No.

The United Republic of Tanzania

THE STUDY
ON WATER SUPPLY IMPROVEMENT
IN COAST REGION
AND DAR ES SALAAM PERI-URBAN
IN THE UNITED REPUBLIC OF TANZANIA

Final Report

MAIN REPORT

December 2005

JAPAN INTERNATIONAL COOPERATION AGENCY
Global Environment Department

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In this report, project costs are estimated based on prices as of July 29, 2005 with an exchange rate of US$1.00 = Tanzania Shilling (Tsh) 1,137 = Japanese Yen ¥ 112.47.

PREFACE

In response to a request from the Government of the United Republic of Tanzania, the Government of Japan decided to conduct the Study on Water Supply Improvement in Coast Region and Dar es Salaam Peri-Urban in the United Republic of Tanzania and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team composed of Pacific Consultants International (PCI) and Japan Techno Co., Ltd., headed by Mr. Yasumasa YAMASAKI of PCI to Tanzania three times between August 2004 and October 2005. In addition, JICA set up an advisory committee headed by Mr. Haruo IWAHORI, Japan International Cooperation Agency, between August 2004 and December 2005, which examined the Study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of the United Republic of Tanzania, and conducted field surveys in the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, 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.

December 2005

Etsuo Kitahara
Vice-President
Japan International Cooperation Agency

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Mr. Etsuo Kitahara
Vice-President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit you the final report entitled "The Study on Water Supply Improvement in Coast Region and Dar es Salaam Peri-Urban in the United Republic of Tanzania". This report has been prepared by the Study Team in accordance with the contracts signed on 11 August 2004 and 20 May 2005 between Japan International Cooperation Agency and the Joint Study Team of Pacific Consultants International and Japan Techno Co., Ltd.

The report examines the existing conditions related to water supply, water resources potential and socio-economy in Coast Region and Dar es Salaam Peri-Urban, proposes master plan for the improvement of water supply and presents results of the feasibility study on priority projects identified in the master plan.

The report consists of the Summary, Main Report, Supporting Reports, Data Book (including drawings). The Summary summarizes the results of all studies. The Main Report contains the existing conditions, the proposed master plan, the results of the feasibility study on the priority project, and conclusions and recommendations. The Supporting Report includes technical details of the Study. The Data Book contains basic data and drawings used in the Study.

All members of the Study Team wish to express grateful acknowledgement to Japan International Cooperation Agency (JICA), JICA Advisory Committee, Ministry of Foreign Affairs, Embassy of Japan in the United Republic of Tanzania, and other donors, NGOs and also to Tanzanian officials and individuals for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the improvement of water supply situation in Coast Region and Dar es Salaam Peri-Urban, and that friendly relations of both countries will be promoted further by this occasion.

Yours Faithfully,

Yasumasa Yamasaki
Team Leader

EXECUTIVE SUMMARY

1 PROJECT BACKGROUND AND EXISTING CONDITIONS

A water supply master plan for Coast Region and Dar es Salaam Peri-Urban was formulated in 1979. In the master plan, group piped water supply schemes were proposed as the main water supply scheme. However, construction of those proposed water supply scheme were not been accomplished due to financial constraints. Accordingly, 65% of inhabitants in the two regions still do not have access to safe and clean water.

In October 2001, the Government of Tanzania requested the Government of Japan to carry out the formulation of water supply plan and feasibility study of the priority projects to be formulated through the study for Coast region and Dar es Salaam Peri-Urban.

It is thought that a compact piped water supply scheme using groundwater of which service area is in and around a village, is a more suitable scheme in Coast Region and Dar es Salaam Peri-Urban area than group piped water supply scheme, considering the socio-economic situations and the view points of operation and maintenance, and water source capacities realised in this Study.

In the Study area, there are three large scale piped water supply schemes namely: Upper Ruvu Water Supply, Lower Ruvu Water Supply (under DAWASA) and Chalinze Water Supply Scheme.

The total number of existing small scale piped water supply schemes in Coast Region and Dar es Salaam Region are 20 and 73. 75% of these schemes were constructed in 1970's in Coast Region, while most of the schemes in Dar es Salaam Region were constructed in 1990's and 2000's. However, not all schemes are in good working condition and the working ratios are 35 % (Coast Region) and 77 % (Dar es Salaam Peri-Urban).

The main reason for malfunction of the schemes is trouble with intake facilities such as diesel engines, generators and pumps. Other main reason is theft of equipment and water source problem. Although damages of pipes are frequent, problem with pipelines is minor reason for malfunction.

