JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE MINISTRY OF WATER,
THE GOVERNMENT OF THE UNITED REPUBLIC OF TANZANIA

THE STUDY ON THE GROUNDWATER DEVELOPMENT FOR HANANG, SINGIDA RURAL, MANYONI AND IGUNGA DISTRICTS IN THE UNITED REPUBLIC OF TANZANIA

FINAL REPORT

VOLUME ONE : MAIN REPORT

AUGUST, 1998

SANYU CONSULTANTS INC. (JAPAN)
JAPAN ENGINEERING CONSULTANTS CO. LTD. (JAPAN)

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EXCHANGE RATE

(as of December 3, 1997)

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Notes:

Tsh : Tanzania Shillings,

US$: United States Dollar,

J¥ : Japanese Yen.

PREFACE

In response to the request from the Government of the United Republic of Tanzania, the Government of Japan decided to conduct the Study on the grandwater Development for Hanang, Singida Rural, Manyoni and Igunga Districts in the United Republic of Tanzania and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Tanzania a study team headed by Mr.Mitsuru YOSHIKAWA, SANYU CONSULTANTS INC., and composed of staff members of SANYU CONSULTANTS INC. and JAPAN ENGINEERING CONSULTANTS CO. LTD., two times between March 1997 and August 1998.

The team held discussions with the officials concerned of the Government 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 wish 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.

August, 1998

Kimio Fujita
President
Japan International Cooperation Agency

August, 1998

Mr. Kimio Fujita
President
Japan International Cooperation Agency (JICA)
Tokyo, Japan

Dear Sir,

Letter of Transmittal

We are pleased to submit to you the final report on the Study on the Groundwater Development for Hanang, Singida Rural, Manyoni and Igunga Districts in the United Republic of Tanzania. The report, during the course of the above-mentioned project formation, has been given due consideration to the advice and suggestions of the authorities concerned of the Government of Japan and your Agency, and to the comments made by the Ministry of Water of the Government of the United Republic of Tanzania during technical discussions on the draft final report which were held in Tanzania.

The existing water sources in the project area are heavily reliant on dug wells, water holes and other temporary water sources with contaminated water quality and seasonally fluctuating water quantity, thus causing poor health conditions for the villagers and heavy workload on women and children for water collection.

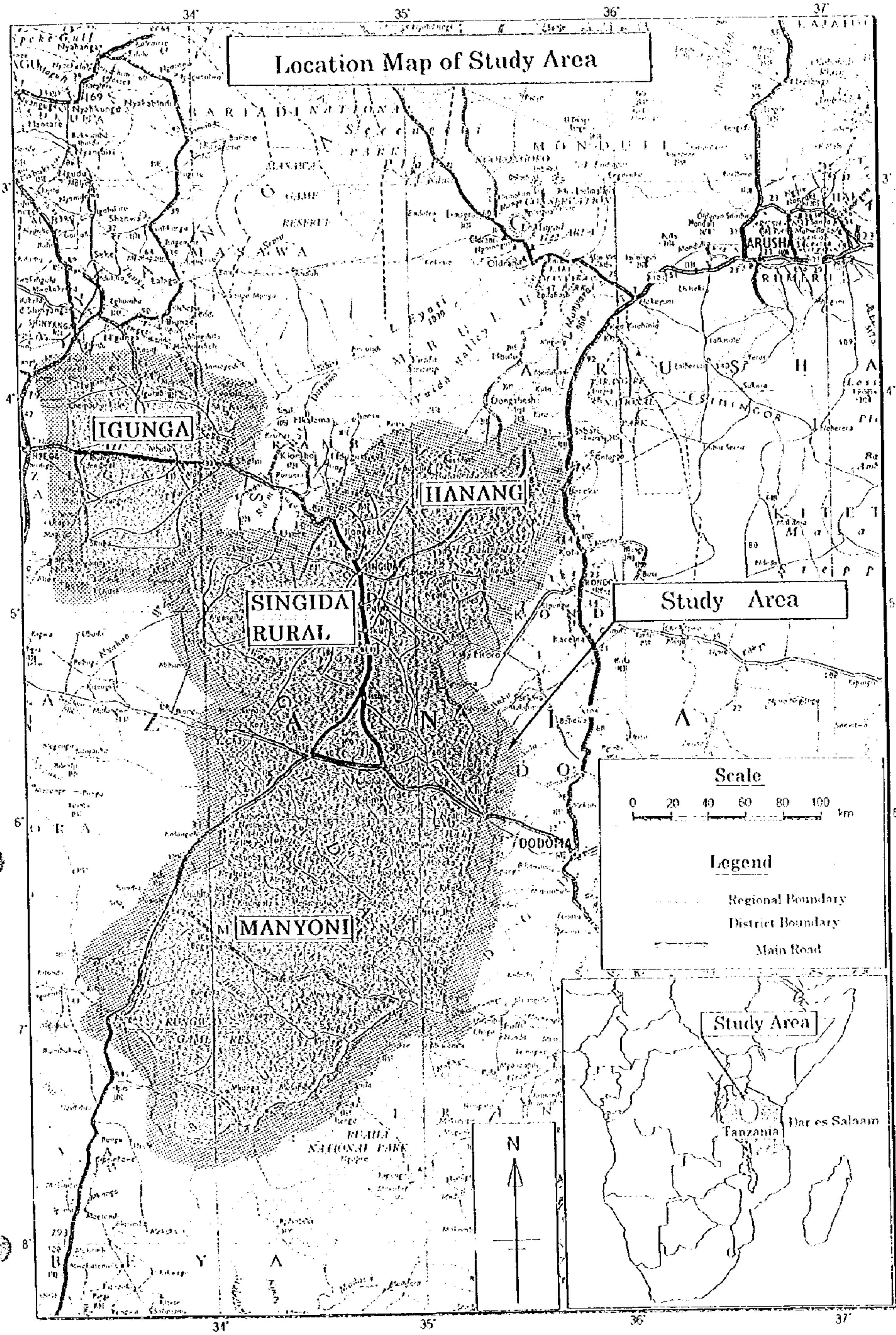
This project is designed to supply clean and safe water to the villagers residing in the 284 villages over the above four districts. One of the most important factors in the sustainable development of the project is positive villagers' participation in the project. The success of the project depends on the creation of a favourable attitude toward the project on the part of the users, the villagers themselves. Information and campaign programs on the project, together with specific commitments of government support, should be provided for the villagers in order to create a desire for the project prior to initiation of construction.

We wish to take this opportunity to express our sincere gratitude to your Agency and the Ministry of Foreign Affairs of the Government of Japan. We also wish to express our deep gratitude to the Ministry of Water of the Government of the United Republic of Tanzania for the close cooperation and assistance extended to us during our studies.

Very truly yours,

吉川 満

Mituru Yoshikawa
Leader of the Study Team


Location Map of Study Area
IGUNGA
HANANG
SINGIDA RURAL
MANYONI
Study Area
Scale
0 20 40 60 80 100 km
Legend
Regional Boundary
District Boundary
Main Road
ARUSHA
DODOMA
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Study Area
Tanzania
Dar es Salaam
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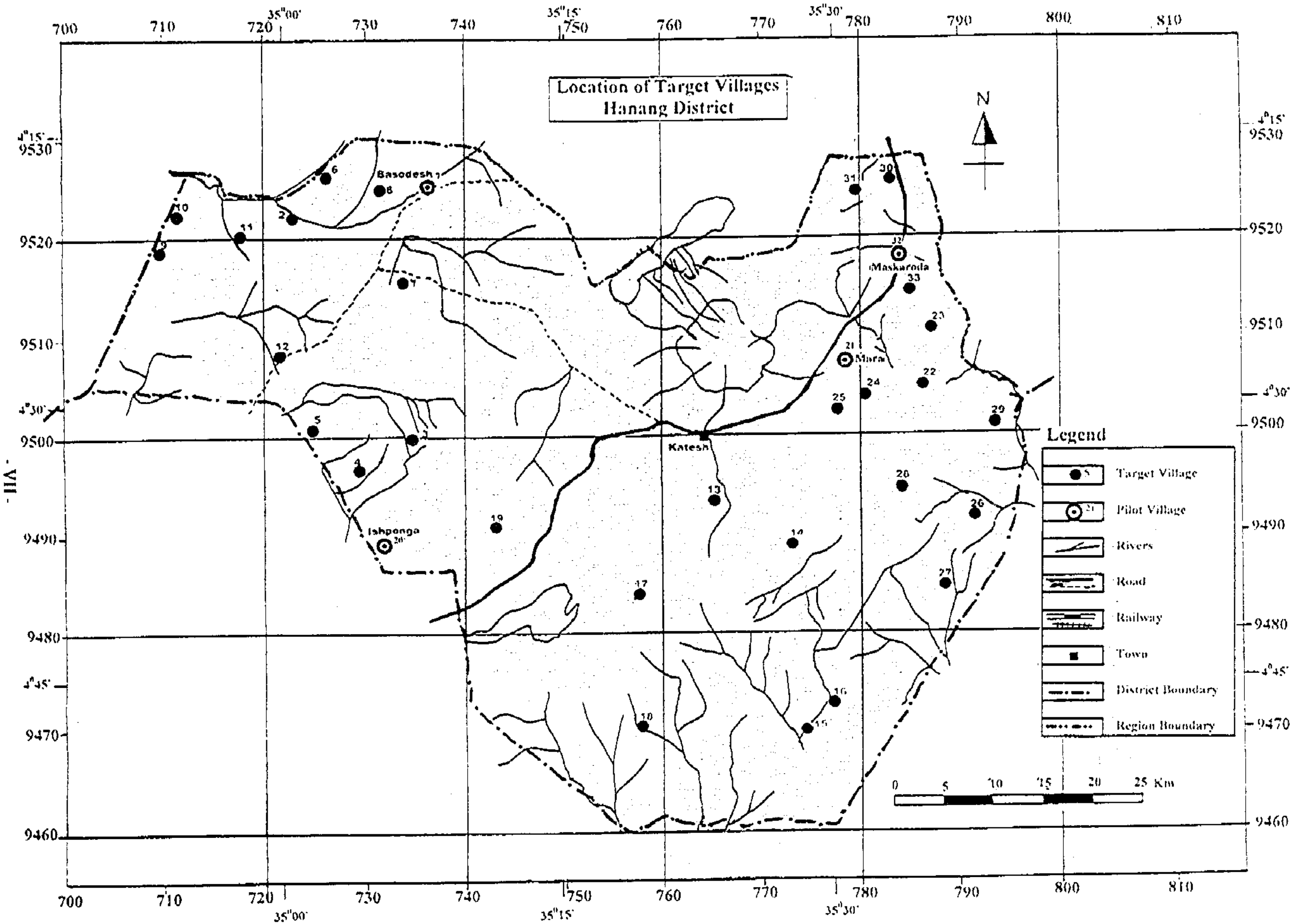
Location of Target Villages
Hanang District
N
Basodesh
Maskaroda
Mara
Katesh
Ishponga
Legend
Target Village
Pilot Village
Rivers
Road
Railway
Town
District Boundary
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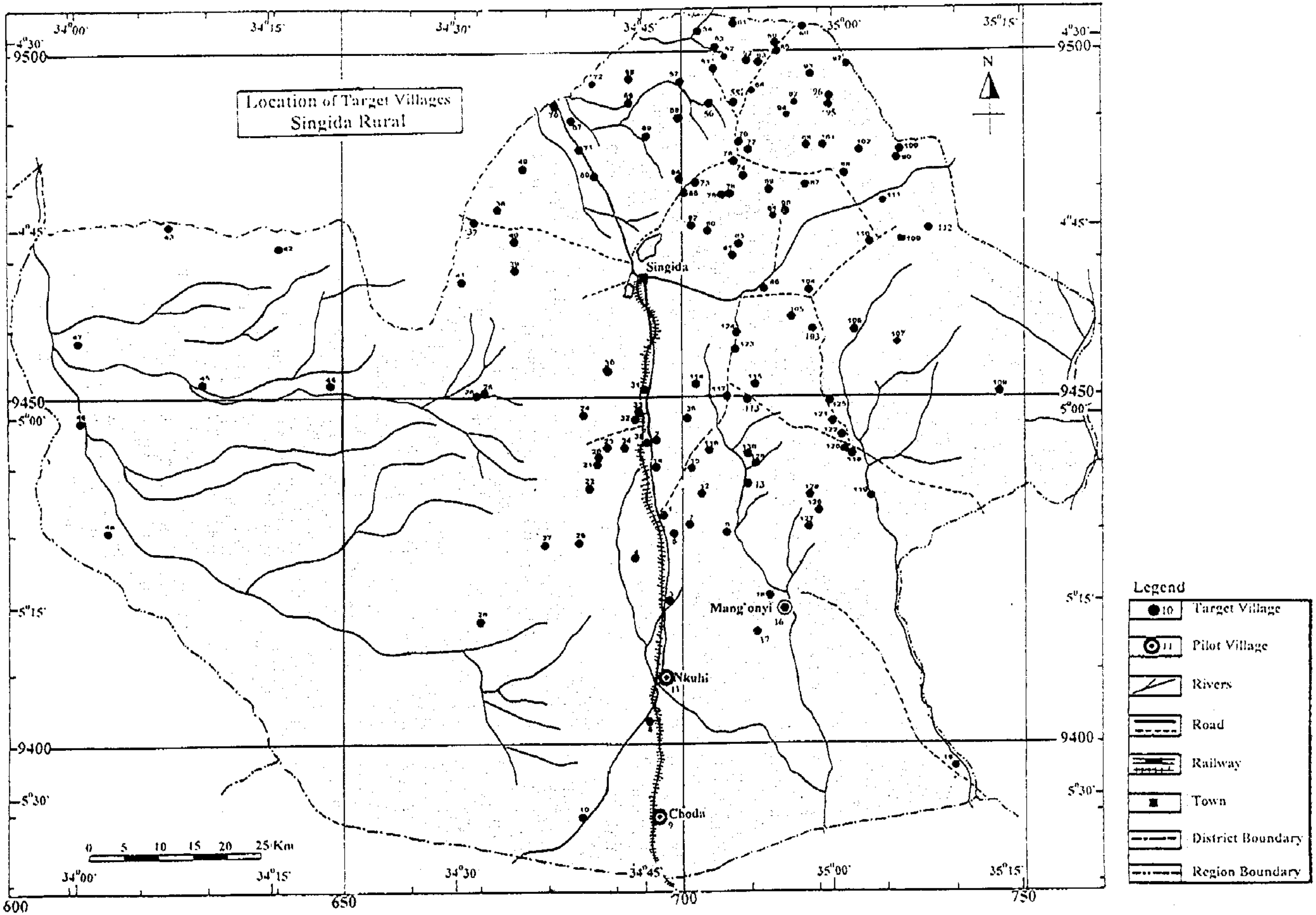
Location of Target Villages
Singida Rural
N
Singida
Mang'onyi
Nkuhi
Choda
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34°15'
34°30'
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35°00'
35°15'
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4°45'
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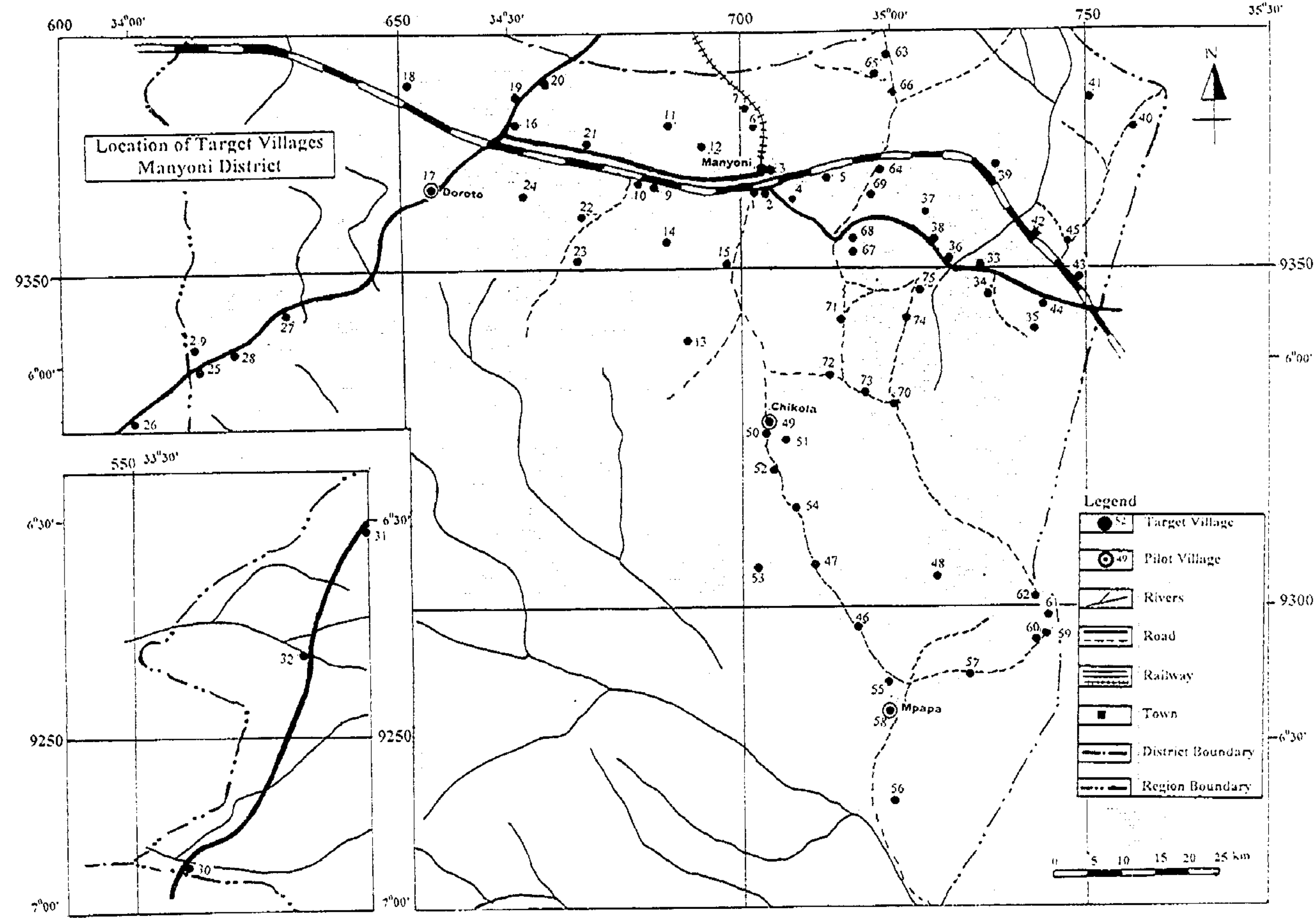
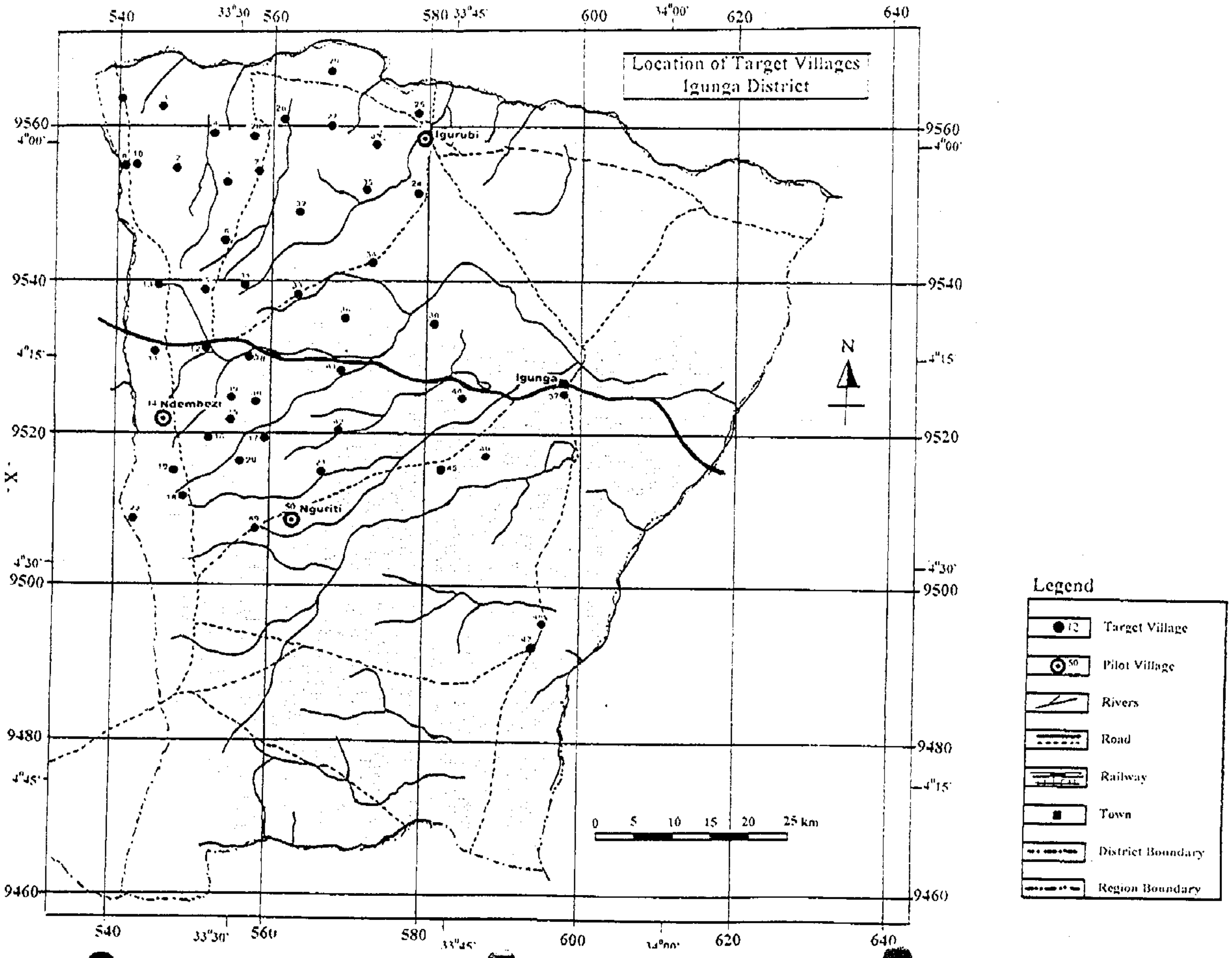
Target Village
Pilot Village
Rivers
Road
Railway
Town
District Boundary
Region Boundary


