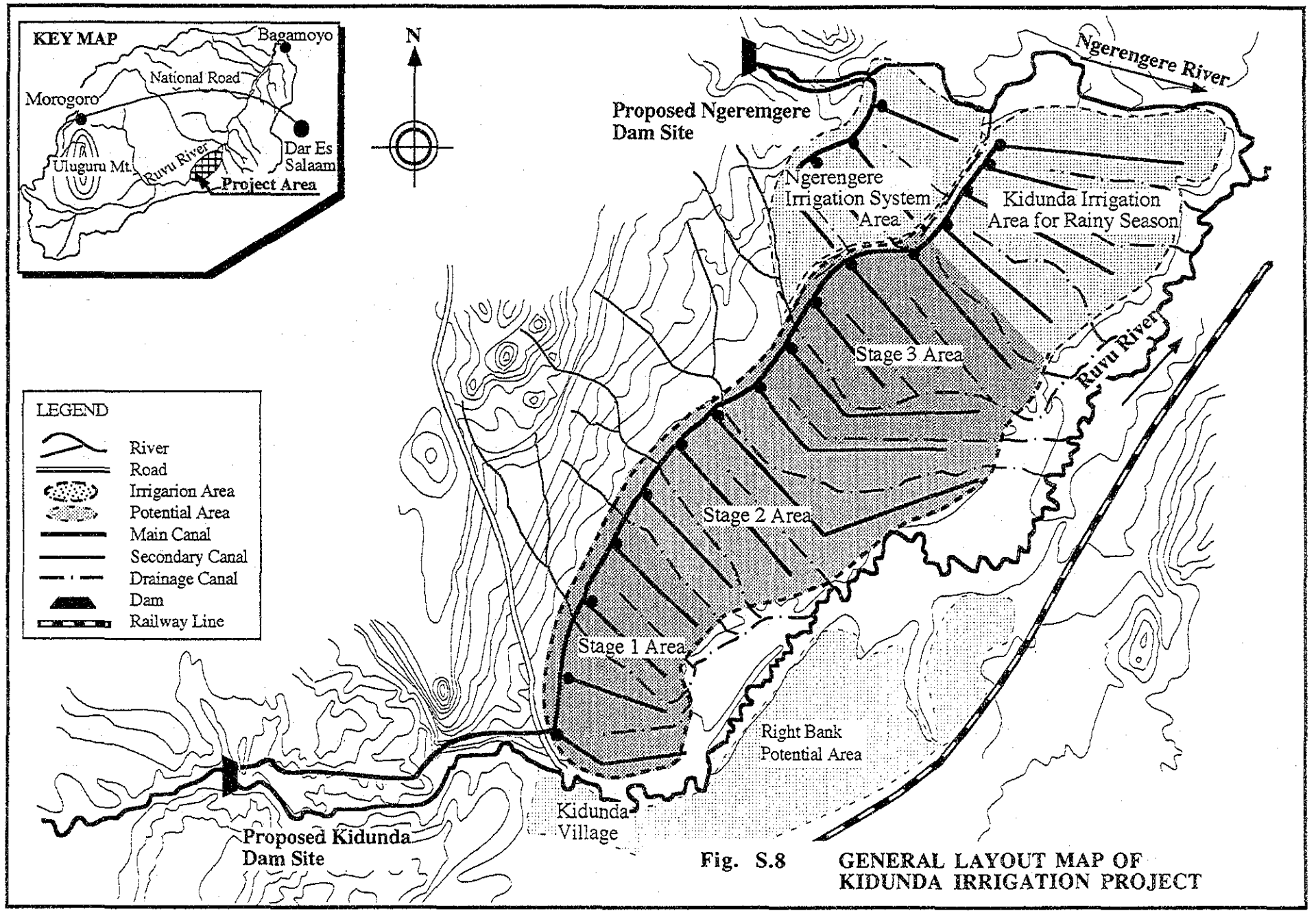

Fig. S.8 GENERAL LAYOUT MAP OF KIDUNDA IRRIGATION PROJECT