2 WATER RESOURCES

Through the studies and investigations, development potential of both surface water and groundwater resources are evaluated.

(1) SURFACE WATER POTENTIAL

In the Study Area, it is identified that the three rivers, namely the mainstream of Wami, Ruvu, and Kizinga are perennial rivers. By the study, it is concluded that only the Wami River has the potential for surface water development, with the total amount of 5.003 m^3/s. Since the required intake amount is beyond the available river discharge, the Ruvu and Kizinga Rivers cannot be developed as new surface water sources.

Taking into account of the capability of water supply facility, potential area by distance is evaluated using the vertical drop of 100 m from the river as an index. As the result, the area within 5km from the Wami River is selected as the potential area of surface water development.

(2) GROUNDWATER POTENTIAL

In the study area, the aquifers are identified as the four types of Quaternary, Neogene, Precambrian and Cretaceous. The aquifer of Quaternary and Neogene are categorized as stratum aquifer, while the Precambrian, Cretaceous and Jurassic are categorized as fractured aquifer of the basement rocks. The results of existing well survey suggest that the Quaternary aquifer is the most promising aquifer in the area. Next to Quaternary aquifer, Neogene aquifer shows relatively higher yield. For the geological formation of Precambrian, Cretaceous and Jurassic, the yields are generally small.

The hydrogeological map and the groundwater resources evaluation map have been prepared by the Study. The evaluation map was drawn in accordance with the distribution of groundwater yield and quality (EC). *Figure 1* shows the combination of factors used in the evaluation map.

Water Quality EC (µS/m)		Allotment Points	Estimated Yield (liters/min) 100 < Good	10 - 100 Fair	< 10 Poor
			4	2	1
< 1000	Good	3	**12**	**6**	**3**
1000 - 3000	Fair	2	**8**	**4**	**2**
3000 <	Poor	0	**0**	**0**	**0**
			Weighting		

Evaluation of Groundwater Resources

Weighting	Evaluation
12, 8	Promising water source for the Piped Scheme to serve more than 2,500 population with single well
6, 4	Fairer water source for the Piped Scheme to serve 2,500 population with multi-well system
3, 2	Can be utilized for Hand Pump
0	Not suitable for drinking water

Figure 1 Matrix of the Classification for Groundwater Evaluation

The evaluation is described as follows.

Weighting: 12 and 8 Good

Promising water source for the Piped Scheme of more than 2,500 populations by single well. EC is good or fair for drinking, and besides the yield expected is 100 liter/min and more.

Weighting: 6 and 4 Fair

Promising water source for the Piped Scheme of more than 2,500 populations by multi-well system. EC is good or fair for drinking, and the yield expected is from 10 to 100 liter/min. This volume is exploitable using a small submersible pump.

Weighting: 3 and 2 Poor

The yield is fair and exploitable for hand pump water supply scheme. EC is good for drinking or fair for drinking.

Weighting: 0 Not Applicable

– EC is poor for drinking. It may be possible to use as a source for small scale industrial water or livestock water, otherwise water treatment facility is necessary.

3. WATER SUPPLY PLAN

The water supply plan was formulated for 278 villages targeting the year 2015. The target population is about 1.4 million in 2015. Estimated water demand is 13.9 x 10^3 m^3/day in Coast Region and 20.9 x 10^3 m^3/day in Dar es Salaam Region, totaling 34.8 x 10^3 m^3/day in the whole Study area.

Alternatives of the water supply scheme and district wise number of each scheme are summarized in *Table 1*. Major water source is groundwater because surplus surface water is available only in the Wami River.

Table 1 Number of Village to be supplied by each Scheme

	Level-2	Level-1	Rehabilitation	Extension
Bagamoyo	3 schemes, 3 villages	24 schemes, 6 villages	1 scheme, 1 village	38 villages
Kibaha	2 schemes, 2 villages	45 schemes, 14 villages		8 villages
Kisarawe	4 schemes, 2 villages	236 schemes, 74 villages		
Mkuranga	5 schemes, 7 villages	237 schemes, 73 villages		
Ilala	3 schemes, 3 villages	43 schemes, 10 villages		11 villages
Kinondoni	1 scheme, 1 village	14 schemes, 2 villages		11 villages
Temeke	4 schemes, 4 villages	8 schemes, 2 villages		19 villages
	22 schemes, 22 villages	607 schemes, 181 villages	1 scheme, 1 village	87 villages

Criteria for selection of type of water supply scheme are size of population and availability of water sources in the village. Level-2 scheme is planned in villages where population in 2015 is more than 2,500 and yield of well is more than 100 liter/min. Level-1 scheme is applied in the villages where criteria for Level-2 is not satisfied and in the areas excluded from the service area of Level-2. Rehabilitation plan is prepared only for Saadani Village, Bagamoyo District. Dar es Salaam Water Supply Sewerage Authority (DAWASA) and Chalinze Water Supply Scheme have their own extension plans. Project cost is estimated as shown in *Table 2*.