Location of Target Villages
Manyoni District
N
Manyoni
Doroto
Chikola
Mpapa
Legend
Target Village
Pilot Village
Rivers
Road
Railway
Town
District Boundary
Region Boundary
0 5 10 15 20 25 km


Location of Target Villages
Igunga District
Igurubi
Igunga
Ndembezi
Nguriti
N
0 5 10 15 20 25 km
Legend
Target Village
Pilot Village
Rivers
Road
Railway
Town
District Boundary
Region Boundary
540
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620
640
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9520
9500
9480
9460
33°30'
33°45'
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ABBREVIATIONS AND GLOSSARIES

ABBREVIATIONS:

BH	Borehole
CBMS	Community Based Management System
CMR	Child Mortality Rate
DWE	District Water Engineer
EC	Electric Conductivity of Water
EIRR	Economic Internal Rate of Return
FC	Foreign Currency
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
HH	Household
HP	Handpump
IMR	Infant Mortality Rate
JICA	Japan International Cooperation Agency
JY	Japanese Yen (JY 128.65/US$; JY 0.206/Tsh)
LC	Local Currency or Local Component
MCDWC	Ministry of Community Development, Women and Children
MCHC	Mother and Child Health Clinic
MOF	Ministry of Finance
MOH	Ministry of Health
MOW	Ministry of Water
NGO	Non-Governmental Organisation
NPV	Net Present Value
O&M	Operation and Maintenance
PRA	Participatory Rural Appraisal
RWE	Regional Water Engineer
SCF	Standard Conversion Factor
Tsh	Tanzanian Shilling (Tsh 624.94/US$; Tsh 4.86/JY)
UN	United Nations
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
US$	United States Dollar(s)
VHC	Village Health Committee
VWC	Village Water Committee
VWF	Village Water Fund
WES	Water and Environmental Sanitation
WID	Women in Development
WUG	Water User's Group

GLOSSARIES:

mm	: millimetre(s)
cm	: centimetre(s)
m	: metre(s)
km	: kilometre(s)
mm^2 or sq.mm	: square millimetre(s)
cm^2 or sq.cm	: square centimetre(s)
m^2 or sq.m	: square metre(s)
km^2 or sq.km	: square kilometre(s)
l or lit.	: litre(s)
lcd	: litre(s) per capita per day
mm^3 or cu.mm	: cubic millimetre(s)
cm^3 or cu.cm	: cubic centimetre(s)
m^3 or cu.m	: cubic metre(s)
km^3 or cu.km	: cubic kilometre(s)
MCM	: million cubic metre(s)
mg	: milligram(s)
g	: gram(s)
kg	: kilogram(s)
t or mt	: metric tonne(s)
sec or s	: second(s)
min	: minute(s)
hr	: hour(s)
day	: day(s)
a or yr	: annum or year(s)
mS/m	: milli-Siemens per metre; unit of EC
ohm	: unit of electric resistivity
%	: percent

SUMMARY AND RECOMMENDATION

1. Introduction

1.1 Background

In order to cover all the population by safe water supply, the Government of Tanzania launched in 1971 a 20-year water supply programme with the target year of 1990. The Government set forth a National Water Policy in 1991. The achievement of programme and policy has been left far behind the target, and the target year was extended to the year 2002. By 1993, only 67% of urban population and 46% of rural people were reported to be covered with water supply schemes. Being located in the central highland, four districts of Hanang, Singida Rural, Manyoni and Igunga have been suffered from water shortage for domestic and livestock uses. The water supply coverage of those districts ranges as low as 40%.

Under such circumstances, the Government of Tanzania made a request in September, 1996 to the Government of Japan to extend its technical cooperation programme for "the Study on Groundwater Development for Hanang, Singida Rural, Manyoni and Igunga Districts in the United Republic of Tanzania" (the Study).

In response to the request, the Government of Japan decided to conduct the Study, and dispatched a preparatory study team which was organised by Japan International Cooperation Agency (JICA) to Tanzania in November 1996. The Ministry of Water of the Government of Tanzania and the preparatory study team of JICA concluded the scope of work for the Study in November 1996.

In accordance with the scope of work concluded by the Ministry of Water and the preparatory team, JICA organised another study team to conduct the Study. The study team was sent to Tanzania to conduct field works in April 1997. Through the field works and succeeding planning works in Japan, the study team concluded the Study and prepared the present report.

1.2 Objectives of the Study

The objectives of the Study as stipulated in the Scope of Work are:

(i) to formulate groundwater development plans for rural water supplies including rehabilitation plan of the existing facilities, operation and maintenance plan, and sanitation improvement plan; and

(ii) to transfer technology on planning, operation and maintenance methods and skills to counterpart personnel in the course of the Study.

1.3 The Scope of the Study

The Study was implemented in three phases over two years from 1997 to 1998 as given below:

Phase 1 Study: Preliminary analysis and field survey in Tanzania;

Phase 2 Study: Pilot study in Tanzania;

Phase 3 Study: Planning and evaluation of proposed projects in Japan.

1.4 The Study Area and Target Villages

The Study area is administratively composed of four districts extending over three regions: Hanang district in Arusha region; Singida Rural and Manyoni districts in Singida region and Igunga district in Tabora region. The number of target villages is 284 as shown below:

Target Villages

Region	*District*	*No. of Target Villages*	*Land Area (sq.km)*
Arusha	*Hanang*	*33*	*4,436*
Singida	*Singida Rural*	*129*	*12,164*
	Manyoni	*72*	*28,620*
Tabora	*Igunga*	*50*	*6,788*
Total		*284*	*52,008*

2. Tanzania in Overview

2.1 The Nation

(Political and Administrative Setups)

The executive of the United Republic consists of the president elected by universal suffrage assisted by a vice president, a Prime Minister and a cabinet of ministers. The cabinet of minister is composed of four ministers of state and 19 ministers who are responsible for the ministries. Tanzania mainland is divided into 20 regions and 87 districts. The district is further divided into several divisions, wards and villages.

The Ministry of Water (MOW), which is the counterpart agency of the present Study, is responsible for ensuring proper and efficient development of water resources for enhanced socio-economic development through provision of clean, safe and adequate water and wastewater disposal. The MOW operates through two service divisions and three operational divisions. Three sections were transformed to semi-autonomous agencies. The MOW consists of some 590 staff and 1,280 employees. The expenditure budget of MOW for 1997/98 was Tsh 10,000 million or US$ 15.8 million.

(Population)

According to the latest census in 1988, the total population of Tanzania was 23.1 millions showing annual growth rate of 3.0 % during the current decade. Other demographic indicators in 1985 are as follows:

- *Population under 15 years (%) : 46*
- *Infant mortality rate per 1000 live birth : 115*
- *Under five's mortality rate per 1000 live birth : 191*
- *Crude death rate per 1000 population : 15*

- *Life expectancy at birth (total)* : 50
- *Crude birth rate per 1000 population* : 46

2.2 National Economy

(Gross Domestic Product)

The GDP at factor cost as of 1994 was estimated at Tsh 1,660 billions.

(Agriculture)

The agriculture is the main stay of Tanzania's economy. It employs some 80% of labour population and accounts over 50% of GDP at factor cost and 75% of foreign exchange earnings. Livestock plays also an important role in the rural economy of Tanzania and is increasing importance in the commercial sector. The livestock sector accounts 25% of agricultural GDP.

(Trade)

The trade sector contributes directly to the national economy accounting for some 15% of total GDP and employing over 25% of the active labour force. The value of exports has over US$ 435 millions per annum during 1991/92 to 1993/94 period. While, imports averaged around US$ 1,500 millions during the same period.

2.3 Land and Climate

(Land)

Tanzania occupies a land area of some 945,000 sq.km inclusive of some 60,000 sq.km of inland water area. Mt. Kilimanjaro, which is the highest peak of Africa, rises to the elevation of 5,895 m. Most of its land lies higher than the elevation of 1,000 m except the coastal belt and Tanganyika basin. A distinct feature of Tanzania is the rift valleys in many places.

(Climate)

The major climatic feature of Tanzania is the long dry spell from May to October followed by a period of low rainfall. The normal annual rainfalls in Dar es Salaam, Dodoma, Tabora and Mwanza are 1,124 mm, 567 mm, 961 mm and 1,077 mm respectively. The maximum monthly mean temperatures in Dar es Salaam, Dodoma and Tabora are 32.1℃, 26.5℃ and 32.3℃ respectively. The minimum monthly mean temperatures in the same places above are 18.1℃, 15.4℃ and 13.6 ℃ respectively.

2.4 Geology

The oldest rocks in the Tanzanian territory are those belonging to Dodoman System which occupies the west-central region. In the north-west the volcanics and quartzite of Nyanzian System are supposed to be deposited upon Dodoman rocks. In the east are rocks of the Usagaran System. On the west is a complementary belt consisting of rocks of the Ubendian System. The rocks of these tree systems belong to

Archaean group. The Karagwe-Ankolean System in the late Precambrian to Palaeozoic ages is located along western border of the territory. The Bukoban System in the same age extends in a belt from Uganda border to Lake Tanganyika.

Following the close of the Bukoban times, there was a long interval before the deposition of the rocks of Kaloo age. Marine rocks from Jurassic to Quaternary ages occupy a belt of limited width adjacent to the present coast-line. Contemporaneous with marine sediment in the east, there was accumulation of inland terrestrial deposit of various kinds. During the late Cenozoic, in the more stable areas of the centre and north, beds of limestone, silt and terrestrial sediments were accompanied rift-faulting movement.

Commencing probably in late Cretaceous age, there was volcanic activity, associated apparently with rift-faulting movements. In the north it extended from Mts. Hanang to Kilimanjaro and northward into Kenya.

2.5 National Plans

(Rolling Plan and Forward Budget)

The Government replaced the former system of a five-year plan and annual plans by the Rolling Plan and Forward Budget (RPFB). The RPFB aims at economic reform. The year 1993/94 was the eight year since the initiation of policy, and institutional reforms aimed at revitalising the national economy. As the result of those reforms, the economy has emerged from the stagnation of the early 1980s. However, the state of economy remains far from satisfactory.

(Rural Water Supply Programme and National Water Policy)

The Government declared in 1970 a 20-year rural water supply programme (1971-1990). The programme aimed at achieving 100% coverage within 400 m of each household. The programme attracted a number of external support agencies and started with the preparation of regional water master plans. By the year 1982, a total of 16 regions were covered by its own water master plan.

By reviewing the programme in 1986, however, it became evident that only 42% of the rural population and 65% of urban population had access to safe and potable water supply; and the targets set for 1991 could not be met. In consideration of the achievement of rural water supply programme, the Government launched the National Water Policy in 1991.

2.6 Current Situation of Water Sector

Since the commencement of 20-year rural water supply programme in 1971 the government implemented a number of rural water schemes under the cooperation of donor organisations and NGOs. In the rural water supply sub-sector, it was estimated in 1993 that some 9.7 million or 46% people out of the total rural population of some 21.1 million were being served with clean water. In the urban water supply sub-sector, it was estimated in 1993 that some 3.3 million or 67% population out of a total 4.9 million people in urban areas received clean water.

3. Hydrogeology and Groundwater

3.1 Geography and Geomorphology

The Study area lies on the Central Plateau of the country between the latitude 4°05' and 7°50' south and between longitude 33°20' and 35°40' east. The study area occupies an area of some 52,000 sq. km.

The Study area consists mainly of vast undulating peneplain made during mid-Tertiary called "African Surface", and which makes up the greater part of Central Plateau extending from Lake Victoria to Mbeya Rang. Another distinct topographic feature is some ranges of rift valleys formed by faulting during the Neogene deforming this peneplain surface.

3.2 Soils, Vegetation and Land-use

The soils in the Study area can be divided broadly into four groups; plateau soil, red earth, non-lateritised red earth and plains soils. Larger tracts of the area are virtually open plain or grasslands. Low land such as Wembere and Bahi depressions is characterised either by open grassland or semi-open acasia-baobab bush. Large tracts of land are cultivated and are planted mainly maize. Grazing of cattle, sheep and goats are common through the study area.

3.3 Meteorology and Hydrology

The meteorological stations in the Study area are at Singida Airport and Manyoni in Singida region; and Sekenke in Igunga district. The daily records on rainfall, air temperature, relative humidity, pan evaporation, sunshine hour and wind-run are available from the stations covering period since 1970 to date.

The rain falls concentrate in the six month period from November to April. The averaged annual rainfall is in between 612 mm and 876 mm. The annual mean temperature in the area is 22.9℃. The annual mean relative humidity in the area is 77.4%. The averaged annual pan evaporation is 2,344 mm over the area. The averaged annual sunshine hours are some 7.7 hr/day. The wind-run records in an annual averaged daily mean show some 220 km/day (2.5 m/sec).

The drainage system of the Study area is characterised by the Wembere-Manonga system, the Mponde-Bubu and the Ruaha systems. The annual average runoff depths observed at three gauging stations are 230 mm, 8 mm and 14 mm. The runoff coefficients range from 0.26 to 0.01.

3.4 Geology

Granitic rocks of Archean Group underlie the majority of the Study area. The rest part of the area is underlain by metamorphosed sedimentary rocks of Archean Group such as Nyansian System in the northern Igunga district and the northern Singida Rural district and Dodoman System in the southern Manyoni district. Lower plains located on Wembere and Bahi basins and others extending to another rift valleys and Kilimatinde surface are underlain by younger sediments in Pleistocene-Holocene age.

3.5 Hydrogeology and Groundwater

(Existing Borehole Record)

Some 287 borehole records related to the target villages are available from Regional Water Engineer's Offices. Out of them, the locations and current situations of 137 boreholes were confirmed by the Study Team through the inventory survey on the existing water supply facilities. Only 46 boreholes are still working. The averaged dimensions of recorded boreholes are 93 m in depth, 20.8 m in static water level and 6.6 m^3/hr in yield.

(Geophysical Soundings)

The geophysical soundings were conducted by the Study Team adopting the electro-magnetic (EM) and resistivity methods. Total number of observatory points were 12,190 for EM and 718 for respectively. The apparent resistivity of layers are, in general, very low ranging from several to several hundreds ohm-m reflecting a low resistivity in the superficial saline condition over the area. The EM sounding was effective to detect a low resistivity fracture zone where is covered by thin superficial sediments. It is not so effective in an area where covered by thick superficial.

(Test Drilling)

The test drilling of boreholes was conducted in the Study by a local drilling contractor for purposes of confirming the groundwater potential under the framework of the pilot study. Borehole sites were selected in 10 pilot villages within four districts. Out of 10 boreholes drilled, two holes were dry and one was called off due to heavy collapsing of hole wall. The yields of seven boreholes completed show 6.2 m^3/hr on an average.

(Hydrogeological Map)

Hydrogeological maps were prepared covering the target village. The maps were compiled basing on the existing geological maps and the result of interpretation of satellite imageries and aerial photographs. They give geological data and information inclusive of the hydrogeological units, geological structures such as faults and rift valleys, the location of existing and test boreholes, statistic level and quality of groundwater and others related to the hydrogeology of the Study area.

(Productive Aquifers)

The major hydrological units and productive aquifer systems in the Study area are shown on hydrogeological maps with summary of groundwater potential. The major productive aquifers which yield several m^3/hr or more of water in appropriate quality are identified in the fractured and weathered granite formations at around 100-m depth. The borehole successful rates by hydrogeological unit range from 70 to 85 %, with the average of 80 %.

(Groundwater)

According to the borehole records, the static water level in the Study area are, in general, 12 m to 24 m below the ground. In some villages nearby fault escarpments in Hanang, Singida Rural and Manyioni districts, the static water level in borehole is supposed to be 40 m or more which is deeper than the limit of application of handpump.

The water quality survey was carried out for 734 water samples collected from different water sources in 284 target villages. In situ and laboratory analysis were conducted to cover 12 items inclusive of EC, pH and colon bacillus.

67% of borehole water have EC value of 100 mS/m or more, whereas 25 % of water samples from dug-well, water-hole, charco dam and household container shown EC value of over 100 mS/m.

Colon bacillus was undoubtedly observed over some 50% of water-holes and charco dams, 33% of dug-wells and 15% of boreholes. Water collected from 453 household containers were identified that the contamination by colon bacillus takes place in the water sources as well as during the collection and stock processes.

(Groundwater Resource)

The water balance analysis was examined to grasp the development potentiality of groundwater. The rate of annual groundwater recharge of the Study area (52,000 km^2) is estimated as the minimum extent at one % of the annual rainfall (say 600 mm/a). The groundwater is rechargeable to some 312 MCM/a, whereas the water demand of the area in the year of 2016 is estimated at the maximum extent at 57 MCM/a, 18% of above annual groundwater recharge. Thus, the groundwater resource of the are seems to be good enough to meet the demand for the socio-economic use in foreseeable future.

4. Target Villages

4.1 Administrative Setup

The Study area covers four districts of Hanang, Singida Rural, Manyoni and Igunga. The districts are administratively divided into divisions, wards and villages. The Study area comprises of 19 divisions, 82 wards and 284 villages.