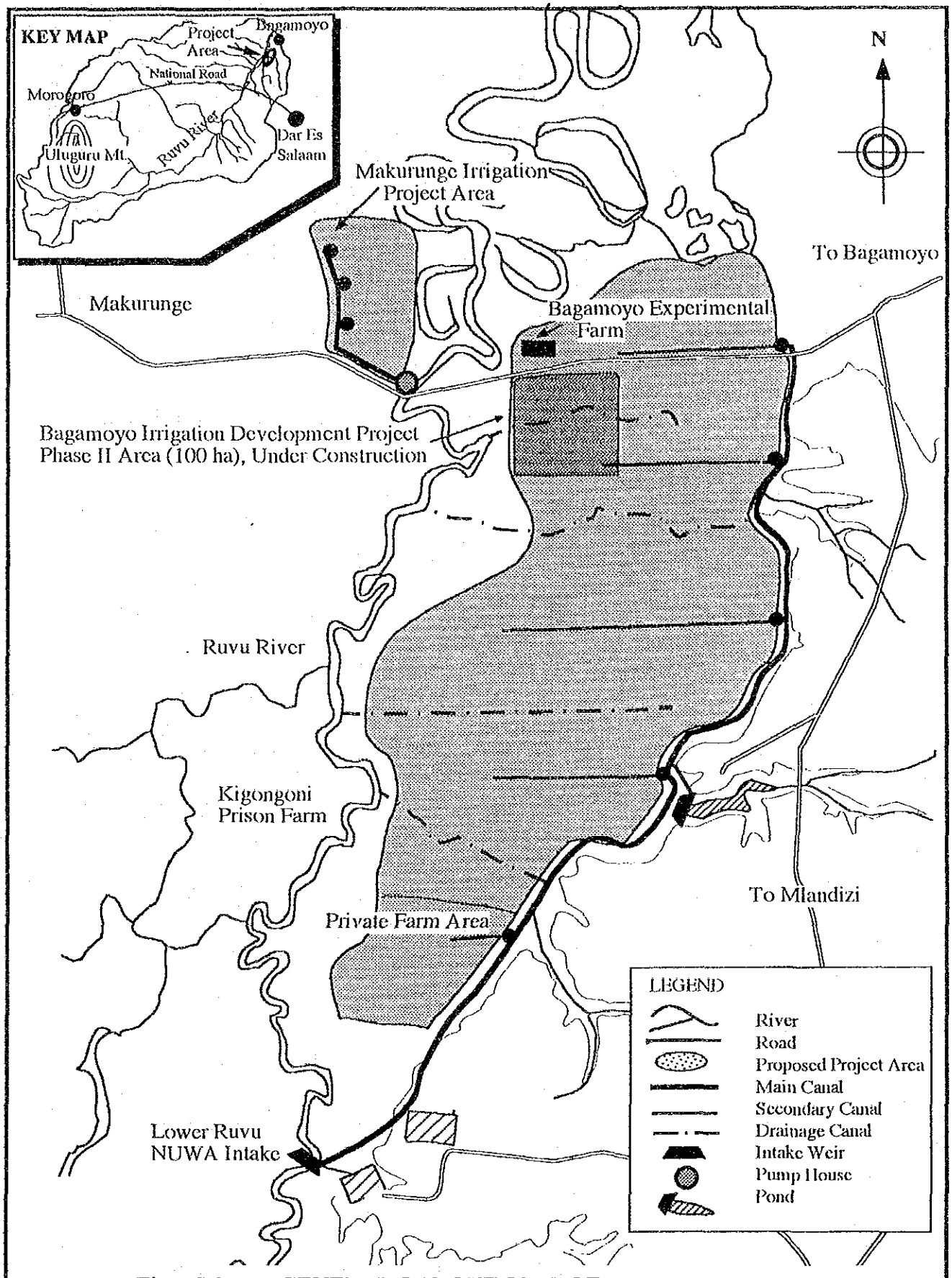

Fig. S.9 GENERAL LAYOUT MAP OF BAGAMOYO IRRIGATION DEVELOPMENT AND MAKURUNGE IRRIGATION PROJECTS