Table 2 Summary of Projects Costs

Unit: Thousand USD

Type of Scheme	Construction Cost	Engineering Service (15%)	Administration Cost (3%)	Physical Contingency (10%)	Total	Note
Level-2	13,979.2	2,516.3*	-	-	16,495.5	22 schemes
Level-1	10,561.8	1,584.3	316.9	1,056.2	13,519.2	607 schemes
Rehabilitation	181.2	27.2	5.4	18.1	231.9	1 scheme
Chalinze (Phase II)	7,546.9	754.7	226.4	754.7	9,282.7	42 villages
Total	32,269.1	4,882.5	548.7	1,829.0	39,529.3	

Note *: Approximately 3% of construction cost was added as the cost for soft component.

Implementation schedule of water supply plan is arranged as shown in *Table 3* considering the financial status of MoWLD.

Table 3 Implementation Schedule for Water Supply Plan

Project	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Priority Project (Level-2)	x	x	x							
Chalinze (Phase II)	x	x								
Level-1				x	x	x	x	x	x	x
Rehabilitation				x						
Mkuranga	x	x	x	x	x					
DAWASA	x	x	x							

Implementation of water supply plan will raise the water supply level up to 66.9 % in 2009 and 68.1 % in the target year 2015. This raising is coherent with Revised Poverty Reduction Strategy of which target is to raise the water supply level up to 65 % in 2009.
Annual disbursement for implementation of water supply plan is shown in *Table 4*.

Table 4 Annual Disbursement Schedule

Unit: thousand USD

Project No.	Project		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	Piped Water Supply Scheme (Level-2)	Engineering	875.9	654.4	986.0								2,516.3
		Construction	4,865.8	3,635.7	5,477.8								13,979.3
		Sub-Total	5,741.7	4,290.1	6,463.8								16,495.5
2	Hand Pump (Level-1)	Engineering				138.0	138.0	138.0	138.0	138.0	138.0	138.0	965.7
		Construction				919.7	919.7	919.7	919.7	919.7	919.7	919.7	6,438.0
		Sub-Total				1,057.7	1,057.7	1,057.7	1,057.7	1,057.7	1,057.7	1,057.7	7,403.7
3	Rehabilitation	Engineering				27.2							27.2
		Construction				204.7							204.7
		Sub-Total				231.9							231.9

As the most preferable option of management, operation and maintenance for water supply schemes, Community-Owned Water Supply Organization (COWSOs) such as Water Users Association (WUA) and Water Trust/Cooperative are proposed.

4. PRIORITY PROJECT

The Priority Project was selected considering the appropriate scale of project and proportion of population in villages. 22 Level-2 schemes in 22 villages were selected as the Priority Project. The list of the Priority Project is shown in *Table 5*. .
Preliminary design of the Priority Project was prepared based on unit water demand of 25 litre/capita/day and institution demand was also taken into consideration. Basic concept of design is to supply by gravity after exploitation of water from the intake by submersible pump. No treatment plant is planned in order to minimize the operation cost of schemes, except for the one village where source is surface water.

The cost for implementation of the Priority is estimated as 16.5 million USD including engineering cost assuming implementation by Japan's Grant Aid Project.
Implementation of the Priority Project is planned to start in 2006 and its completion in 2008 as shown in *Table 6*.