4.2 Existing Water Supply Projects

(Water Master Plan of Arusha Region)

The interim water master plan of Arusha region was formulated in 1993. The plan aimed to provide by the year 2012, water schemes to cover about 76% of total population in Hanang district.

(Water Master Plan of Tabora Region)

The water master plan of Tabora region was made in 1979. The master plan contents the evaluation of water resources and water demand; the analyses on hydrology and water quality; survey on the existing water schemes and *sources; and preparation of engineering recommendations for construction of rural water supplies. Out of 23 priority villages recommended, four villages are overlapped with the target villages of the present Study.*

(Activities of NGOs)

The NGOs such as TCRS, CPPS, CARITAS, CBCH, CDTF and ADRA engage in rural development activities inclusive of water supply schemes. TCRS and CPPS and Caritus provided already some 730 water schemes. The above NGOs plan to conduct their further activities.

4.3 Inventory of Target Villages

(Methodology)

The inventory survey covered all the 284 target villages and 4,489 sample households within the target villages. The village survey included general profiles of villages, administrative setup, economic activities, gender division of labour, current water supplies, public health and health education and others. And the sample household survey covered household information, current water supply, water required, health and sanitation, gender issues and willingness to pay for water.

(Village Inventory)

The total population of the 284 target villages was 692,538 as of 1996. The village population ranges from 410 at Kitanula village, Manyoni district to 8,258 at Itigi village, Manyoni district; 2,439 per village on an average.

Out of 284 target villages 278 villages have organised a Village Water Committee (VWC) and similarly 241 villages have established a Village Water Fund (VWF). The total numbers of VWC's member are 1,834 persons with an average of 6.6 persons per VWC. The seats of women members are less than half of the VWC members in 102 villages. The total VWF's amount to Tsh 132,000 per VWF.

There are 191 of health facilities including hospitals, health centres, mother and child health clinics and dispensaries. 283 villages have organised a Village Health Committee. There are 257 primary schools with a total enrolment of about 103,000 pupils. The elements of hygiene education are taught under the health subject and domestic science and science (nutrition) subject in most of the primary schools.

(Sample Household Survey)

A total of 4,489 respondents were interviewed using questionnaires. The situation of current water supplies in the Study area is given as the weighted average of the four districts as follows:

- Distance to water sources	:	*3.1 km*
- Time for water collection	:	*1.8 hours*
- Number of persons for water collection	:	*2.4 persons*
- Daily frequency	:	*2.4 times*
- Total time spent for water collection	:	*10.4 hours/day/household*
- Volume of water collected per day	:	*4.1 bucketful*
- Water consumption rate	:	*12.0 lcd*

The interviewees have responded to the question "How much will you pay for water if water for domestic use with good quality is provided throughout the year?". The weighted average is Tsh 81.5/bucketful (Tsh 4.1/lit) for the whole Study area.

The incidences of top five diseases in the Study area are 81% for malaria, 56% for diarrhoea, 45% for typhoid, 31% for skin diseases and 30% for worms infestation. An annual medical expenditure per household is Tsh 23,000 or US$ 37 on an average.

(Household Economy)

In the Study area, households usually engage in two or more kinds of economic activities. The percentage of households by their economic activities are 100% of growing crops, 78% of livestock raising, 33% of commerce and 11% of others. The average annual household income worked out to Tsh 410,276 or US$ 449. The median of the household income is Tsh 245,000 or US$ 392.

(Gender Issues and WID)

In the Study area, women have to take responsibilities for most of work in agriculture and for all household activities. Being mostly farmers, the division of labour between men and women is quite unequal. Overall picture connotes the facts that women in most of the villages have been deprived of their basic human rights. The majority of women are poor, who are being exploited as agricultural producers involved in food and cash crop production. Women do all household activities, and they do not have any access and control over resources. They are not even involved fully in decision making structures at different levels of the society.

In the Study area, a very small portion (10 to 26%) of women are members of women groups. The sample household survey showed that most (66% or more) of women interviewed are not aware of any training programmes to be provided to women groups on how to run income generating activities. Women in all villages do not have access and control over available resources. As a result, women can not carry out production activities effectively. The basic fact is that when farm products are sold, it is men who have control over cash money obtained.

Although the Government has issued various policy directives to ensure increased participation of women in decision making, women in the Study area are not equally represented like men in the decision making structures at different levels. The sample household survey revealed that very few (some 30%) women have ever participated in village meetings.

(Village Type)

Four parameters were selected in order to provide the representative indices of the characteristics of individual target village. They include: village population, average annual household income, number of livestock and current water service coverage.

• Village Population

The village population of 284 target villages was classified into four equal number of village groups (71 each), namely A (3,000 population and over), B (2,200 to 2,999 population), C (1,600 to 2,199 population) and D (410 to 1,599 population). Majority (some 60%) of villages in Singida Rural and Igunga districts is in A and B categories. While, the majority (60 to 70%) of villages in Hanang and Manyoni districts is in C and D categories.

• Annual Household Income

The annual household income groups are classified into four equal number of village groups (71 each), namely A (Tsh 410,000 and over), B (Tsh 308,000 to 409,000), C (Tsh 205,000 to 307,000) and D (less than Tsh 205,000. The majority of villages in Singida Rural district is in A and B categories. The majority in Igunga district is in B and C categories. While, the majority of villages in Hanang and Manyoni is in C and D categories.

• Livestock

The livestock unit per capita are classified into four equal number of village groups, namely A (1.36 unit and over), B (0.80 to 1.35 unit), C (0.55 to 0.79 unit) and D (less than 0.54 unit). The majority of villages in Hanang, Manyoni and Igunga districts is in A and B categories. The majority in Singida Rural district is in C and D categories.

• Current Water Supply

The service coverage groups are classified into four village groups, namely A (100% coverage), B (50% to 99% coverage), C (10% to 49% coverage) and D (0% coverage). It is clear that service coverage of 54 villages is 100% and that of 94 villages is 0%. Villages of 27% in Singida Rural, 19% in Manyoni and 10% in Igunga are 100% coverage. While, villages of 88% in Hanang district, 29% in Singida and 37% in Manyoni are 0% coverage.

4.4 Inventory of Existing Water Supply Facilities

The inventory survey on the existing water facilities over 284 target villages was conducted by the Study Team. The rural population in the target villages depend upon some 1,400 water sources, of which 107 or 8% sources are out of operation. The existing water sources include water-holes (627 or 45%), dug-wells (506 or 36%), boreholes (170 or 12%), charcos (67 or 5%) and others such as springs and other sources (130 or 2%). The water supply coverage by borehole and dug-well systems as of 1997 was estimated at 40% over the Study area.

4.5 Pilot Study

(Objectives of the Pilot Study)

The pilot study was conducted in order to identify an actual situation of the user's participation in the water scheme. The pilot project was composed of the new construction and rehabilitation of water facilities at two service levels, L-1 and L-2; the mobilisation, education and training of users; and the monitoring of the pilot project after completion of the construction work.

(Pilot Project)

29 candidate villages were selected in consideration of geographical distribution, types of existing water facilities and levels of current water services. Finally, 13 villages were warranted for the implementation of the pilot study.

Test drilling was conducted at 10 pilot villages. Two test boreholes at Ishponga and Nguriti villages were dry. The test borehole drilled at Igurubi village was encountered with collapse of borehole walls and the completion of hole was finally called off. The rehabilitation works of the existing facilities at Mang'onyi village was to replace the engine with new one. After several days since the pump was operated, the pump-shaft was broken down; and the pilot project was suspended. Finally, the pilot study at nine villages has been implemented.

Pilot Villages and Construction Works

District	*Village*	*Types of Works and Service Level*	
Hanang	*Bassodesh*	*New construction*	*: BH, L-1*
	Ishponga	*New construction*	*: BH, L-1*
	Mara	*New construction*	*: BH, L-1*
	Maskaroda	*New construction*	*: BH, L-1*
Singida	*Choda*	*New construction*	*: BH, L-1*
Rural	*Nkuhi*	*New construction*	*: BH, L-2*
	Mang'onyi	*Rehabilitation*	*: BH, L-2*
Manyoni	*Doroto*	*Rehabilitation*	*: BH, L-2*
	Chikola	*New construction*	*: BH, L-2*
	Mpapa	*New construction*	*: BH, L-1*
Igunga	*Ndembezi*	*Rehabilitation*	*: DW, L-1*
	Igurubi	*New construction*	*: BH, L-2*
	Nguriti	*New construction*	*: BH, L-1*

Notes: BH; Borehole, DW; Dug-well

(Participatory Rural Appraisal)

The participatory rural appraisal (PRA) was carried out at the 13 pilot villages in order to inform the villagers of the proposed pilot study and implementation procedures of the study, as well as to elaborate on their responsibilities as regards the pilot study and hence get feedback on their preparedness and willingness actively to participate in the study.

PRA has revealed the fact that in all the 13 pilot villages, water is a major problem and it affects the overall socio-economic development of the villagers. Women are the most affected group as far as water problems are concerned as they have overall responsibilities of providing water for domestic use at their houses. Although the villagers are eager to develop their village water schemes, very few are aware of their responsibilities as regards planning, implementation and management of their own village water projects.

Most of villagers keep livestock. Almost 90% of the villagers were very much concerned about water for their livestock. Gender awareness in all the pilot villages needs to be promoted as it appeared to be lagging behind.

(Training and Sensitisation of Villagers)

Draft training materials were prepared for use at the pilot villages. The materials were revised for use at the target villages after consideration of the results of the trials. The training materials contain three major subjects related to rural water supplies: health and environmental sanitation; management of the rural water supply projects; and gender awareness.

Two teams of task forces were organised. Each team consisted of three facilitators qualified in the field of health and environmental sanitation; management of the rural water supply projects; and gender issues. District officers concerned were invited to join in the programme. Participatory methodologies were used in conducting the training programme with a view of enabling the participants to apply their own experiences and knowledge in discussing different subjects presented. Methodologies used included role plays, story-telling, group work and plenary discussions. Application of these participatory training methods proved to be efficient as it creates quick and better understanding of subjects discussed by the participants.

Lessons learnt from the implementation of the programme are; (i) the importance of being self reliant; (ii) cooperation between different actors; (iii) factors affecting effective community participation; (iv) village water fund; (v) water fees and (vi) gender division of labour.

(Monitoring)

The monitoring and evaluation of the pilot project management was conducted by the monitoring teams in February and May/June in 1998. The outcomes of the monitoring are as follows:

- *All villages expressed their satisfactory in the quality of water.*
- *Of newly constructed seven boreholes, four boreholes were handed over to villages with the water right; other three boreholes are scheduled to be transferred to villages on completion of repair works.*
- *Women share more than half of the seats in the village water committees in four villages.*
- *Six villages organised the water users' groups on the basis of sub-village as proposed in the Study.*
- *Five villages fixed their water-fees, of which three villages have reasonable rates to meet O&M requirement.*
- *Water leakage in two villages was solved in August 1998 by providing engineering services by the district water engineer's office.*

5. Project Plan

5.1 Basic Strategy and Criteria

(Basic Strategy)

The major objective of the project is set forth to provide safe and stable water, easily accessible, in quantities adequate for domestic use of the rural population in the Study area. In consideration of the huge *size of service population in the project and possible extent of available resource, the "some for all" principle is proposed to be taken into the basic strategy for the project formulation.*

(Planning and Design Criteria)

- ***Target Year***

The Study has applied a 20 year design period with the short-term target year in 2001, mid-term target year in 2006 and long-term target year in 2016..

- ***Water Consumption Rate***

The Study proposes the following design domestic water consumption rates of 20 lcd for the short- and mid-term target and 30 lcd for the long-term target. The water consumption of livestock is 25 litter per livestock unit per day as designed by the Ministry of Water.

- ***Water Source***

The water source facilities to extract groundwater are boreholes and dug-wells for the domestic use. The Study proposes to provide small dams (charcos) as the water source facilities for livestock use.

- ***Level of Service***

Two service levels will be provided in the proposed projects: service level-1(L-1) and service level-2(L-2). The service level-1 provides a water point (point source) such as a dug-well protected by lining with a pump or a borehole with a pump, but no water distribution system. The service level-2 provides a water source of borehole fitted with an engine-driven pump and a simple distribution system with a few public taps.

- ***Design Coverage by Target Year***

The design water supply coverage over the Study area will be 60 % in the year 2001, 80 % in the year 2006 and 100 % in the year 2016.

- ***O&M Plan and User's Participation***

The O&M plan in the project will be formulated in consideration of: (i) involvement of communities; (ii) governmental intervention; (iii) establishment of water user's group under the village water committee; and (iv) an appropriate water fees affordable to users.

- ***Design of Pumps***

The water facilities are to be designed as simple, trouble-free operation, and be capable to be operated and maintained by village technicians. The parts required for the repairing and replacement of equipment are to be readily available from the nearest market. The pumps required for the project are selected among handpump, engine-driven pump, wind- or solar-pump appropriate to the facility type.

5.2 Water Source Development Plan

(Population Growth Rate and Projection of Service Population)

- ***Population Growth Rate***

The following annual population growth rates are proposed to estimate the future population in the Study Area:

Annual Population Growth Rate (%)

District	1997 - 2001	2002 - 2006	2007 - 2016
Hanang	3.36	3.32	3.24
Singida Rural	2.97	2.93	2.85
Manyoni	2.85	2.81	2.73
Igunga	0.71	0.71	0.71

- ***Projection of Service Population***

The total population in the Study Area is projected to increase from 696,311 in 1997 to 1,148,000 in 2016, being about 1.6 times of the current population.

(Allocation of Facilities)

The project will provide 3,515 of new water source facilities: 280 facilities for the short-term target (2001), 704 facilities for the mid-term target (2006) and 2,531 facilities for the long-term target (2016) as given in the following table 1.

Table 1 Summary of Facilities Allocation (New Construction)

Facilities	Target Year	District				Total
		Hanang	Singida Rural	Manyoni	Igunga	
Borehole with handpump (L-1-1)	2001	45	106	59	54	264
	2006	100	317	147	127	691
	2016	339	1,240	555	372	2,506
	Sub-total	484	1,663	761	553	3,461
Borehole with Engine-pump (L-2)	2001	1	4	2	2	9
	2006	-	2	-	-	2
	2016	1	-	-	-	1
	Sub-total	2	6	2	2	12
Borehole with Solar System (L-1-1-4)	2001	-	4	3	-	7
	2006	-	7	4	-	11
	2016	-	17	7	-	24
	Sub-total	-	28	14	-	42
Total	2001	46	114	64	56	280
	2006	100	326	151	127	704
	2016	340	1,257	562	372	2,531
Grand-total		486	1,697	777	555	3,515

5.3 *Facility Plan*

(Design of Borehole)

- ***Design of Borehole***

The average depth of project boreholes is designed to be 100 m; 40 m of soft formation and 60 m of bed-rock formation. The size of permanent casing and screen pipes is 100 mm (4 inches) for a handpump borehole and 150 mm (6 inches) for an engine-pump and solar-pump borehole.

(Pumping Facilities)

- ***Handpump***

The specifications and application of handpump for deep well are as follows:

- Actual pumping volume	*: 720 litre/hr (at 30m deep of water level)*
- Limit of pumping depth	*: 40m*
- Operation hour	*: 12 hr/day*
- Pumping water per day	*: 8,640 litre/day*
- Service population	*: 430 (at 20 litre/capita/day)*
	: 290 (at 30 litre/capita/day)

- ***Engine-pump and Wind-pump***

Borehole pumps of a vertical turbine type and a diesel engine as the prime mover of pumps are recommendable for the project because most of the existing water facilities in and around the Study area are of these types.

Preliminary study made by the Study team revealed that the wind-pumps are not recommended due to wind conditions prevailing in the Study area.

- ***Solar-pump System***

In view of the sunshine condition of the Study area and performance (service population: 900), the solar-pump is recommendable to those villages where any handpump is not applicable due to deep groundwater level and its population size is smaller than the affordability of L-2 system (service population: 4,500).

(Design of L-2 System)

L-2 system is proposed for the villages which meet the conditions that (i) the service population to be covered by a new facility is more than around 4,500; and (ii) possible yield of borehole meet the water requirement. In consideration of the service population and possible borehole yield, the L-2 system will be adopted to 12 villages: 2 in Hanang district, 6 in Singida Rural district, 2 in Manyoni district and 2 in Igunga district.

(Design of Charco Dam)

The topography of the Study area is characterised by open, rolling, or flatfish plains where well defined streams and valleys are scarce. Given the rainfall conditions prevailing in the area, it is estimated that 1,000 livestock units could be raised with one standard charco dam with a storage capacity of 6,800 m^3. 463 charco dams in total over the Study area will be constructed: 64 dams by 2001, 127 dams by 2006 and 272 dams by 2016.

(Facility Rehabilitation Plan)

The rehabilitation plan includes replacement of the equipment for the facilities which are out of use due to mechanical reason, replacement of the equipment for the facilities which are in use but are aged, and reconstruction of dug-wells.

253 water facilities will be rehabilitated by the year 2001: 238 L-1 facilities and 15 L-2 facilities.

5.4 Equipment Procurement Plan

In order to enhance the activities of the district water engineer's offices, the procurement of equipment for use of operation and maintenance of the rural water facilities is proposed as shown bellow:

Equipment	*Quantity*	*Remarks*
Pickup trucks	*7*	*4WD*
Workshop equipment	*5*	
Water quality kits	*5*	
Office equipment	*4*	
Tools	*10*	*for local mechanic*

5.5 Sanitary Improvement Plan

(Introduction)

The proposals for Health Sector Reform stipulate that although the policy formation and provision of specific health sector guidelines will continue to be vested in the Ministry of Health, greater emphasis should now be moved towards the district level, and eventually it should go down to the level of the village where health activities need to be boosted.

One way to help the villagers to have full say as regards their health and environmental sanitation is to prepare educational materials for villagers and for use in primary schools by teachers and pupils.

(Water and Environmental Sanitation)

The development efforts in providing safe and clean water have been given strong emphasis. However, past experiences have shown that provision of safe and clean water alone was not sufficient to assist in an improvement of environmental sanitation of household as well as community. Therefore, integration of *sanitation and water is a positive approach to effective utilisation of water resources for improved quality of life.*

(Water, Environmental Sanitation and Health)

It is imperative to address the relationship between water, environmental sanitation and health. This can be done in the following manner; to inform individuals, households and the community as a whole on how to enjoy better health through proper water use and environmental sanitation; and to assist individuals, households and the community as a whole to adopt the concept.

(Prevention of Water Related Diseases)

Prevention of water related diseases is based on proper human waste disposal; water collection and transportation; water storage; and proper hygiene habit of individuals, households and community.

(Sanitation)

Several diseases can be prevented by hygienic habits such as washing hands with soap and water after contact with faeces and before handling food. Children often put their hands into their mouths. Therefore, it is important to wash a child's hands, especially before giving food. People can get sick from eating dirty food. They can protect themselves from diseases by taking measures. Utensils should be washed with clean water; be dried with clean cloth or be put on a dish rack to dry in the sun or wind so as to prevent flies from landing on them.

From the findings regarding sanitary conditions in the Study area, there is a need to do an effort to improve the environmental sanitation to improve the health conditions of the members of the community.

(Hygiene Education)

To stimulate attention and comprehension about sanitary education, education programmes should be prepared through pre-testing, two-way communication, and the social network approach.

The environment of the school is important for the health of the school children. If schools do not have good provision for sanitation, clean water and facilities for hygienic preparation of food children can not be expected to take seriously the hygiene education they receive in the classroom.

The most important task in developing a curriculum is to plan the content to match the level and age of the child as he/she progresses through the school. This involves taking into account the various stages of development. The primary school is a good place for laying the foundations of health that can be built upon in later schooling.