Table 5 List of Priority Project

District/Municipality Village/Mitaa	Name of Village	Serial No. of Scheme	Service Population (2002)	Service Population (2010)	Service Population (2015)	Number of Wells	Water Production (m^3/day)
BAGAMOYO							
KIBINDU	KIBINDU	BGM-1	4,904	5,746	6,344	2	173
KWAMDUMA	KWAMDUMA	BGM-2	2,545	2,982	3,292	2	86
MKANGE	MATIPWILI	BGM-3	1,948	2,283	2,518	Wami	72
KIBAHA							
RUVU	MINAZI MIKINDA (1/2)	KBH-1A	1,624	2,083	2,508	1	72
RUVU	MINAZI MIKINDA (2/2) /KITOMONDO	KBH-1B	1,627	2,102	2,513	1	72
KISARAWE							
CHOLE	CHOLE	KSW-1	2,685	3,001	3,217	2	106
MSIMBU	MSIMBU	KSW-2	2,199	2,458	2,635	2	76
MKURANGA							
LUKANGA	NJOPEKA	MKR-1	3,371	4,439	5,272	Spring	132
VIKINDU	MWANDEGE/KIPALA	MKR-2	2,100	2,370	2,815	1	79
VIKINDU	KISEMVULE	MKR-3	2,260	2,731	3,244	2	86
VIKINDU	MOROGORO MFURU MWAMBAO	MKR-4	1,945	2,036	2,635	1	72
VIKINDU	VIANZI	MKR-5	1,871	2,463	2,926	1	79
ILALA							
KITUNDA	KITUNDA-Kivuke (1/2)	ILL-4A	2,614	3,746	4,690	2	126
	KITUNDA-Kivuke (1/3)	ILL-4B	1,744	2,499	3,129	1	90
	KITUNDA-Mzinga	ILL-4C	4,114	5,895	7,382	2	198
MSONGOLA	MSONGOLA	ILL-5	1,410	2,021	2,530	1	72
PUGU	PUGU STATION	ILL-6	6,481	9,287	11,629	1	72
KINONDONI							
GOBA	MATOSA	KND-1	2,580	3,558	4,350	1	72
TEMEKE							
MJIMWEMA	KIBUGUMO	TMK-1	1,883	2,698	3,379	1	84
MJIMWEMA	MJIMWEMA	TMK-2	2,000	2,866	3,589	1	90
PEMBA MNAJI	YALEYALE PUNA	TMK-3	3,113	4,461	5,586	1	150
PEMBA MNAJI	TUNDWI SONGANI	TMK-4	1,475	2,114	2,647	1	72

Table 6 Implementation Schedule of Priority Project

District/Municipality	2006	2007	2008	2009	2010
Bagamoyo	←→				
Kibaha	←→				
Kisarawe	←→				
Mkuranga		←→			
Ilala			←→		
Kinondoni		←→			
Temeke			←→		

Implementation of the Priority Project will contribute to 5.4 % of raise in the water supply level by the target year 2015.

5. EVALUATION OF PRIORITY PROJECT

Results of the economic analysis are summarized in *Table 7*. NPV and B/C ratio indicate that the economic benefit will exceed the cost. EIRR is calculated as 13% in Coast and 16% in Dar es Salaam. The results suggest that the project is economically viable.

Table 7 Summary of Results of the Economic Analysis

Region	NPV	B/C Ratio	EIRR
Coast	722	1.07	13%
Dar es Salaam	2,123	1.27	16%

Water tariff is set at 1 Tsh/litre, which is same as the amount of Willingness to Pay (WTP) examined in the Study. The 80 % of recovery rate would assure the full operation, and maintenance cost over 10 years for the Priority Project including replacement cost. The profit-loss break-even point of revenue collection is the average recovery rate of 74 % in Coast Region and 51 % in Dar es Salaam Region. It can be concluded all the priority projects could gain operational surplus, thus financially viable.

Formation of COWSO and establishment of District Water and Sanitation Team (DWST) are all in line with the national strategies and aims to assure effectiveness, efficiency, and sustainability of the water supply service. From those points of views, the plan is assessed as feasible and efficient in institutional and organizational aspects as well.

Providing facilitation package for capacity development of COWSO and DWST will enhance effectiveness, while contracting-out will increase competency and expertise in operation and maintenance of the schemes.

The results of Initial Environmental Evaluation (IEE) show that all the evaluated categories of the Priority Project fall in Category C, therefore, Environmental Impact Assessment (EIA) is not required.

The construction works for implementation of water supply plan require no special technique. Conventional methods are adequate. Thus, technique, machineries and materials necessary for the Priority Project are evaluated as technically appropriate.

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ABBREVIATIONS

ATP	Affordability-to-Pay
B/C Ratio	Benefit Cost Ratio
BTC	Belgian Technical Cooperation
CBOs	Community-Based Organizations
CIDA	Canadian International Development Agency
COWSOs	Community-Owned Water Supply Organizations
DAWASA	Dar es Salaam Water and Sewerage Agency
DD	Draw Down
DDCA	Drilling & Dam Construction Agency
DRWS	Division of Rural Water Supply
DSM	Dar es Salaam
DTH	Dawn-the-hole Hammer
DWL	Dynamic Water Level
DWSP	District Water Supply and Sanitation Team
DWST	District Water and Sanitation Team
EC	Electric Conductivity
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
ESAs	External Support Agencies
EWURA	Energy and Water Utilities Regulation Authority
FRP	Fiber Reinforced Plastic
GDP	Gross Domestic Product
GIS	Geographical Information system
GNP	Gross National Product
GPS	Global Positioning System
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IEE	Initial Environmental Examination
JICA	Japan International Cooperation Agency
LGRP	Local Government Reform Policy
M/M	Minutes of Meetings
MOL	Ministry of Land
MoNRT	Ministry of Natural Resource and Tourism
MoWLD	Ministry of Water and Livestock Development
NEMC	National Environmental Management Council
NPV	Net Present Value
NGOs	Non-Governmental Organizations
NWP	National Water Policy
NWSDS	National Water Sector Development Strategy