6. Operation and Maintenance Plan

6.1 Introduction

There are 170 water supply systems with boreholes; however, 68 systems are out of operation due to breakdown of engines and pumps. The major reason of malfunctioning of the completed projects is lack of *periodical and preventive maintenance, particularly as the project begin to age. The proposed O&M system after the project implementation is summarised as shown in Table1. The major roles and responsibilities of each levels are as stated in the following sections.*

6.2 Community Involvement

(Village Water Committee)

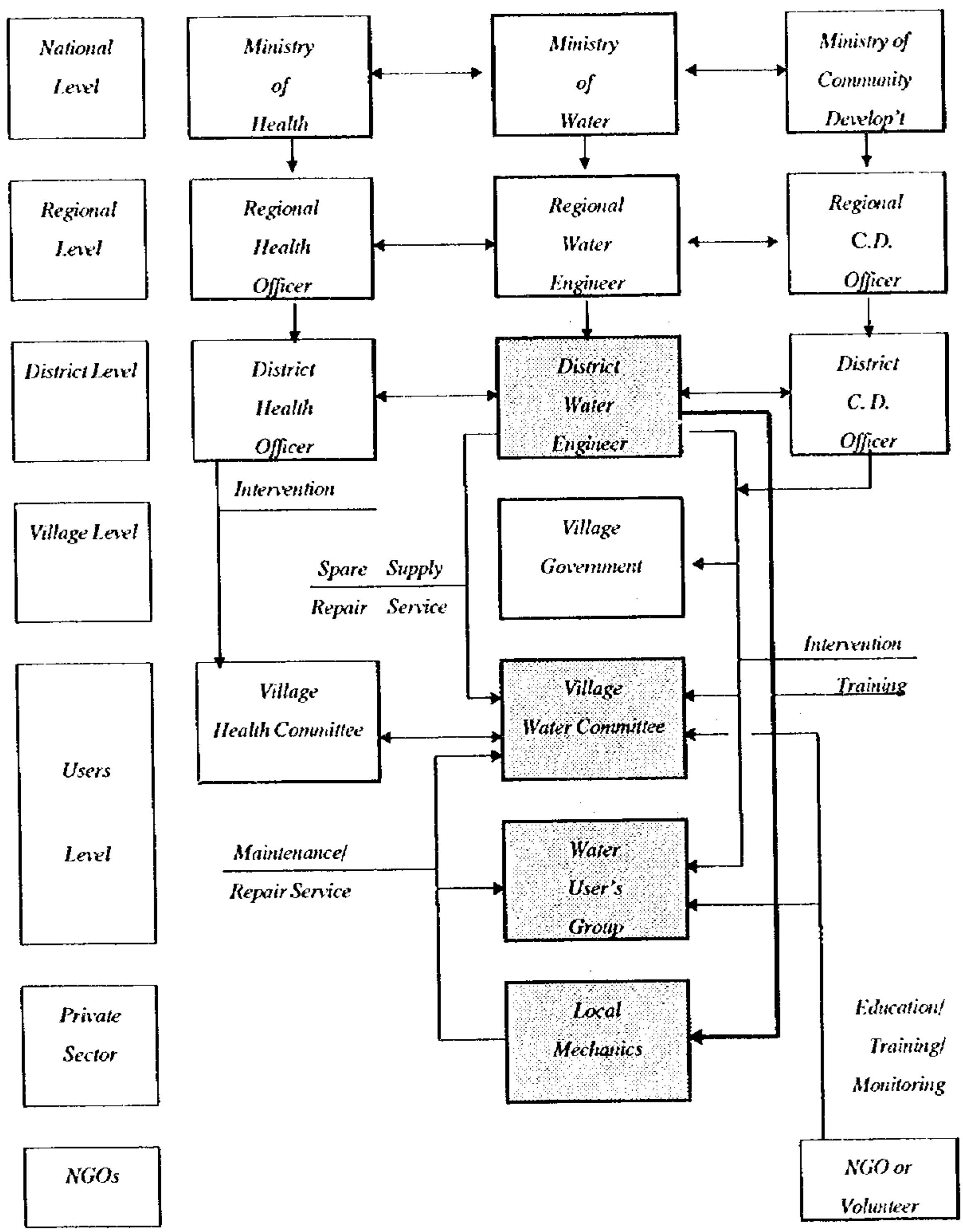
The village water committee (VWC) is the administrative machinery responsible for O&M of the water supply facilities and management of the rural water supply projects. To this end, the village water committee is to provide the villagers with full responsibilities of supervising their water supply facilities and other related services.

(Village Water Fund)

All villages with water scheme shall establish a village water fund (VWF) which shall be kept in special and separate bank account. Intended benefit of such a fund are;

- *to create an understanding of users that the water supply is not a free service;*
- *to enable the users to adequately materials, cash in kind in national building activities towards construction, operation and maintenance of their water schemes; and*
- *to enable the users to own, operate and maintain the water schemes in their respective villages.*

Table 2 Flow of Propose O&M System (After Project Implementation)



(Water Users Group)

For sustainable management of rural water schemes, it is proposed to establish water users groups for their own water supply scheme in order to be closer to the water facilities and also able to mount maximum security. Nevertheless these WUG will be directly accountable to the VWC which in turn will operate as an umbrella organisation.

(Local Mechanic Service)

No systematic services for repairing of water pumps and provision of spare-parts exists in the Study area. The district water engineer's offices are responsible for such services in order to maintain the rural water supply schemes; however, their services are not active at present due to lack of outfits as well as financial constraints.

With the implementation of this proposed project in the Study area, more than three thousand of boreholes with handpumps are scheduled to be constructed. Under the such environment, it is proposed to implement a local mechanic services programme under the control of the district water engineers. The purpose of the local technical services programme is to provide the periodical preventative maintenance of handpumps and to repair handpumps, when necessity arise, on a commercial basis by local handpump mechanics to be qualified by the district water engineers and be appointed by the village water committees.

6.3 *Governmental Intervention*

(National and Regional Governments)

In order to enhance a sustainable O&M of the completed rural water projects, the intervention of governments in all levels is indispensable. The ministries in the national government related to the WES sector and the related officers in the regional governments shall play the role to secure the qualified officers and the recurrent budget enough for daily activities of them to guide and support the district governments.

(District Government)

The officers in charge of water, health, community development and others in the district government play a leading role in the sustainable O&M of rural water scheme. The district water engineer (DWE) is responsible for extension of support services to villages including establishment and management of VWC, supply of spare-parts, repairing services to sophisticated equipment and so forth. The principal services to be provided by the DWE include training programmes for village pump attendants, caretakers and local mechanics, and implementation of community health and education programmes in conjunction with the other authorities involved.

6.4 Donor, NGO and Others

In case that the project is implemented under the fund provided by a donor, the fund may cover not only facility construction but also the related activities in the O&M such as the provision of O&M equipment, the training of local mechanics, the education and training of users, the monitoring and evaluation of the project and so forth. After the project implementation, the said O&M related activities may be conducted under the cooperation of NGO or volunteers.

In the project implementation under the external fund, the MOW is to employ a consultant and a construction contractor. The MOW may render a part of the said O&M related activities to the consultant and contractor.

6.5 Education and Training

(Introduction)

In order to effectively and efficiently manage the village water schemes, the villagers must be equipped with the necessary skills and knowledge. All training activities will focus on the empowerment of the individuals users, especially women, in the community.

(Basic Principles)

Most of activities to be done should strongly be guided by the principles of community participation and bottom up planning and decision making process. There is a need to actively promote the participation of both women, youth men in all activities in order to succeed in mobilising all available human resources for development activities. Most health activities should be targeted towards women.

The issues of ownership should be explained, discussed, understood and agreed upon by the community. The financial management issues must be cleared and agreed upon within the group.

(Implementation Programme)

During the design period of the proposed project, the district water engineer's offices will conduct the participatory rural appraisal (PRA) at all villages covered by the proposed programme. The principal objectives of PRA are to inform the villagers of the proposed water supply scheme and implementation procedures of the project, as well as to elaborate on their responsibilities as regards the water scheme.

Just after the completion of the construction works, the training and education of villagers will be conducted by a group of facilitators under the supervision of the district water engineer's office in cooperation with other related district offices.

6.6 Project Monitoring Plan

The project monitoring seeks to ensure that inputs, plans, budget, targets and other necessary actions are proceeding according to expectation. The monitoring exercise consists of (i) physical and financial monitoring, (ii) process monitoring, (iii) effect monitoring and (iv) follow-up monitoring.

All development management is concerned with four other critical issues. They are (i) efficiency of the project, (ii) effectiveness of project activities, (iii) impact of the project and (iv) sustainability of the project. The main purpose of evaluation is to provide a basis for any or all of above information.

6.7 Users' Affordability to Water Fees

(O&M Costs)

The annual O&M costs of three types of water supply facilities are estimated at Tsh 732,000 or US$ 1,171 for L-1-1 system (handpump borehole; service population of 430), Tsh 1,758,000 or US$ 2,812 for L-1-4 system (solar-pump borehole; service population of 900) and Tsh 9,788,000 or US$ 15,661 for L-2 system (engine-pump borehole; service population of 4,500).

(Estimated Water Fees)

Standard water fees were estimated by facility at Tsh 0.26/lit or Tsh 5.2/bucket for L-1-1 system; Tsh 0.30/lit or Tsh 6.0/bucket for L-1-4 system; and Tsh 0.33/lit or Tsh 6.6 /bucket for L-2 system.

(Household Income and Payment for Water)

The values of two representative average indicator of the annual household income are Tsh 410,000 ($656) as the mean and Tsh 245,000 ($392) as a median. Annual water consumption of an average household with a family size of 5.8 persons is 42,340 lit. The annual water fees to be paid by an average household are estimated at Tsh 11,000 for L-1-1 system Tsh 12,700 for L-1-4 system and Tsh 14,000 for L-2 system

(Affordability)

The percentage of the annual water fees to the representative annual household income (Tsh 145,000) ranges from 7.6% to 9.7%. Above figures may imply that the estimated water fees are deemed to be payable by 60% of households in the Study area, but hardly affordable to the lowest 20% income group. Another indicators related to evaluation of water fees are current prices of water sold by water vendors (Tsh 50 to 100 per 20 litres) and the villagers' willingness to pay for water (Tsh 82 per 20 litres on an average).

7. Project Cost

7.1 Introduction

The total project costs is composed of seven items: facility construction, procurement of O&M equipment, education and training, project monitoring, engineering services, administration and physical contingencies. The total project costs work out at US$ 181.7 million with a local currency portion of US$ 62.2 million (34%) and a foreign currency portion of US$ 119.5 million (66%) as given below:

Total Project Costs in US$ Million

Project	LC	FC	Total
Year 2001	6.9	11.4	18.3
Year 2006	14.5	25.8	40.3
Year 2016	40.8	82.3	123.1
Total	62.2	119.5	181.7

The breakdown of the total project cost in relation to the project purpose is as follows:

Breakdown of Total Project Costs in US$ 1,000

Project	Year 2001	Year 2006	Year 2016	Total
Domestic Water Scheme	13,400	30,565	102,245	146,210
Livestock Water Scheme	4,895	9,714	20,805	35,414
Total	18,295	40,279	123,050	181,624

8. Project Implementation Plan

8.1 Implementation Programme

The ministry of Water will be the executing agency responsible for implementation of the proposed rural water supply project with the project area extending over three regions of Arusha, Singida and Tabora. The Ministry of Water will appoint a project manager who has responsibilities for promoting the project and coordinating and directing the local organisations at all levels of region, district, ward and village.

The proposed construction works will be carried out on the contract basis, under the supervision of the district water engineer's offices, by employing an engineering consulting firm and a construction contractor.

The project will be implemented as a package project composed of three stage projects: year 2001 project, year 2006 project and year 2016 project. In consideration of work quantities and annual working days (225 days) under the rainfall conditions in the project area, the construction years are planned to be four years for the 2001 project, five years for the 2006 project and 10 years for the 2016 project (Table3).

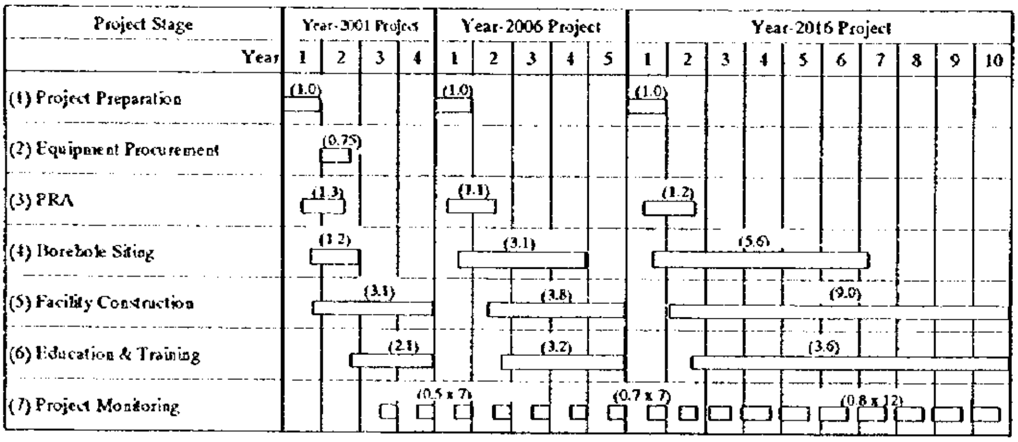
8.2 Education and Training

During the early stage of the project implementation, participatory rural appraisal (PRA) will be conducted at all target villages in cooperation with the district offices concerned. The PRA will be carried out *by a group of facilitators qualified in the sectors of rural water supply scheme, health and environmental sanitation and gender issues. Just after the completion of construction work of water facilities, the education and training programme mentioned in chapter 6 will be conducted by the group of facilitators. The programme focuses on the leaders of related organisations such as village government, village water committee, village health committee and women's group as well as users.*

8.3 Project Monitoring and Evaluation

The task forces shall be organised under the control of the district water engineer's offices in conjunction with other district officers concerned. Monitoring and evaluation are the process to provide effective information necessary for formulation of development plans of the overall project through generalising findings from the on-going/completed village water schemes to other target villages.

Table3 Project Implementation Schedule



Notes : (1) Project preparation includes the detailed design and tendering of construction contractor.
(2) Figures on bars mean required numbers of year during a period shown by the bar.

Monitoring and evaluation take place at defined and critical intervals of he project cycle namely: during (on-going), towards (at the end of construction), and after (on completion). It is proposed to implement the monitoring and evaluation programmes once a year for a five-year period after completion of the construction works. Monitoring will be administered to two target groups including village government officials, other related officials and representatives of committees and organisations concerned with rural water schemes; and villagers.

9. Project Evaluation

9.1 Environment

(Environmental Setups)

The laws and regulations concerning the environment are not enacted in Tanzania. Responsible agencies for the environmental management are the National Environment Management Council and the Division of Environment in the Ministry of Tourism, Natural Resources and Environment. The international conventions on environment to which the Government is a party are the Convention on Biological Diversity; Basel Convention and the Convention on International Trade in Endangered Species.

There are three forest reserves, one game and forest reserve and three game reserves in the Study Area. Nine target villages are located in the above reserve areas.

(Environmental Impact Assessment (EIA))

An initial environmental examination (IEE) was made in the Study according to the guideline of JICA. As a result of screening and scoping, it is clarified that, two major impacts to the existing dug-wells and boreholes may take place unless the design and construction of boreholes are properly conducted as presented bellow:

- ***Vested Water Right of the Existing Dug-wells***

Some 474 dug-wells are distributed over the Study area. A new borehole which is constructed nearby a dug-well might give water level influence to the existing well. The measures recommended are to design and construct the borehole properly so as to extract groundwater from a depth deeper than 30 m.

- ***Influence to the Existing Borehole***

In case that a borehole(s) is constructed in a village where borehole(s) is already existing, new hole site is to be selected at enough distance from the existing one to avoid any impact to the existing hole.

9.2 Institutional Aspect

(Governmental Setup in WES Sector)

The governmental setup of the WES sector is formed on the practical basis under the leadership of the related ministries of the national government. The WES officers at the district level shoulder the most important role in the daily supporting services to the village level organisations. However, their daily services are not so active due to lack of transportation vehicles, refresher training course for the officers and teaching materials for the villagers as well as financial constraint.

Their activities would be more functional, when certain budget is allocated to the district offices. This is evident from the experience learnt by conducting the PRA and education programmes in the pilot villages. In order to achieve a sustainable community based management system of the WES sector, the governmental *intervention is indispensable. The government should seek a self-reliance measure through development of own resources for a long term intervention.*

(Village Water Committee(VWC))

Most of the target villages have established a VWC together with a village water fund; however, many village water schemes are not functioning due to lack of engineering capabilities of the villages; lack of funds; and inefficiency of supporting services to be done by the district water engineer's office.

The monitoring of the pilot water supply projects have revealed that once water facilities are provided for the villagers, they are able to maintain their water scheme provided that the district water engineer's office renders proper guidance and engineering services to the villagers.

9.3 Technical and Engineering Aspect

(Drilling and Construction Contractor)

Some ten (10) number of drilling contractors are operating in Tanzania. They are running under small size in terms of capital, finance, staff and outfit. The contractors used to exclusively apply the DTH (air-hammer) drilling even in very collapsible layers not the mud-circulating drilling. And in case of drilling through those layers, unexpected times were lost and the proposed borehole could not be finally completed in some case.

The largest drilling firm in Tanzania is the Drilling and Dam Construction Agency of the MOW which is semi-autonomous body and holds a number of staff and old but enough outfits inclusive of 30 drilling rigs.

(Climate and Road Conditions)

The rainy season in the Study area lasts for some five months starting from November to end in March. A three month period is, therefore, taken for the shutdown of construction works in the project implementation plan in the Study.

(Geophysical Sounding for Borehole Siting)

The resistivity and double-loop EM soundings were adopted in borehole siting in the Study. The soundings above were effective to a 100-m depth and in case that the superficial formation is thin and the bed-rock formation is in shallow depth. The Study recommends to introduce the time-domain electromagnetic (TDEM) sounding to the borehole siting during the project implementation stage.

9.4 Project Benefits

(Financial Benefits)

The expected financial benefits were estimated through three model cases in L-1-1, L-1-4 and L-2 systems. The annual revenues by system are:

- *L-1-1 system : US$ 1,306,*
- *L-1-4 system : US$ 3,070,*

- L-2 system : US$ 17,345.

(Economic Benefits)

The two major benefits are expected in the time saving and medical cost reduction. The benefit of whole project in 18-year period from 1999 to 2016 are estimated at US$ 2,069 thousand by 2003, US$ 7,181 thousand by 2008, US$ 17,712 thousand by 2013 and US$ 27,496 thousand by 2016.

9.5 Economic and Financial Evaluation

(Project Cost)

In accordance with the implementation schedule, the project costs in economic and financial terms were estimated at US$ 175 million and US$ 170 million respectively.

(Economic and Financial Evaluation)

Applying the cost benefit streams with the project life of 20 years and discount rate of 10%, the FIRR of L-1-1, L-1-4 and L-2 systems are evaluated at 16%, 8% and 22% respectively. From the above results the project is judged to be financially feasible.

Using the cost benefit streams with the project life of 37 years and the opportunity cost of capital of 10%, the EIRR of whole project is evaluated at 15%. From the above results the project is judged to be economically feasible.

9.6 Synthetic Evaluation

Water is not only one of basic human needs but humanitarian issue in terms of the minimum wages, security from physical danger, protection from diseases and primary health care. It was made amply clear as a result of institutional and financial analysis that the rural population in the Study area can by themselves manage water facilities to be constructed under the project in a financially stable and successful manner.

Together with the above described quantitative evaluation, a more mention must be made of the qualitative benefits of this project. In short, it will work as a saviour for those who suffer and for women.

The rural population in the Study area now mostly use unsafe water sources which are biologically contaminated. This state of affairs gives rise to a high incidence of water-related diseases. The project is expected to contribute to reducing sufferings from such illnesses.

It was found as a result of the sample household survey that a household on an average spends 10 hours per day for water collection. Such a practice is not only a great economic loss to the household itself as well as to the nation, but also forces heavy physical exertions and mental stresses to women and children. This is a typical case of female discrimination. The project is expected to contribute to the alleviation of such gender sufferings.

10. Conclusion

The Study identified that the water supply coverage of the Study area as of 1997 is only 40%. Out of total population of 696,000 in 284 target villages, the daily lives of 420,000 population depend on the water collected from water-holes, lakes and other distant, unsafe and unstable sources. Such population is obliged to endure heavy workload to collect water and medical expenses for water-related diseases.

Through a series survey and study on hydrogeology and groundwater, the Study identified that the groundwater resource is available in terms of quantity and quality for the proposed project, 3,515 locations of groundwater source facilities of various types need to be constructed by the year 2016 to supply safe water to all 1,148,000 population in the Study area. In addition, 463 charco dams need to be constructed for livestock use which is an important income source of the people in the study area.

In consideration of the large project size and available resources, the Study has proposed to implement the project in three phases with the target year of 2001, 2006 and 2016. By the year 2001, 280 new water facilities will be constructed together with the rehabilitation of 36 existing water facilities in order to cover some 60 % of the estimated population of 789,000. By the year 2006, the construction of 704 new water facilities and rehabilitation of 375 systems will be implemented so as to cover 80 % of the estimated population of 895,000. And, by the year 2016, it is proposed to construct 2,650 new water facilities and rehabilitate 970 systems to cover all the estimated population of 1,148,000.

Charco dams will be constructed at 64 locations by the year 2001; 127 locations by the year 2006; and 272 locations by the year 2016 in order to meet the water requirement for livestock purpose.

Women are the major bearer as well as beneficiary of water sector. They play important roles in the management, finance and child-care in their household. Simultaneously they have to participate themselves more into the decision-making process in VWC as the major bearer and beneficiary.

The Study concluded that a sustainable O&M system at village level could be realised if certain interventions in education, training and support services are properly extended to the village water committees.

The total project cost is estimated at US$ 181.7 million. The project costs by stage are:

Year-2001 project :	*US$*	*18.3 million,*
Year-2006 project :	*US$*	*40.3 million,*
Year-2016 project :	*US$*	*123.1 million.*

A distinguished socio-economic effects will be derived from the implementation of the proposed project in terms of the stabilisation of daily life of water users through the provision of stable and safe water source, revitalisation of economic activities, generation of education opportunity, decrease of water-related diseases and so forth.

Recommendation

(1) Urgent Commencement of the Project

The current water supply coverage of the Study area ranks the lowest in Tanzania. Therefore, in order to improve the situation of water supplies for the rural people, the rural water supply schemes should be urgently implemented. In this context, it is recommended to commence the proposed project, which will generate significant project benefits as closely as possible to the proposed implementation schedule.

(2) Phasing of the Project

The project has been proposed to be implemented in three stages with the different target years of 2001, 2006 and 2016. In case that further phasing regarding the implementation of the project is necessitated, it is recommended to strictly follow "some for all" principle; not giving priority to any district(s) or villages but covering all the target villages at any implementation stage.

(3) Self-reliance Measure to Charco Dam Scheme

In consideration of the more importance and effectiveness of water supplies for human being, an option may be available that the resources for investment is more weighted in favour of domestic water schemes; and the self-reliance measure be taken to promote the implementation of charco dam schemes as one of the rural development projects.

(4) Revision of Water Supply Plan

It is recommended to revise in 2006 the water supply plan with the target year of 2016 proposed under this overall water supply plan, basing on the outcomes of the implementation of the previous project and the socio-economic situation of the Study area.

(5) Strengthening of District Water Engineer's Office

In order to assure sustainable management of the community based system of rural water supply schemes, the district water engineer's office shall play a leading role in the implementation of the project and O&M after the completion of the construction work. It is recommended that the Government shall make more efforts to earmark the appropriate recurrent budget and provide the training programme regarding the capability building of the district water engineer's offices.

(6) "Drink Boiled Water" Campaign

The groundwater collected from boreholes is the most favourable safe water. The water facilities other than boreholes, however, also remain important water sources in the rural area. It is recommended to extend a more extensive campaign in "Drink Boiled Water" and "Wash Your Hand by Soap" to all rural population.

(7) Introduction of TDEM in Borehole Siting

The Study identified the effectiveness of resistivity and simplified electro-magnetic soundings. In view of the depth and situation of productive aquifers, the time-domain electro-magnetic (TDEM) sounding is recommended to be introduced for the borehole siting during the project implementation stage.

CHAPTER ONE: INTRODUCTION

CHAPTER ONE: INTRODUCTION

1.1 Background

In order to cover all the population by safe water supply, the Government of United Republic of Tanzania (hereinafter referred to as "the Government of Tanzania") launched in 1971 a 20-year water supply programme to the target year of 1990. The Government set forth a National Water Policy in 1991. Due to various constraints, the achievement of programme and policy have been left far behind the target, and the target year of programme was extended to the year 2002. Two decades have been elapsed since the Government launched the water programme. By 1993, only 67% of urban population and 46% of rural people were reported to be covered with water supply schemes.

Being located in the central highland, four districts of Hanang, Singida Rural, Manyoni and Igunga have been suffered from water shortage for domestic and livestock uses; many villages lack in stable water sources; many of existing water facilities are not functioned. The water supply coverage of those districts ranges as far low as 40% when compared with the national average in the rural areas. The improvement of water supply in the districts has been recognised as one of urgent issues in view of fulfilment of human basic needs and rural development.

Under such circumstances, the Government of Tanzania made a request in September, 1996 to the Government of Japan to extend its technical cooperation programme for "the Study on Groundwater Development for Hanang, Singida Rural, Manyoni and Igunga Districts in the United Republic of Tanzania" (hereinafter referred to as "the Study"). In response to the request, the Government of Japan decided to conduct the Study. The Government of Japan dispatched to Tanzania in November, 1996 a preparatory study team organised by Japan International Cooperation Agency, the official agency responsible for the implementation of technical cooperation programmes of the Government of Japan (hereinafter referred to as "JICA"). The Ministry of Water of the Government of Tanzania and the preparatory study team of JICA concluded the Scope of Work for the Study in November, 1996.

In accordance with the Scope of Work, JICA organised another study team composed of experts from Sanyu Consultants Inc. and Japan Engineering Consultants Co. Ltd. to conduct the Study. The study team was sent to Tanzania to conduct field works in April, 1997. Through the field works for a eight-month period and succeeding planning works in Japan for another two-month period, the study team concluded the Study and provided the present report.

1.2 Objectives of the Study

The objectives of the Study as stipulated in the Scope of Work are:

(i) to formulate groundwater development plans for rural water supplies including rehabilitation plan of the existing facilities, operation and maintenance plan, and sanitation improvement plan; and

(ii) to transfer technology on planning, operation and maintenance methods and skills to counterpart personnel in the course of the Study.

1.3 The Scope of the Study

The Study was implemented in three phases over two years from 1997 to 1998 as given below:

Phase 1 Study: Preliminary Analysis and Field Survey in Tanzania in 1997

- Collection, review and analysis of related data and information,
- Selection of villages for pilot study,
- Planning of pilot study; and
- Initial environmental examination.

Phase 2 Study: Pilot Study in Tanzania in 1997

- Geophysical sounding in the pilot villages,
- Implementation of the construction works of the pilot study including test drilling, electric logging, pumping test, water quality analysis and model water facilities,
- Pilot study covering villagers' participation in planning, construction, operation and maintenance of water supply facilities, and sanitary education; and
- Monitoring of pilot study.

Phase 3 Study: Planning and Evaluation of Proposed Projects in Japan in 1997/98

- Formulation of basic strategy,
- Formulation of water supply projects,
- Planning of villagers' organisations for operation and maintenance of the proposed water supply projects,
- Planning of improvement of sanitary conditions,
- Cost estimates,
- Project evaluation; and
- Implementation programme of priority projects.

1.4 The Study Area and Target Villages

1.4.1 The Study Area

The Study area is administratively composed of four districts extending over three regions: Hanang district in Arusha region; Singida Rural and Manyoni districts in Singida region and Igunga district in Tabora region. They lie between Latitude 4°S and 7°50' S; Longitude 34°20' E and 35°40' E. The total land area is some 52,000 sq.km, representing 5.5% of the land area of Mainland Tanzania (refer to Location Map of the Study Area).

The Study area is located in the western part of the central plateau. Most of the Study area lies at an elevation between 1,000 and 1,500 m, except mountainous areas of Mt. Hanang rising to the elevation of 3,417 m.

The Study area connects with Dar es Salaam through the national roads via Dodoma. The distance between Dar es Salaam and Singida town is 710 km along the above national roads, of which 480 km long roads between Dar es Salaam and Dodoma are paved with asphalt; however, other roads are dirt.

1.4.2 Target Villages

There are large numbers of villages, which are sparsely located over the vast extent of land, among which 284 villages have become the target villages for the Study. 33 villages in Hanang district, which are listed by the Arusha Water Master Plan, are incorporated into the target villages of the Study. Almost all villages in two districts of Singida Rural and Manyoni in Singida region, except several villages with functional water supply schemes, are the target villages. As for Igunga district in Tabora region, there are 73 villages, of which a NGO has already elaborated development plans of rural water supply in 23 villages, thus selecting 50 villages for the Study. Total number of the target villages amounts to 284 as summarised below:

Table 1. 1 Number of Target Villages by District

Region	District	Target Villages	Land Area (sq.km)
Arusha	Hanang	33	4,436
Singida	Singida Rural	129	12,164
	Manyoni	72	28,620
Tabora	Igunga	50	6,788
Total		284	52,008

CHAPTER TWO: TANZANIA IN OVERVIEW

CHAPTER TWO: TANZANIA IN OVERVIEW

2.1 The Nation

2.1.1 Political and Administrative Setups

(1) Political Setup

Tanzania is a sovereign state composed of former Tanganyika and Zanzibar. Two nations formed a political union in 1964 and became the present United Republic of Tanzania. The United Republic has an unicameral legislature called the National Assembly which consists of 275 members elected every five years.

The executive of the United Republic consists of the president elected by universal suffrage assisted by a vice president, a prime minister and a cabinet of ministers. The president and vice president are elected together every five years. The prime minister is appointed by the president from the members of the national assembly and confirmed by a resolution of the majority of the members of national assembly.

(2) Administrative Setup

The cabinet of minister is composed of four ministers of state and 19 ministers who are responsible for the ministries of foreign affairs and international cooperation; water; health; community development; women affairs and children; and so forth.

Tanzania (mainland) is, for the local administrative purpose, divided into 20 regions and 87 districts. The district is further divided into several divisions, wards and villages.

A regional commissioner leads his regional government which consists of departments and standing committees. As one of departments, a regional water engineer and his staff administer water supplies for urban and rural areas of region.

The district council administers its district, under the guidance and support of regional government, through standing committees and departments headed by a district executive director. A district water engineer with his staff is responsible to supply water to all villages within the district.

The divisions are the replacement of former chiefdoms and not empowered any administrative responsibility.

Several wards make physically up a division. They are, however, administratively under the district council.

A village government is the smallest administrative unit in Tanzania. It consists of an assembly and a council.

(3) Ministry of Water

The Ministry of Water (MOW) which is the counterpart agency of the present Study, is responsible for ensuring proper and efficient development of water resources for enhanced socio-economic development through provision of clean, safe and adequate water and wastewater disposal.

The MOW was recently reorganised; and its new structure is shown in Figure 2.1. The MOW operates through two service divisions of Policy & Planning and Administration & Personnel and three operational divisions of Urban Water Supply & Sewerage, Rural Water Supply and Water Resources Assessment & Exploration. Three sections of Maji Central Stores, Drilling & Dam Construction and Water Resources Institute were transformed to semiautonomous agencies. The Drilling & Dam Construction Agency is composed of 98 staff inclusive of four staff officers, zonal inspectors of drilling, regional drilling officers and others; and equipped with some 30 rotary and 10 cable-tool drilling rigs, most of which are more than 20-year old, and other drilling supporting equipment.

The MOW consists of some 400 administrative staff, 190 technical staff and other 1,280 employees. The expenditure budget of the MOW in the current three years were as shown below:

Table 2.1 The Budget of Ministry of Water

(unit: Tsh million)

	1995/96 (actual expenditure)	1996/97 (approved estimates)	1997/98 (estimates)
Recurrent	963	1,019	2,301
Development	86	3,222	7,595
Total	1,049	4,241	9,896

Figure 2.1 Organisational Structure of the Ministry of Water (as of 1997)

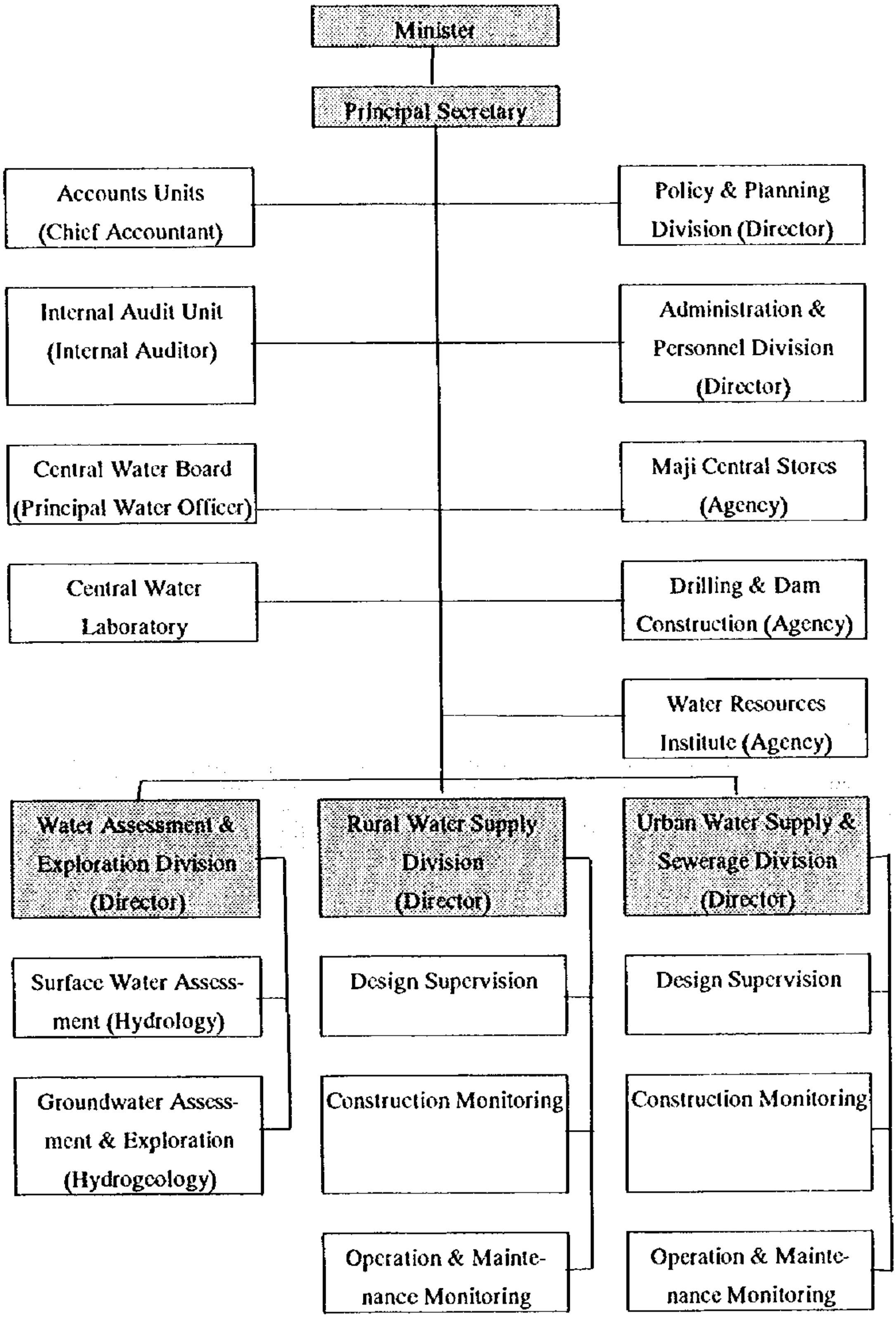
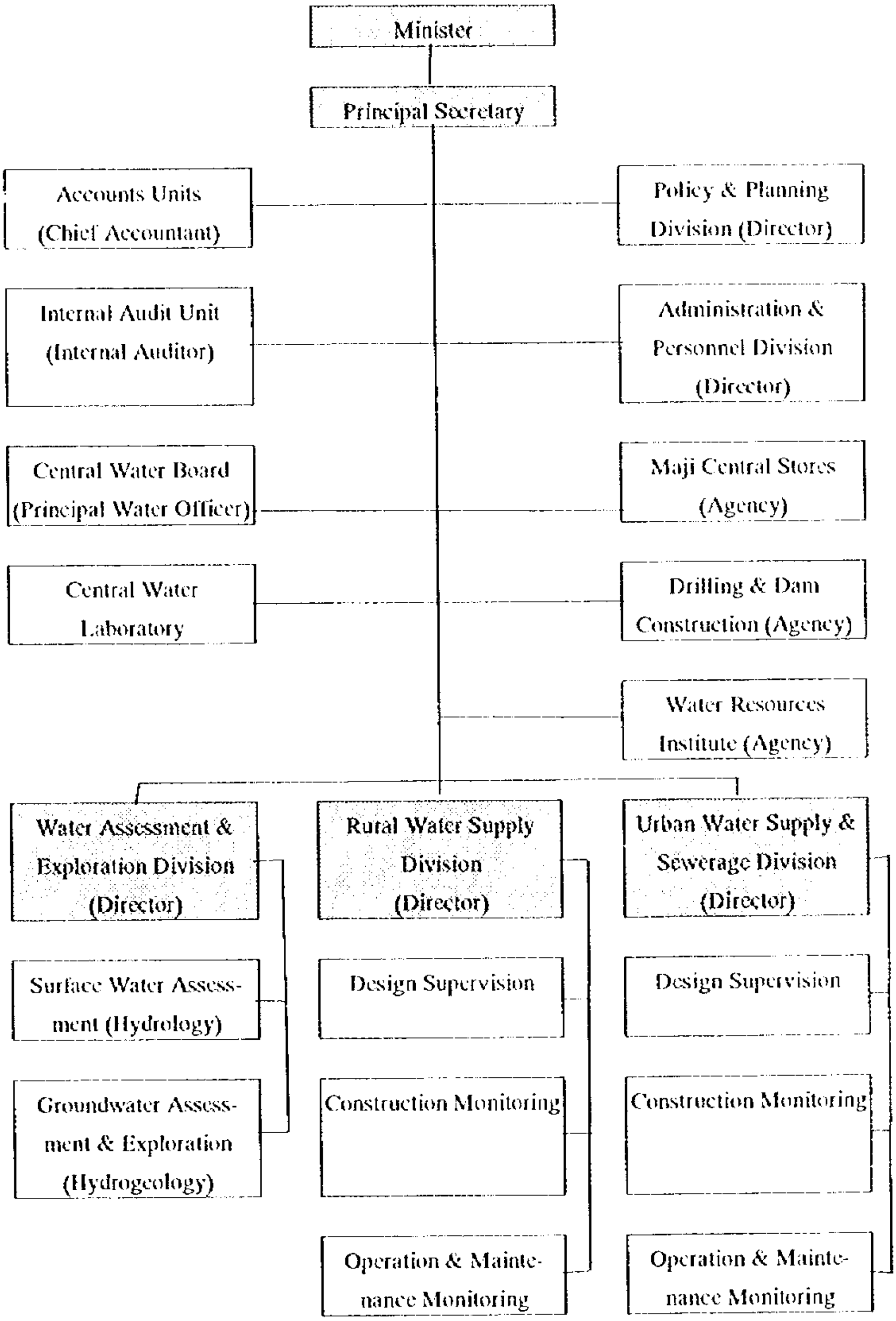


Figure 2.1 Organisational Structure of the Ministry of Water (as of 1997)



2.1.2 Population

According to the latest population census in 1988, the total population of the Tanzania was 23.1 million showing annual growth rate of 3.0 % during the current decade. Other demographic indicators in 1985 are as follows (Bureau of Statistics, 1996):

- Population under 15 years (%)		:	45.8
- Infant mortality rate per 1000 live birth		:	115
- Under five's mortality rate per 1000 live birth		:	191
- Crude death rate per 1000 population		:	15
- Life expectancy at birth	(male)	:	49
	(female)	:	51
	(total)	:	50
- Crude birth rate per 1000 population		:	46

2.2 National Economy

2.2.1 Gross Domestic Product

The gross domestic product (GDP) at factor cost as of 1994 was estimated at Tanzanian Shilling (Tsh) 1,660 billion. The same by kind of economic activity is as follows (Bureau of Statistics, 1996):

Table 2.2 GDP by Sector as of 1994

Sector	Tsh (Billion)
Agriculture	948
Mining and Quarrying	27
Manufacturing	126
Electricity and Water	38
Construction	86
Trade	254
Transport and Communication	108
Finance and Insurance	78
Services	83
Total Industries	**1,740**
Bank service charge	- 80
GDP at factor cost	**1,660**

2.2.2 Agriculture

The agriculture is the main stay of Tanzania's economy. It employs some 80% of labour population and accounts over 50% of GDP at factor cost and 75% of foreign exchange earnings. The performance of agriculture during past three years was quite satisfactory. The annual GDP growth in agriculture marked 4.0 % in 1991 and increased to 7.3 % in 1993 compared to a population growth rate of 2.8 %.

Food production balanced, in general, to the demand. The production of major food crops as of 1992/93 was 2,282,000 tons of maize, 417,000 tons of rice, 929,000 tons of sorghum and millet, 59,000 tons of wheat, 406,000 tons of beans, 1,708,000 tons of cassava and 260,000 tons of potatoes. The production of major cash crops as of 1992/93 was 58,000 tons of coffee, 306,000 tons of cotton, 24,000 tons of sisal, 21,000 tons of tea, 33,000 tons of cashewnut, 19,000 tons of tobacco and 3,000 tons of pyrethrum.

Livestock plays also an important role in the rural economy of Tanzania and is increasing importance in the commercial sector. The livestock sector accounts 25% of agricultural GDP.

2.2.3 Trade

The trade sector contributes directly to the national economy accounting for some 15% of total GDP and employing over 25% of the active labour force. The value of exports has over US$ 435 millions per annum during 1991/92 to 1993/94 period. While, imports averaged around US$ 1,500 millions during the same period.

2.3 Land and Climate

2.3.1 Land

Tanzania lies just south of the equator between the Great Lakes of Victoria, Tanganyika and Nyasa one hand and the Indian Ocean on the other. Tanzania borders on Kenya, Uganda, Rwanda, Burundi, Zaire, Zambia, Malawi and Mozambique.

It occupies a land area of some 945,000 sq.km inclusive of some 60,000 sq.km of inland water area. Mt. Kilimanjaro, which is the highest peak of Africa, rises to the elevation of 5,895 m. Most of its land lies higher than the elevation of 1,000 m except the coastal belt and Tanganyika basin.

A distinct feature of Tanzania is the rift valleys in many places. The Great Rift Valley runs from the mouth of Zambezi River northward through Tanzania, Kenya and Ethiopia forming the lakes of Tanganyika, Kivu and others.

The rivers flow into the Indian Ocean or the Great Lakes. Only the Rufiji River, entering the Ocean, and the Kagera River, flowing into the lake Victoria, pour water flow through a year and others are seasonal.

2.3.2 Climate

The major climatic feature of Tanzania is the long dry spell from May to October followed by a period of low rainfall, which is often concentrated into few-day-long heavy shower. The major rainy season on the coast is from March to May and minor season form October to December. In the area around the Lake Victoria the rainfall is well distributed throughout a year with a peak season during March to May. The total annual rainfall increases toward the north. The normal annual rainfalls in Dar es Salaam, Dodoma, Tabora and Mwanza are 1,124 mm, 567 mm, 961 mm and 1,077 mm respectively.

The maximum monthly mean temperatures in Dar es Salaam, Dodoma and Tabora are 32.1°C, 26.5°C and 32.3°C respectively. The minimum monthly mean temperatures in the same places above are 18.1°C, 15.4°C and 13.6 °C respectively.

2.4 Geology

The oldest rocks in the Tanzanian territory are those belonging to Dodoman System. They occupy the west-central region. They are coarsely crystalline metamorphic rocks of sedimentary volcanic origin, as well as migmatites. Granite occupies large areas.

In the north-west and probably deposited upon a rigid shield of Dodoman rocks are the volcanics and quartzite of Nyanzian System. The characteristic rock is "banded ironstone". The volcanics have suffered low grade metamorphism. Associated with these are rocks of the Kavirondian System consisting principally of conglomerates, grit, quarzites and volcanics. There has been large scale emplacement of "younger" granite into the area of Nyanzian and Kavirondian rocks.

In the east are rocks of the Usagaran System which belong to orogenic belt extending northward into Kenya and southward into Mozambique. On the west is a complementary belt, parallel to Lake Tanganyika, consisting of rocks of the Ubemdian System which is believed to be same age as the Usagaran. The rocks of these two systems have close resemblance to those of the Dodoman System. The boundary is in place obscure by migmatisation. The rocks of these tree systems belong to Archaean group.

The Karagwe-Ankolean System is located along western border of the territory and consists of phyllite and quartzite with granite intrusion. The Bukoban System is made up of sandstone, shale and basalt and extends in a belt from Uganda border to Lake Tanganyika. The age of the system is from late Precambrian to Paleozoic.

Following the close of the Bukoban times, there appears to have been a long interval before the deposition of the rocks of Kaloo age (Upper Carboniferous - Lower Jurassic). These are principally terrestrial sediment consisting of sandstone, shale, conglomerate and limestone.

Marine rocks, chiefly marl, limestone, sandstone and shale of Jurassic, Cretaceous, Tertiary and Quaternary age, made up a disconformable sequence occupying a belt of limited width adjacent to the present coast-line. Contemporaneous with marine sediment in the east, there was accumulation inland of terrestrial deposit of various kinds. During the late Cenozoic, in the more stable areas of the center and north, beds of limestone, silt and terrestrial sediments were accompanied with rift-faulting movement. The Pleistocene lake-bed of Olduvai Gorge are famous for remains of early man.

Commencing probably in late Cretaceous times, there was volcanic activity, associated apparently with rift-faulting movements, which produced the Tertiary-Recent volcanics. In the north it extended from Mts. Hanang to Kilimanjaro and northward into Kenya.

2.5 National Plans

2.5.1 Rolling Plan and Forward Budget

(1) Introduction

The Government of Tanzania replaced the former system of a five-year plan and annual plans by the Rolling Plan and Forward Budget (RPFB). The RPFB is the major annual statement of the government's development strategy, economic targets and budgetary projections. It is rolled over and updated every year. The first and second RPFB covered 1993/94 to 1995/96 and 1994/95 to 1996/97, and the next will cover 1995/96 to 1997/98. The RPFB aims at economic reform:

- to combat poverty and deprivation and thus improve people's welfare,
- to create an enabling environment for a strong private sector,
- to reduce government involvement in directly productive activities,
- to improve efficiency in the use of public resources,
- to ensure macroeconomic stability, and
- to maintain an environmentally sustainable development path.

(2) Macroeconomic Framework

The year 1993/94 was the eight year since the initiation of policy, and institutional reforms aimed at revitalising the national economy. As the result of those reforms, the economy has emerged from the stagnation of the early 1980s. However, the state of economy remains far from satisfactory (Planning Commission and MOF, 1994). The main policy objectives and associated specific targets for the year 1994/95 - 1996/97 period are:

- to raise the annual rate of growth of GDP to about 6% by 1996/97,
- to reduce inflation from present level of over 25% to around 5% per annum over the next three years,
- to strengthen the balance of payment,
- to achieve fiscal stability through prudent fiscal management and reduce dependence on external finance,
- to maintain monetary stability and strengthen the fiscal sector; and
- to continue institutional reforms of the parastatal sector.

(3) Sector Policy

(a) Water

The Government is guided by a National Water Policy aiming at availing the population with safe water within a distance of 400 meters by the year 2002. The major objectives in the water sector are:

- to provide adequate, clean and safe water by the year 2002,
- to identify and develop new water sources,
- to improve efficiency in the development and management of water supplies; and
- to ensure that the development of the sector is environmentally, socially and financially sustainable.

(b) Health

The overall objective is to ensure health for all by the year 2000. Specific objectives include:

- to provide health service to all Tanzanians especially those at risk,
- to make health services more responsive to the needs of people; and
- to incorporate traditional medicine into the health care system.

(c) Community Development, Women and Children

The overall objective in this sector is to prepare and enable communities to undertake those roles effectively and efficiently. This means ensuring that communities understand their problems and their potential to solve them as well as rational why they should assume and fulfil this role. In more specific terms, the sector aims at attaining the following objectives:

- to develop and sustain the self reliance sprit amongst the community,
- to built community problem solving capacities,
- to impart appropriate technological skills to communities,
- to reduce workloads especially those of women by popularising the use of modern and appropriate technology; and
- to raise the social and economic status of women and children.

(d) Environment

During the past three years several achievement have been made in development of appropriate institutional arrangement for addressing environmental issues. These include the completion of the draft national conservation strategy and environmental protection laws, embarking on the formulation of a national environmental policy. The overall goal for this sector is to achieve sustainable development that maximises the long-term welfare of both present and future generation of Tanzanian population. The above goal embraces the following broad objectives:

- to ensure sustainable and equitable use of resources,
- to prevent and control degradation of land, pollution of water and air, and
- to conserve Tanzania's natural and man-made heritage and biological diversity.

(e) Rural Development

Rural development involves the same objectives as those of the other related sectors including:

- to create a productive environment and provision of production infrastructure for increased agriculture, livestock and small scale industries to raise the living standards of rural people,
- to provide basic needs such as health, education, clean and potable water supply,
- to improve the quality of life in the rural areas by providing productive employment and encouraging private sector,
- to protect the environment and practising proper use of natural resources and to prevent environmental degradation, and
- to strengthen the planning and budgeting capacities at regional and local government levels.

2.5.2 Rural Water Supply Programme and National Water Policy

(1) Rural Water Supply Programme

The Government declared in 1970 a 20-year rural water supply programme (1971-1990). The programme aimed at achieving 100% coverage within 400 m of each household. The programme attracted a number of external support agencies and started with the preparation of regional water master plans. By the year 1982 a total of 16 regions were covered by its own master plan.

The UN's "International Drinking Water and Sanitation Decade (1981-1990)" gave yet another impetus to the programme. By reviewing the programme in 1986, however, it became evident that only 42% of the rural population and 65% of urban population had access to safe and potable water supply; and the targets set for 1991 could not be met.

(2) National Water Policy

In consideration of the achievement of rural water supply programme, the Government launched the National Water Policy in 1991. The objectives of policy are:

- to bring about equal and socio-economic development through the provision of adequate and safe water for different uses for the benefit of the entire population;
- to ensure that this precious resource is effectively explored, developed, utilised and conserved for the benefit of the present and future generation;
- to meet human water demands taking different uses into consideration;
- to give priority to drought-stricken areas and those with critical water shortage by identifying potential water sources and development; and
- to develop and strengthen local capacity so as to reduce donor dependence by emphasising training and use of professionals, innovation, manufacture and use of locally available resources.

A workshop on strategies for the implementation of the Policy was held in 1993. The various observation were clarified, and recommendations to aspects of technology, finance, institution, legislation and others came out by the workshop.

2.6 Current Situation of Water Sector

Since the commencement of 20-year rural water supply programme in 1971 the Government implemented a number of rural water schemes under the cooperation of donor organisations of Sweden, Germany, Norway, Denmark, Japan, World Bank, UNDP, UNICEF etc.; and NGOs such as Tanganyika Christian Refugee Services (TCRS), Water Aid, Caritas and so forth.

In 1993 the MOW initiated a review of water and sanitation sector with an aim of building on and supporting a number of ongoing sector initiatives. The objective of review was to identify constraints, to plan additional intervention for facilitating sector progress, to improve access to information and information sharing for assisting future planning; and to seek commitments of external support agencies and NGOs for supporting specific initiatives.

In the rural water supply sub-sector, it was estimated by 1993 that some 9.7 million or 46% people out of the total rural population of some 21.1 million were being served with clean water. Since the development water resources entails a heavy capital outlay, the following strategies were set forth:

- to ensure that the available resources are used to the maximum benefit of the country and its people, a priority is given to appropriate low cost technologies using less sophisticated skills to construct, operate and maintain;

- the mobilisation of self-help effects of local population is regarded as a necessity; and
- the community-based management of any scheme is realised through the establishment of water committees.

In the urban water supply sub-sector, it was estimated by 1993 that some 3.3 million or 67% population out of a total 4.9 million people in urban areas receives water. The level of service varies from a town to another. All urban centres in Tanzania face water shortage. Supply is far behind from demands in terms of quantity and quality. Major urban centres such as Dar es Salaam, Moshi, Tabora, Mbeya, Shinyanga, Lindi and Singida face on acute water shortage. The water policy advocates full cost recovery for urban water supplies. Presently all urban water supplies are not collecting enough revenue to meet the cost of operation and maintenance due to low tariff structure, poor revenue collection, poor billing system, poor customer database, large unaccounted losses and so forth.

CHAPTER THREE: HYDROGEOLOGY AND GROUNDWATER

CHAPTER THREE: HYDROGEOLOGY AND GROUNDWATER

3.1 Introduction

In order to identify the hydrogeological feature and groundwater resource in the Study area, various hydrogeological and groundwater surveys were conducted in the Study, including:

- collection and review of the existing records on geomorphology, geology, borehole, meteorology, hydrology and others,
- compilation of hydrogeological maps,
- water quality survey,
- geophysical soundings,
- test drilling of boreholes; and
- others.

The findings of said surveys and the evaluation of groundwater resources in the Study area are presented in this chapter.

3.2 Geography and Geomorphology

3.2.1 Geography

The Study area lies in Central Plateau of the country between South Latitude 4° 05' and 7° 50' and between East Longitude 33°20' and 35°40'. Total land area is approximated to 52,000 sq. km.

3.2.2 Geomorphology

The Study area consists mainly of vast undulating peneplain made during mid-Tertiary called "African Surface", and which makes up the greater part of Central Plateau extending from Lake Victoria to Mbeya Rang. Another distinct topographic feature is some ranges of rift valleys formed by faulting during the Neogene deforming this peneplain surface. The Study area is classified into the following topographical units:

- Low-lying Plain, Rift Valley (Swamp, Mbuga, Flood plain, Lakebeds);
- Peneplain (Peneplain with inserberges, Pediment, Depositional surface of Kilimatinde cement);
- Fault Escarpment and Mountain; and
- Volcano (Volcanic cone, Volcanic crater, pyroclastic cone)

(1) Low-lying Plain, Rift Valley

(a) Wembre basin and Bahi basin

Most developed low-lying plains are formed along Wembre and Bahi basins which are formed of peneplains covering Igunga, Singida Rural, Manyoni and Dodoma districts. The Wembre basin extends over Lake Eyasi rift valley. These low-lying plains consist of swamps, mbugas and flood plains.

(b) Lake-bed

Lake-bed consists of lacustrine deposit of proto-Victoria Lake and extends to the Manonga and Wembere basins north of Igunga district forming a flat low terrace.

(c) Rift Valley

The ranges of rift valleys are located on Hanang and north of Singida Rural district extending in the NE-SW direction covering Bassotu-Lake Singida, Balangida-Singida Fault and Balangida Lelu-Turu. Along another continuous rift fault, alluvial plains are formed such as Ititi swamp-Nkuhi-Manyoni Fault in Singida and Manyoni districts and Nzega Fault in Igunga district.

(2) Peneplain (Peneplain with Inserberges, Pediment, Depositional Surface of Kilimatinde Cement)

(a) Peneplain underlain by Synorogenic Granitic Rocks

A huge area is occupied by undulating peneplain forming a part of African Surface. There is formed thick weathered crust on the surface of granitic rocks. Inserberg is ranged parallel to direction of rift valleys. Characteristics of river patterns, which are engraved on peneplain surface controlled by geological structures, are interpreted through analyses of the satellite imagery and aerial photographs covering the northwest of Igunga district, the northern and eastern parts of Singida Rural district, the south and southeast of Hanang district and the middle and south of Manyoni district.

(b) Peneplain underlain by Metamorphosed Sedimentary Rocks

The northern part of Igunga district which is underlain by Nyanzian system shows some different landform from an area underlain by granitic rocks characterised by steep rock hills overtopping on flat undulating peneplain. The southern half of Manyoni district, which is underlain by Dodoman Systems composed of metamorphosed sedimentary rocks, gneiss and migmatite, is also characterised by a range of steep rock hills.

(c) Depositional Surface of Kilimatinde Cement

Kilimatinde cement is a terrestrial sediment of Neogene overlain Precambrian basement rocks expanding from south of Singida Rural district to north of Manyoni district. Depositional surface of Kilimatinde cement makes flat or slightly undulating topographic feature and on which drainage pattern has not been developed. On satellite image Kilimatinde surface can be distinguished as dark coloured spot.

(3) Fault Escarpment and Mountain

Fault escarpments were formed along boundaries between peneplain and rift valley. Typical escarpments are located on Nzega Fault, a continuous fault from Lake Eyasi to east of Wembre basin in Igunga district and Basotu-Lake Singida rift valley, Balangida rift valley, Singida Fault and Balangida Lelu-Turu rift valley in Singida Rural district, and Kilimatinde Fault and west escarpment of Bahi basin in Manyoni district. Steep mountains underlain by hard basement rocks overtopping on peneplain are located in the north of Igunga district and the southern part of Manyoni district.

(4) Volcano (Volcanic cone, Volcanic crater, Pyroclastic cone)

Mt. Hanang which raises to an elevation of 3,678 m overtops on the peneplain of Africa Surface in an elevation of some 1,700 m. There are many volcanic and pyroclastic craters surrounding the volcanic cone of Mt. Hanang. Along Basotu Fault, many volcanic craters in a small size are also spread out.

3.3 Soils, Vegetation and Land-use

(1) Soils

The soils in the Study area can be divided broadly into the following four groups:

- A complex of plateau soils on the highest ground, non-calcareous plains soils on the lower ground and black calcareous clay in the depressions.
- A complex of red earth passing through yellow and grey sands on granite on the higher ground, to black, calcareous clays in the bottom lands.
- Non-lateritised red earth on volcanic and doleritic rocks.
- A complex of calcareous plains soils with calcareous black clays in the low-lying lands, characteristic of the Wembere Steppe.

(2) Vegetation

Larger tracts of the area are virtually open plain or grasslands, with patches of stunted thicket, commonly thorny. Low land such as Wembere and Bahi depressions is characterised either by open grassland or semi-open acasia-baobab bush. The broad area located from the south of Singida district to the north of Manyoni district underlain by Kilimatinde Cement formation is covered by relatively dense thorny thicket. More luxuriant forest is found at some forest reserved areas.

(3) Land-use

Large tracts of land are cultivated and are planted mainly to maize. Grazing of cattle, sheep and goats are common through the Study area.

3.4 Meteorology and Hydrology

3.4.1 Meteorology

The meteorological stations in the Study area are at Singida Airport (Station No.2K/R10) and Manyoni (Station No.2RR12) in Singida region, and Sekenke (Station No.2K/R11) in Iramba district. No station is available in Hanang district. The daily records on rainfall, air temperature, relative humidity, pan evaporation, sunshine hour and wind-run are available from the stations covering period since 1970 to date. The meteorological features of the Study area are as follows:

(1) Rainfall

The rain in the Study area falls concentrately in six month period from November to April. An averaged annual rainfall at three stations above are 626 mm, 612 mm and 876 mm respectively.

(2) Temperature

The annual mean, maximum and minimum monthly mean daily temperature at Singida are 22.5°C, 24.6°C (March) and 20.6°C (August) respectively. Those at Manyoni are 22.1°C, 24.4°C (November) and 19.3°C (July). Those at Sekenke are 24.2°C, 24.2°C (April) and 22.8°C (August).

(3) Relative Humidity

The annual mean, maximum and minimum monthly mean daily relative humidity at Singida are 74.6%, 80.7 % (March) and 61.7 %(October) respectively. Those at Manyoni are comparatively high showing 80.6 %, 86.0 % (February) and 73.4 % (July). Those at Sekenke are relatively low showing 66.6 %, 76.0 % (February) and 55.2 % (October).

(4) Pan Evaporation

An averaged annual pan evaporation is 2,400 mm at Singida, 2,144 mm at Manyoni and 2,488 mm at Sekenke. The maximum and minimum monthly mean daily evaporation are; 8.7 mm/day (October) and 5.5 mm/day (July) at Singida; 6.9 mm/day (November) and 5.3 mm/day (January) at Manyoni; and 10.3 mm/day (October) and 5.1 mm/day (April) at Sekenke.

(5) Sunshine Hour

An averaged annual sunshine hours at three stations are 7.7 hr/day at Singida, 7.9 hr/day at Manyoni and 7.1 hr/day at Sekenke. The maximum and minimum monthly mean daily sunshine hours at three stations are; 9.2 hr/day (July) and 6.2 hr/day (December) at Singida; 9.2 hr/day (September) and 6.5 hr/day (January) at Manyoni; and 8.7 hr/day (July) and 5.6 hr/day (November) at Sekenke.

(6) Wind-run

The wind-run record at Singida shows 220 km/day (2.5 m/sec) as an annual averaged daily mean; 380 km/day (September) and 108 km/day (January) as the monthly maximum and minimum respectively. Windy season which exceed 150 km/day (1.7 m/sec) covers from March to November.

The wind-run record at Manyoni shows a very gentle wind-run as 94 km/day (1.1 m/sec) of an annual averaged daily mean; 140 km/day (September) and 53 km/day (February) as the monthly maximum and minimum respectively. Windy season which exceed 100 km/day (1.2 m/sec) covers only from August to December.

The wind-run record at Sekenke shows 104 km/day (1.2 m/sec) as an annual averaged daily mean; 172 km/day (September) and 48 km/day (March) as the monthly maximum and minimum respectively. Windy season which exceed 100 km/day (1.2 m/sec) covers from July to November.

3.4.2 Hydrology

The drainage system of the Study area is characterised by the Wembere-Manonga system, the Mponde-Bubu and the Ruaha systems. All rivers in Igunga district flow into the Wembere or the Manonga river and river of western Singida district flow into the Wembere. Ndurumo river flows to the north from northern Singida to join in Lake Eyasi-Wembere system. There are closed river system along the rift valley of Hanang district such as Basotu, Balangida and Balangida Laru. The Mponde flows, gathering flows from tributaries, down to southward along Turu rift valley and pour into the Bahi basin. The Bubu also flows from the southeast plateau of Hanang district into the Bahi basin. The Ruahs flows from plateau of south of

Manyoni district down to east toward the Indian Ocean. All the rivers are seasonal, and form closed basins.

Three gauging stations for river runoff observation are operated at Kirondatal on the Karonda River, one of tributary of the Wembere, since 1955, Msememlso on the Msememlso River (Bahi system) since 1968 and Makuru on the Maduma River (Bahi system) since 1969. The annual average runoffs at Karonda, Msememlso and Maduma stations are 56 MCM or 230 mm, 9 MCM or 8 mm and 14 MCM or 14 mm respectively. The runoff coefficients are variable in 0.26 at Karonda, 0.01 at Msememlso and 0.02 at Maduma.

3.5 Geology

3.5.1 Introduction

The majority of the Study area is underlain by granitic rocks of Archean Group. The rest part of area is underlain by metamorphosed sedimentary rocks of Archean Group such as Nyansian System in the northern Igunga district and the northern Singida Rural district, and Dodoman System in the southern Manyoni district. Lower plains located on Wembere and Bahi basins and others extending in another rift valleys and Kilimatinde surface are underlain by younger sediments in Pleistocene-Holocene age. A geological map of study area is shown in Figure 3.1.

3.5.2 Geological Formations

(1) Granite

Almost 61 % of the Study area is underlain by the "Granites" made during Archean age. It is composed of granite, granodiorite locally foliated, migmatitic and porphyroblastic. During the peneplaination, granites were weathered deeply and thick surperficials have been formed, especially being crushed and weathered strongly along fault.

The southern half of Igunga district is underlain by granite forming undulating peneplain. There are predominant lineaments in the southwest-northeast direction.

Except the northern part, whole district of Singida Rural and the east of Hanang are underlain by granites. It is supposed that granites are crushed and weathered deeply along the rift fault, especially from northeast of Singida Rural to the east of Hanang district. A flat and slightly undulating peneplain spreads out in the western part of Singida Rural district on which lineaments run but these are not so remarkable than the northern part of the district. Over an area covered by Kilimatinde Cement from the southern part of Singida Rural to the northern part of Manyoni district, granites are only exposed along river courses and fault escarpment.

(2) Bubu Cataclasite

Eastern and southern peneplains of Hanang district are underlain by Bubu Cataclasite composed of sheared and granulated granites, migmatites and gneisses. Predominant lineaments which range parallel to the direction of rift fault along the Balangida Lelu Lake control the courses and patterns of river engraved on the peneplain.

(3) Nyanzian System

The north of Igunga district is underlain by Nyanzian System composed of banded ironstone, metamorphosed volcanic rock and schist. Some limited areas in the north and south of Singida Rural and the north-west of Hanang district are also underlain by the system. The structure of Nyanzian System follows with the east-west and northwest-southeast direction.

(4) Dodoman System and Bukoban System

A wide and undulated peneplain with overtopping hills located in the south of Manyoni district is underlain by Dodoman System accompanied by Bukoban and Nyanzian Systems. The Dodoman System is composed of granite, gneiss and migmatite, and Bukoban System is composed of shale, sandstone and phyllite.

(5) Dyke Rocks

Dyke rocks are located along faults especially nearby a rift fault. The types of dyke rock are mainly dolerite, porphyrite and kimberlite which is mother rock of diamond and located north of Igunga and Singida Rural. Usually dyke rocks are fractured and being excellent aquifers.

(6) Kilimatinde Cement

About 1.3 km^2 or 8.5% of the Study area is underlain by Kilimatinde Cement. The area spreads out along the boundary between Singida Rural and Manyoni districts. It is hard, sometimes porous, composed largely of sand, cemented either by clay or lime or silica, and often contains sub-angular relics of granite and gneiss. It's thickness may be 30 m or more.

(7) Manonga-Wembere Lake Deposit

A wide area extended on the north of Igunga along with the Manonga river and Wembere basin is underlain by Manonga-Wembere Lake-beds of Pliocene-Pleistocene age. It consists of lacustrine limestone, clay, sand and gravel. It's thickness may be 100 m or more.

(8) Hanang Volcanics

Volcanic activities were associated with the rift fault such as Balangida and Basotu fault. The main cone of Hanang Volcano consists of nephelinitic lava. Volcanic craters and pyroclastic cones consist of calcareous crystal tuff and tuffaceous agglomerate.

(9) Alluvial Deposit

Flood plains, mbugas and alluvial fans which are located on Wembere and Bahi basins, rift valleys and another alluvial plains are underlain by superficial deposit consisting of clay, silt and fine sand.

3.6 Hydrogeology and Groundwater

3.6.1 Existing Borehole Record

Some 287 borehole records related to the target villages are available from Regional Maji Offices. Out of them, the locations and current situations of 137 boreholes were confirmed by the Study Team through the inventory survey on the existing water supply facilities. Out of boreholes confirmed, only 46 boreholes are still working. The borehole inventory with the location map are compiled in Volume Three of the present report. The numbers and situation of recorded boreholes by district are summarised in the following table.

Table 3.1 Numbers and Situation of Recorded Boreholes by District

District	No. of Recorded Borehole	Location Confirmed	No. of Working Borehole	Averaged Dimensions		
				Depth (m)	S.W.L (m)	Yield (m^3/hr)
Hanang	14	9	1	65.3	12.4	8.7
Singida rural	111	60	14	86.0	22.4	8.8
Manyoni	138	49	27	106.1	24.4	5.8
Igunga	24	19	4	60.9	14.8	8.8
Total/Ave.	287	137	46	93.5	22.5	7.0

3.6.2 Geophysical Soundings

(1) Methodology

In order to obtain general hydrogeological information of the Study area and to identify possible borehole sites in the pilot villages and some target villages, the geophysical soundings were conducted by the Study Team adopting the electro-magnetic (EM) and resistivity methods. The EM sounding was mainly applied to detect the fracture zone in bed-rocks and the resistivity sounding was adopted to identify aquifer structures. The general methodology and specification are as follows:

Electro-magnetic (dual loop) sounding

- System : MAXMIN I-6 EM System
- Observatory interval : 10 m
- Frequency : 3520 Hz and 880 Hz

Resistivity sounding

- Electrode configuration : Wenner method
- Observatory depth : 150 - 250 m
- Interval of observatory point : 70 - 150m.

The observatory lines and points were selected to cross over the geological structures such as faults and lineaments identified through the integration of interpretation aerial photographs, hydrogeological maps, the existing boreholes records and field inspection. Total number of observatory points amounted to 12,016 for EM and 701 for resistivity.

(2) General Outcome of Soundings

Regardless the specific resistivities which could be identified by the resistivity borehole logging, the apparent resistivity of layers are, in general, very low ranging from several to several hundreds ohm-m reflecting a low resistivity in the superficial saline condition over the area.

The majority of ρ- a (apparent resistivity - electorode interval relation) curve draws a "high-low-high" type. The first "high-low" portion indicates the superficial formations; and the break point of "low-high" curve clearly indicates the bed-rock surface. The last high curve which indicates the bed-rocks in weathered or fresh condition goes linearly upward in a magnification of 30 to 50 times. In fact, some existing boreholes, as well as the test-boreholes drilled under the Study, stroked water at a depth of 100 m or more at around the bottom of weathered zone of bed-rock formation. It is deemed to be difficult to identify weathered or fresh zone by the resistivity sounding.

The EM sounding was effective to detect a low resistivity fracture zone where is covered by thin superficial sediments. Due to low signal output and limited range of frequencies, it is not so effective in an area where covered by thick superficials.

It is concluded that a more effective manner, such as Time-Domain Electro-Magnetic (TDEM) sounding, is to be introduced to identify specific hydrogeological structures in depth.

3.6.3 Test Drilling

The test drilling of boreholes was conducted in the Study by a local drilling contractor for purposes of confirming the groundwater potential under the framework of the pilot study.

Borehole sites were selected in 10 pilot villages within four districts. The outline of the test drillings is given below :

Table 3. 2 Location and Completed Depth of Test Boreholes Drilled

District	Village	Borehole No. *	Depth (m)	Yield (m^3/hr)	Water EC (mS/m)	Aquifer System
Hanang	Bassodesh	AR.257/97	87	8.0	338	Nyanzian
	Ishponga	AR.258/97	110	Dry	-	Granite
	Masqaroda	AR.259/97	78	9.0	140	Gneiss
	Mara	AR.260/97	40	9.0	59	Gneiss
Singida	Nkuhi	SG.255/97	100	7.2	66	Nyanzian
	Choda	SG.256/97	102	9.0	84	Granite
Manyoni	Mpapa	SG.251/97	120	0.2	-	Granite
	Chikola	SG.252/97	150	1.0	172	Granite
Igunga	Igurubi	TA.253/97	--**	-	284	L-bed/ Ny'n
	Nguriti	TA.254/97	110	Dry	-	Granite
Total			897			

Notes: * Borehole No. registered in the Ministry of Water.

** Drilling was called off due to wash-out of access road by the flood in December 1997.

A summary of each test drilling is as follows:

[Bassodesh]

The lithology is sandstone of Nyanzian system and porphylite intruded into sandstone layer. Both rocks are fractured and form excellent aquifers. EC of water is relatively high as 338 mS/m. A high yield of 8.0 m^3/hr at drawdown of 5.14 m was measured by pumping test.

[Ishponga]

The lithology of borehole is composed of granite which shows almost intact and hard rock facies. The hole was drilled to 110m depth but was dry. The electric resistivity of granite by logging is as high as 1,500 to 2,000 ohm-m.

[Maskaroda]

The lithology of borehole is composed of alluvial sediments and underlying gneiss and schist of Bubu Cataclasite. The bed-rocks are weathered and fractured. 54m depth and below is remarkably fractured, and the hole was collapsed frequently. The EC of water is somewhat high as 140 mS/m. A high yield 9 m^3/hr at drawdown of 25.5 m was measured by pumping test.

[Mara]

The lithology of borehole consists of volcanic ash and underlying gneiss of Bubu Catacrasite which is remarkably weathered and fractured. The hole was collapsed frequently. Water quality is good for drinking (EC = 58.6 mS/m pH = 7.34). High yield of 9 m^3/hr at drawdown of 0.33 m was measured by pumping test.

[Nkuhi]

The lithology of borehole is composed of Kilimatinde Cement and underlying siltstone and sandstone of Nyanzian System. Kilimatinde Cement consists of loose and impervious limestone, calcareous mud and conglomerate showing very low resistivity of 10 to 120 ohm-m. Water was stricken at 73 m depth. Crushed and weathered siltstone and sandstone form excellent aquifers. Borehole was drilled up to 134 m and casing was installed to 100 m depth. Water quality is good for drinking (EC = 65.5 mS/m, pH = 6.64). High yield of 7.2 m^3/hr at drawdown of 13.32 m was measured by pumping test.

[Choda]

The lithology of borehole is composed of loose limestone or calcareous mud of Kilimatinde Cement to 28 m depth and then granite and intruded dolerite. Water strikes were at 44 m and 46 m depth. Main aquifers are fractured granite and intruded dolerite dikes. Water quality is good for drinking (EC = 84.4 mS/m, pH = 7.18). High yield of 9 m^3/hr at drawdown of 2.79 m was measured by pumping test.

[Mpapa]

The lithology of borehole is composed of weathered and fresh granite. Though water strikes were at 54 m, 66 m and 77 m depth , a small yield was observed by pumping test (0.15 m^3/hr at drawdown 11.4 m).

[Chikola]

The lithology is composed of highly weathered granite to 16 m depth, then slightly weathered granite. Some weathered and fractured part were found in various thickness of one to six m. Fresh and hard granite appeared from 110 m to bottom. Water strikes were at 28 m, 50 to 53 m and 71 to 72 m. Water quality is good for drinking (EC = 172 mS/m, pH = 7.54). A small yield of one m^3/hr at 55.6 m drawdown was measured by pumping test.

[Igurubi]

The borehole was drilled up to 144 m depth and struck a high water yield. The hole, however, could not be cased with pipes due to high water head and collapsing hole wall. The contractor tried several times to prevent collapsing of hole, but it was hardly beyond their technology and outfits. Finally borehole was called off due to washing out of access road by flood taken place In December 1997.

The lithology of borehole was composed of loose silt, sand and gravel of Manonga-Wembere Lake-beds up to 83m depth and then metamorphosed igneous rock of Nyanzian System. Sand and gravel layers and fractured weathered igneous rocks form an excellent aquifer. Water strikes were at 54 m, 70 m and 88 m depth. Water quality is relatively good while conductivity is a little high as 284 mS/m.

[Ngruti]

The lithology was composed of superficial sediments to 23 m, and then weathered granite to 43 m depth. From 43 m almost intact and slightly fractured granite continues to bottom. The hole was almost dry.

3.6.4 Hydrogeological Map

In order to compile all the hydrogeological and groundwater data and information into maps covering target district and target village, hydrogeological maps were prepared.

Four satellite imageries were provided by JICA covering the whole Study area. Some 2,300 sheets of aerial photographs with scales of 1/30,000 and 1/50,000 (taken during 1990 to 1995) along 48 flight courses were procured from the Service and Mapping Division of Ministry of Land. The basin-wide hydrogeological structures were detected through the interpretation of the satellite imageries, and the local hydrogeological structures on the pilot villages and target villages were detected by interpreting aerial photograph.

Two kinds of hydrogeological maps were prepared for the Study. One is a hydrogeological map of target districts with a scale of 1/100,000 as shown in Figures 3.1 (1) to (4). The map was compiled basing on the existing geological maps called the "quarter degree sheet" and the result of interpretation of satellite imageries and aerial photographs. They give geological data and information inclusive of the hydrogeological units, geological structures such as faults and rift valleys, the location of existing and test boreholes, statistic level and quality of groundwater and others.

Another is a hydrogeological map of target village with a scale of 1/25,000, which shows the local hydrogeological structures being compiled on the basis of the interpretation of aerial photographs and the field inspections. The map gives the data and information on the hydrogeological units, faults, lineaments and dyke rocks; locations of existing and test boreholes, dug wells and water sampling; and other information obtained through the field inspection.

3.6.5 Productive Aquifers

The aquifer systems in the Study area are summarised in Figures 3.1 (Hydrogeological Maps of District) and Appendix-3 (1) (Summary of Groundwater Potential). The major productive aquifers by district and by the hydrogeological unit are as described below.

(1) Hanang District

[Unit A]

The unit is located in Hanang Volcano and it's southern slope; and classified into A-1 and A-2 sub-unit. Main aquifer of A-1 is Hanang Volcanics composed of lava and phyroclastics. Fractured lava is expected to form the potential aquifer. Some springs are found on the mountain-foot and used for domestic purpose. A-2 unit is located between rift valley faults and aquifers composed of volcanics and underlying fractured gneiss of Bubu Catacrasite. The required borehole depth may be 100 to 150 m. The expected borehole yield of the unit is high and the static water level is 20 to 30 m below the ground. The successful rate of borehole of the unit is estimated to be 70 to 75%.

[Unit B]

The unit occupies the eastern and southern parts of the district and classified into B-1 and B-2 sub-unit. Main aquifer is fractured gneiss and granite. Two test boreholes were drilled in Mara and Maskaroda villages belonging to B-1 sub-unit, and high yields were hit at the both sites. A high groundwater potential is expected in B-1 sub-unit along the rift fault. The borehole depth in the unit may be around 80 to 100 m. The expected borehole yield is high and the static water level is 15 m below the ground. The successful rate of borehole of the unit is estimated to be 70 to 80%.

[Unit C]

This is located in the east and northeast part of the district and classified into four sub-units. C-1, C-2 and C-3 sub-units are located in high land and C-4 is located in the rift valley. Relatively high groundwater potential is expected for C-4 sub-unit in the fractured granite and/or Nyanzian system. A test borehole was drilled at Bassodesh village belonging to C-4 sub-unit and hit high yield. On the other hand, another test borehole was drilled at Ishponga village belonging to C-2 sub-unit but this was dry. The required borehole depth in the unit may be around 100 m. The expected borehole yield is one to five m^3/hr and the static water level is 25 m below the ground. The estimated successful rate of borehole of the unit is 70 to 80%.

(2) Singida Rural District

[Unit A]

The unit is observed in the northern part of Bassotu fault escarpment and classified into A-1 to A-3 sub-unit. Main aquifers are fractured and weathered granite and Nyanzian system. Groundwater potential is relatively high in A-1 and A-3 units, while A-2 unit is not so high. The required borehole depth in the unit may be 80 to 100 m. The expected static water level is 10 to 30 m below the ground. The successful rate of borehole of the unit is estimated to be 70 to 75%.

[Unit B]

The unit is located in the rift valley between Bassotu fault and Singida fault escarpment and classified into B-1 to B-4 sub-unit. High groundwater potential is expected in the units except B-4 unit which situates on the hilly area above Singida fault escarpment. B-3 unit is located around Singida town and many boreholes were sunk for the urban water supply. The expected borehole depth is about 100 m. Static water level is estimated to be relatively shallow in B-1, B-2 and B-3 units, while it may be deeper in B-4 unit where is nearby the fault escarpment. The successful rate of borehole of the unit is 75 to 80%.

[Unit C]

This is located in Turu rift valley. High groundwater potential is expected for this unit. The expected borehole depth is about 100 m. Static water level is estimated at deeper horizon in a strip along the fault escarpment. The successful rate of borehole of the unit is around 70 to 75%.

[Unit D]

The unit is located in the east of the C unit and the outside of rift valley. Groundwater is expected to be available only for the area along lineament running in SW-NE direction.

(3) Manyoni District

[Unit A]

The unit is located in Bahi basin, the eastern part of the district, and classified into A-1 to A-4 sub-unit. A-1 and A-4 sub-units are located nearby the fault escarpment with high groundwater potential. A-2 unit is located along A-1 sub-unit and relatively high groundwater potential could be expected. A-3 sub-unit is located in Bahi basin and hydrogeological structure of granite is hidden by overlying Kilimatinde Cement formation. The expected borehole depth is some 70 to 80 m. Static water level is estimated at 35 to 45 m in A-1 sub-unit. The successful rate of borehole of the unit is 70 to 80%.

[Unit B]

The unit is located along the Kilimatinde fault escarpment and classified into B-1 and B-2 sub-unit. B-1 unit is confined within an area below the escarpment and there is a borehole supplying water to Manyoni town. B-2 sub-unit is located in an area between two fault escarpments along Bahi basin. High groundwater potentials are expected for both sub-units. Static water levels are estimated at 35 to 55 m. The expected borehole depth is around 110 to 150 m. The successful rate of borehole of the unit is 75 to 80%.

[Unit C]

This is spread out on the slightly undulating hill underlain by Kilimatinde Cement and classified into C-1 to C-4 sub-unit. C-1 sub-unit is located along the fault escarpment through Manyoni town and high groundwater potential is expected. C-3 sub-unit is located in the low and flat area along the railway to Tabora and along an assumed fault zone. Relatively high groundwater potentials is expected from the sub-unit. It is difficult to estimate groundwater potential of C-2 and C-4 sub-units because hydrogeological structure of granite is hidden by overlaying Kilimatinde Cement. The EC of groundwater in the unit shows sometimes relatively high affected by groundwater from aquifer of Kilimatinde Cement. The successful rate of borehole of the unit is 70 to 75%.

[Unit D]

This is located on the plateau extending over the south of the district, underlain directly by granite, and classified into D1 to D3 sub-unit. Groundwater potentials are relatively high in a strip along distinct faults in D-1 sub-unit. A test borehole was drilled in Chikola village in D-1 sub-unit but a small yield was measured. D-2 sub-unit is located in the plateau extending in the east of Bahi basin. A test borehole was drilled at Mpapa village in D-2 sub-unit but small yield was met as well. C-3 sub-unit is located in the western end of the district. The expected borehole depth is 70 to 80 m and the static water level is estimated at 10 to 30m depth in the unit. The successful rate of borehole of the unit is 70 to 75%.

(4) Igunga District

[Unit A]

The unit is located in the southern half of the district and classified into A-1 to A-4 sub-unit. Main aquifer is weathered and fractured granite along the fault and lineament running in SWW-NEE direction. The target villages concentrate in A-1 sub-unit. A test borehole was drilled in Nguruti village but was dry. Relatively high groundwater potential may be expected along the relatively distinct lineament in A-1 sub-unit and the fault running in NS direction in

A-4 sub-unit. The expected borehole depth is 70 m and the static water level is 20 to 30 m. The successful rate of borehole of the unit is 70 to 75%.

[Unit B]

This is located in the northwest part of the district and classified into B-1 to B-3 sub-unit. Main aquifer is fractured and weathered part of Nyanzian System composed of schist and metamorphosed volcanic rock. B-1 sub-unit is located along faults and is expected to have a relatively high groundwater potential than B-2 sub-unit. The expected borehole depth is 70 m and the static water level is 30 m. The successful rate of borehole of the unit is 70%.

[Unit C]

The unit is located in the northeast portion of the district and classified into C1 to C3 sub-unit. Main aquifers are formed in Manonga Wembere Lake-beds and fractured rock of Nyanzian System. C-1 sub-unit is located along a distinct fault. A test borehole was drilled in Igrubi village and met an excellent aquifer but the borehole construction was failed due to heavy collapse of layers. C-2 sub-unit is located along a distinct fault, and high groundwater potential is expected for aquifers within Manonga Wembere Lake-beds and fractured granite along the fault. The groundwater in aquifers may be saline. The successful rate of borehole of the unit is 70 to 80%.

3.6.6 Groundwater

(1) Groundwater Level

According to the borehole record, the static water levels in the Study area are, in general, 12 m to 24 m below the ground (refer to Table 3.1). The level is appropriate in terms of application of deep-well type handpump which is practically effective to a water level of 40 m or less. In some villages located on the following hydrogeological units (refer to Figure 3.2), the static water level in borehole is supposed to be 40 m or more:

[Hanang district]: C-1, C-2 and C-3 units located on the plateau between rift valley.
[Singida district]: B-4 and E-4 units located nearby the fault escarpment.
[Manyoni district]: A-1, B-1, B-2, C-2, C-3 and C-4 units located nearby the fault escarpment.

The data and information of existing boreholes were drawn out from 22 villages where located on the above-mentioned hydrogeological units to indicate them on the hydrogeological maps; and, as a result, it is found that the static water levels for eight villages are deeper than 45 m. For groundwater development in the eight villages, installation of a powered pump such as engine-pump, wind-pump or solar pump will be needed.

(2) Groundwater Quality

(a) Water Quality Survey

The water quality survey was carried out over 284 target villages. The Study Team collected 737 water samples from different water sources such as boreholes, dug-wells, water-holes and others. In situ and laboratory analysis were conducted to cover the items of colour, muddiness, smell, temperature, electric conductivity (EC), pH, F, NO_2 , NO_3 , NH_4 and colon bacillus.

(b) Water Quality of Deeper Aquifer

Water quality of different water sources were compared regarding four items of EC, Colon bacillus, F and Colour based on a result of water quality survey for whole target villages. Water sources were classified into borehole (BH), dug-well which is manually dug shallow well lined with concrete ring (DW), water-hole which is traditional dug hole without any lining (WH) and charco dam which is simple small water-pond. Water quality of samples from household containers was also measured. Results of analysis are shown in Figure 3.3 and as described below:

[Colour]: 60 % of water-hole samples and 40% of charco dam samples showed milky or turbid colour. On the other hand boreholes water was very clean. 20% of dug-well samples showed milky colour. About 30% of stocked water in household showed milky colour.

[Colon bacillus]: Colon bacillus was undoubtedly observed over 59 % of water-hole samples and 42% of charco dam samples (undoubted number means more than 11 number of colony of colon bacillus). On the other hand, they were observed from 33 % of dug-well samples and 15 % of borehole samples.

[F]: F (fluorine) was observed relatively high over the granite area, but the difference between water sources was not so clear.

[EC]: EC value of samples from boreholes was higher than that of other water sources; 67% of water samples gave EC value of more than 100 mS/m. The ratio of water samples with EC value of more than 100 mS/m is 25% for dug-well, 13% for water-hole, 12% for charco dam and 20% for household water container. The survey reveals that about 40 % of villagers are depending on turbid or unhealthy water sources contaminated with colon bacillus. On the other hand, the water from boreholes and dug-wells showed better water quality.

(c) Water Quality of Boreholes

Typical values of EC and pH are shown on Figure 3.3 and Appendix-2.

[EC]: The allowable value of EC is 200 mS/m in accordance with the Standard of Tanzania as shown in the design criteria of the Ministry of Water. High EC value are, however, supposed to be in some hydrogeological units especially those units within the Manonga-Wembere basin, Bahi basin and some of rift valleys. About 10% of boreholes in the units have high EC value of more than 300 mS/m.

[pH]: 73 % of borehole water show pH values within the allowable value of Tanzanian Standard (6.50 to 9.20). 27 % of borehole water show pH between 5.01 to 6.49, especially in Manyoni district, 41 % of borehole show lower than 6.5 (but higher than 5.0).

(d) Water Quality of Household Container

Water quality of 453 household containers in the whole Study area were measured. 58% of water in household container were collected from water-holes and charco dams, 34% of water were from dug-wells and 8 % from boreholes. A comparison of number of colon bacillus between household container and those original sources is shown in Table 3.5 and described as follows:

- 57% of water kept in household containers are contaminated by colon bacillus.
- 47% of water kept in household containers are collected from borehole contaminated by colon bacillus although only 14% of original water of boreholes contaminated.
- 50% of water collected from dug-wells and 44% from water-holes are contaminated by colon bacillus although the original water are contaminated by 32% and 62% respectively. This rate shows almost same percentage as water from boreholes.
- In conclusion, it is important to keep household container clean and make a proper hygiene habit to prevent water contamination by colon bacillus during collection and stock of household water.

3.6.7 Groundwater Resource

As stated in the foregoing sections, the groundwater potential in the Study area is, in general, in an excellent category in terms of yield, depth and successful rate of borehole and groundwater quality. The extent of groundwater resource is examined in view of the basin-wide water balance in this section.

The rate of annual groundwater recharge is, in general, not less than 1 % of annual rainfall even in an arid regions where annual rainfall reaches around 100 mm. The rate in a monsoon region reaches, in general, to 10% or more. The rate in a savannah region is not known well. It is, however, believed to be not less than few %, and might be in between those rates in the arid and monsoon regions.

Assuming that the rate of annual groundwater recharge of the Study area is 1 % of the annual rainfall (say 600 mm/a), the groundwater is rechargeable to some 312 MCM/a (0.01 x 0.6 m x 52,000 km^2). Supposing the annual runoff coefficient of river flow at 2 % (refer to Section 3.4.2), the total hydrological balance of the Study Area is made as shown in the following table:

Table 3.3 Hydrologic Balance of the Study Area

Factors	Water Amount (MCM/a)	Remarks
Rainfall	31,200	600 mm/a x 52,000 km^2
Evapo-transpiration	30,264	97% of annual rainfall or 25% of pan evaporation of 2,400 mm/a
Surface Runoff	624	2% x 600 mm x 52,000 km^2
Groundwater Recharge	312	1% x 600 mm x 52,000 km^2

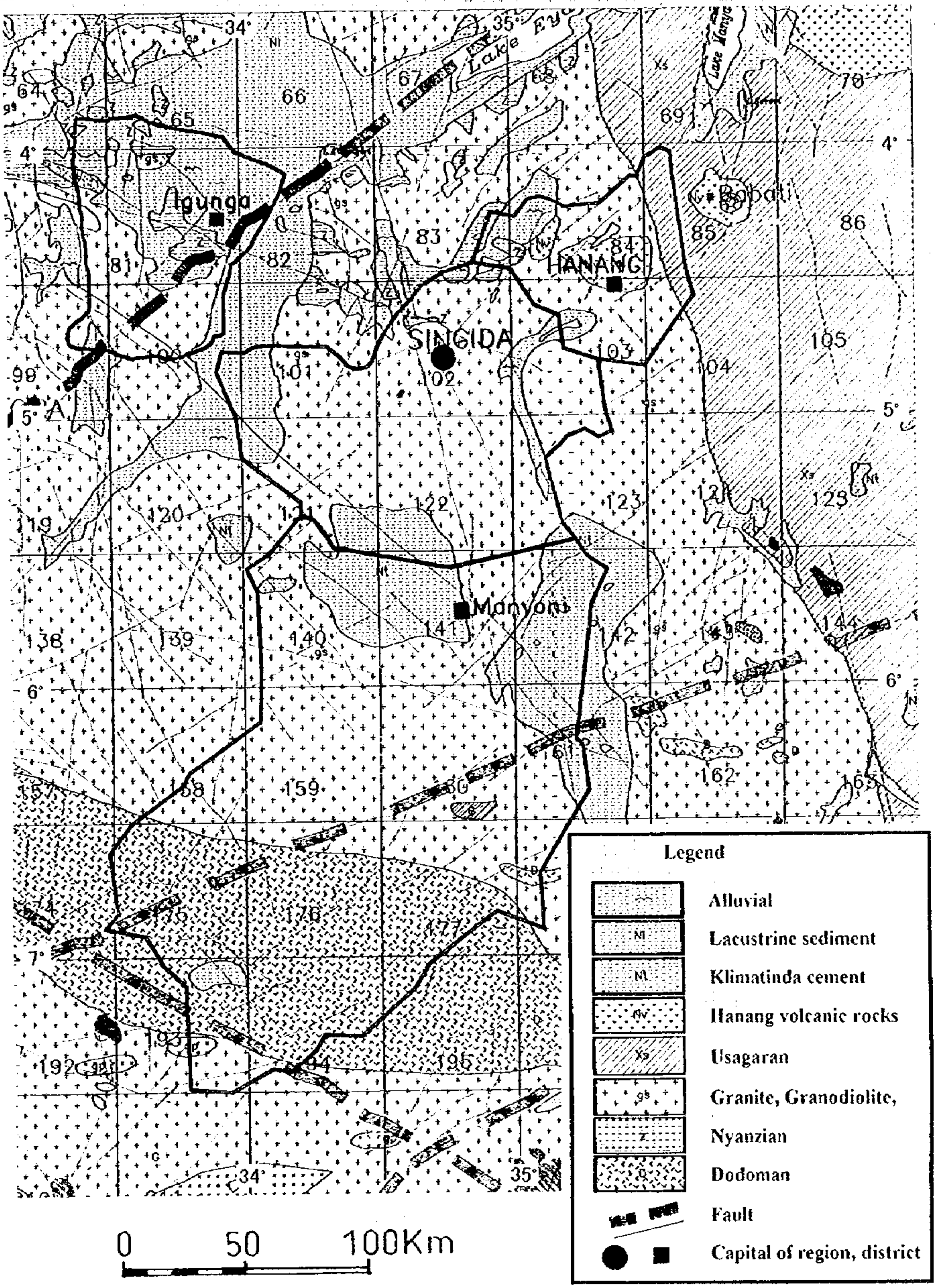
The water demand of the Area in the year of 2016 is estimated at 57 MCM/a (18% of above annual groundwater recharge) as shown in the table below:

Table 3.4 Future Water Demand of the Study Area

Purpose	Water Demand in 2016 (MCM/a)	Remarks
Domestic	18.6	Projected popul'n of 1.7 million x 30 lcd x 365 day
Livestock	18.3	Livestock unit of 2.0 million x 25 lcd x 365day
Others	20.0	For industries and others
Total	56.9	

The groundwater resource of the Study area seems to be good enough for the socio-economic use in foreseeable future.

Figure 3.1
Geological Map of the Study Area



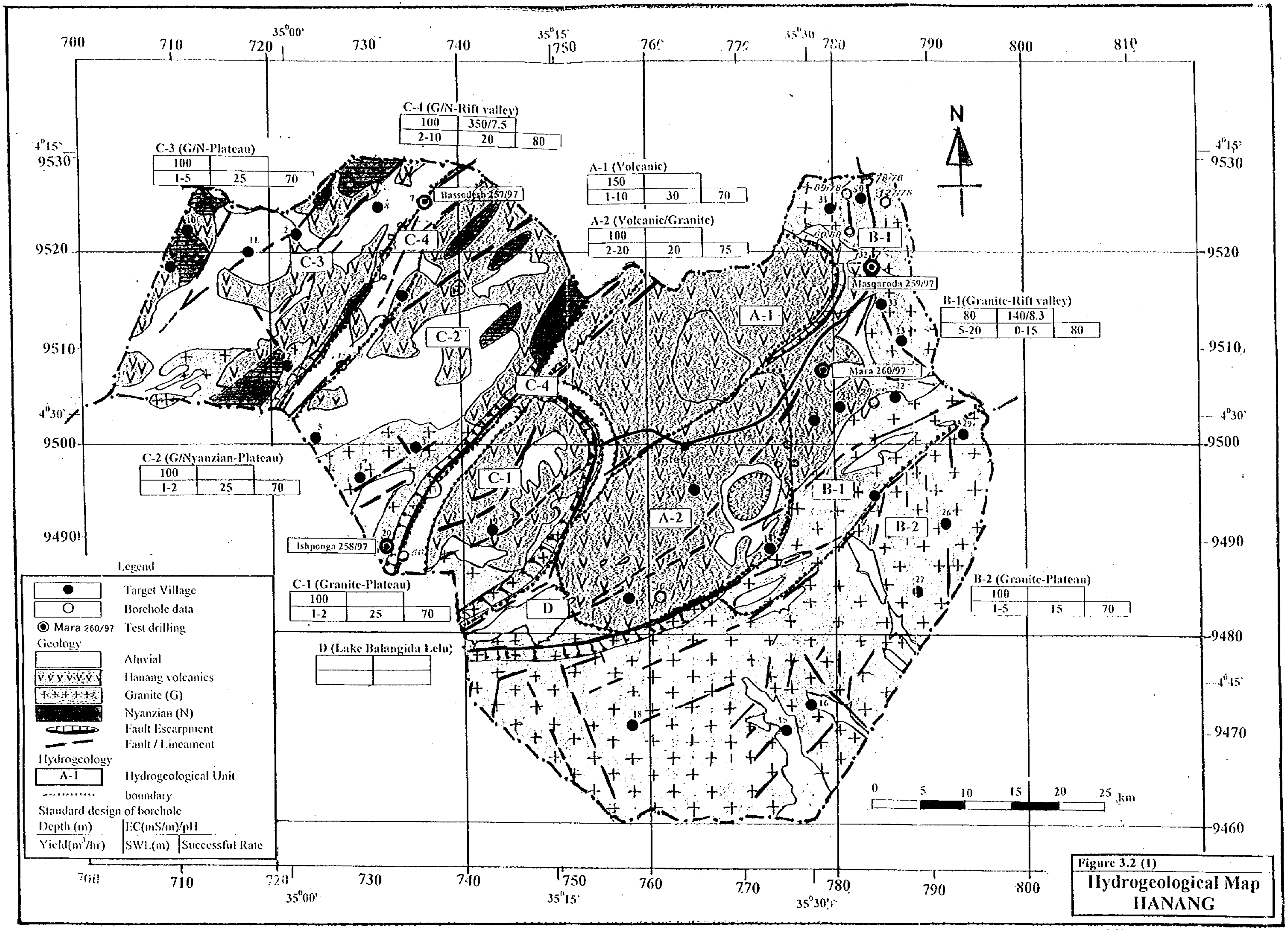


Figure 3.2 (1)
Hydrogeological Map
HANANG