O&M	Operation and Maintenance
PEDP	Primary Education Development Programme
PER	Preliminary Environmental Report
PHAST	Participatory Health and Sanitation Transformation
PRSP	Poverty Reduction Strategy Paper
PWP:	Public Water Point
RF	Registration Form
RWSD	Rural Water Supply Division
RWSSP	Rural Water Supply and Sanitation Program
SC	Specific Capacity
SR	Scoping Report
SW	Scope of Work
SWAP	Sector Wide Approach
SWL	Static Water Level
TDS	Total Dissolved Solid
TOR	Terms of Reference
TRC	Technical Review Committee
UFW	Unaccounted-for water
UNICEF	United Nations International Children's Fund
VES	Vertical Electrical Sounding
VWCs	Village Water Committees
WDC	Ward Development Committee
WRI	Water Resources Institute
WSS	Water Supply System
WSSAs	Water Supply and Sanitation Authorities
WSSMC	Water Supply System Management Center
WTP	Willingness-to-Pay
WUAs	Water User Associations
WUGs	Water User Groups

<unit>

l/min	liter/minute
masl	meter above sea level
mbgl	meter below grand level
min	minute

Chapter 1

Introduction

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The United Republic of Tanzania is located in the eastern part of Africa covering 945 thousand km^2. The total population reached 34.57 million in 2002. GNP is low, US$270/capita in 2001. The coastal area in which Coast and Dar es Salaam Regions lie, has two rainy seasons, from March to May and from November to December. Annual precipitation ranges from 800 to 2,000mm.

The Government of Tanzania started Rural Water Supply Project in 1971 aimed to provide safe and clean water to the entire nation within a distance of 400m. A water supply master plan for Coast Region and Dar es Salaam Peri-Urban was formulated in 1979. In the master plan, group piped water supply schemes were proposed as the main water supply scheme. They cover many villages with extensive distribution systems using surface water. Detailed groundwater evaluation was not implemented. However, construction of those proposed water supply scheme were not been accomplished due to financial constraints. Only Chalinze Water Supply Scheme was constructed. Major factor inhibiting the provision of water supply schemes proposed in the master plan is thought that the plan being not suited for the socio-economic situations in Coast Region and Dar es Salaam Peri-Urban area. Accordingly, 65% of inhabitants in the two regions still do not have access to safe and clean water.

It is thought that a compact piped water supply scheme using groundwater of which service area is in and around the village, is a more suitable scheme in Coast Region and Dar es Salaam Peri-Urban area than group piped water supply scheme, considering the socio-economic situations and the view points of operation and maintenance, and water source capacities realised in this Study.

In October 2001, the Government of Tanzania requested the Government of Japan to carry out the formulation of water supply plan and feasibility study of the Priority Projects to be formulated through the study for Coast region and Dar es Salaam Peri-Urban.

In response to the request, the Government of Japan decided to conduct "The Study on Water Supply Improvement in Coast Region and Dar es Salaam Peri-Urban" (hereinafter referred as "the Study") based on the results of the Preliminary Study conducted in March 2004.

1.2 OBJECTIVES OF THE STUDY

The objectives of the Study are;

- To formulate a water supply plan for Coast Region and Dar es Salaam Peri-Urban,
- To conduct a preliminary design on the priority projects,
- To develop the capacity of counterpart personnel of Ministry of Water and Livestock Development and other authorities concerned in the course of the Study, and

Technical transfer on geophysical prospecting method to the Water Resources Institute.

1.3 STUDY AREA AND STUDY TARGET MITAA/VILLAGES

1.3.1 STUDY AREA

The Study covers the following area as shown in *Figure 1.1*.

- Bagamoyo, Kibaha, Mkuranga and Kisarawe Districts in Coast Region
- Dar es Salaam Peri-Urban excluding the service area defined in Dar es Salaam City Water Supply Plan.

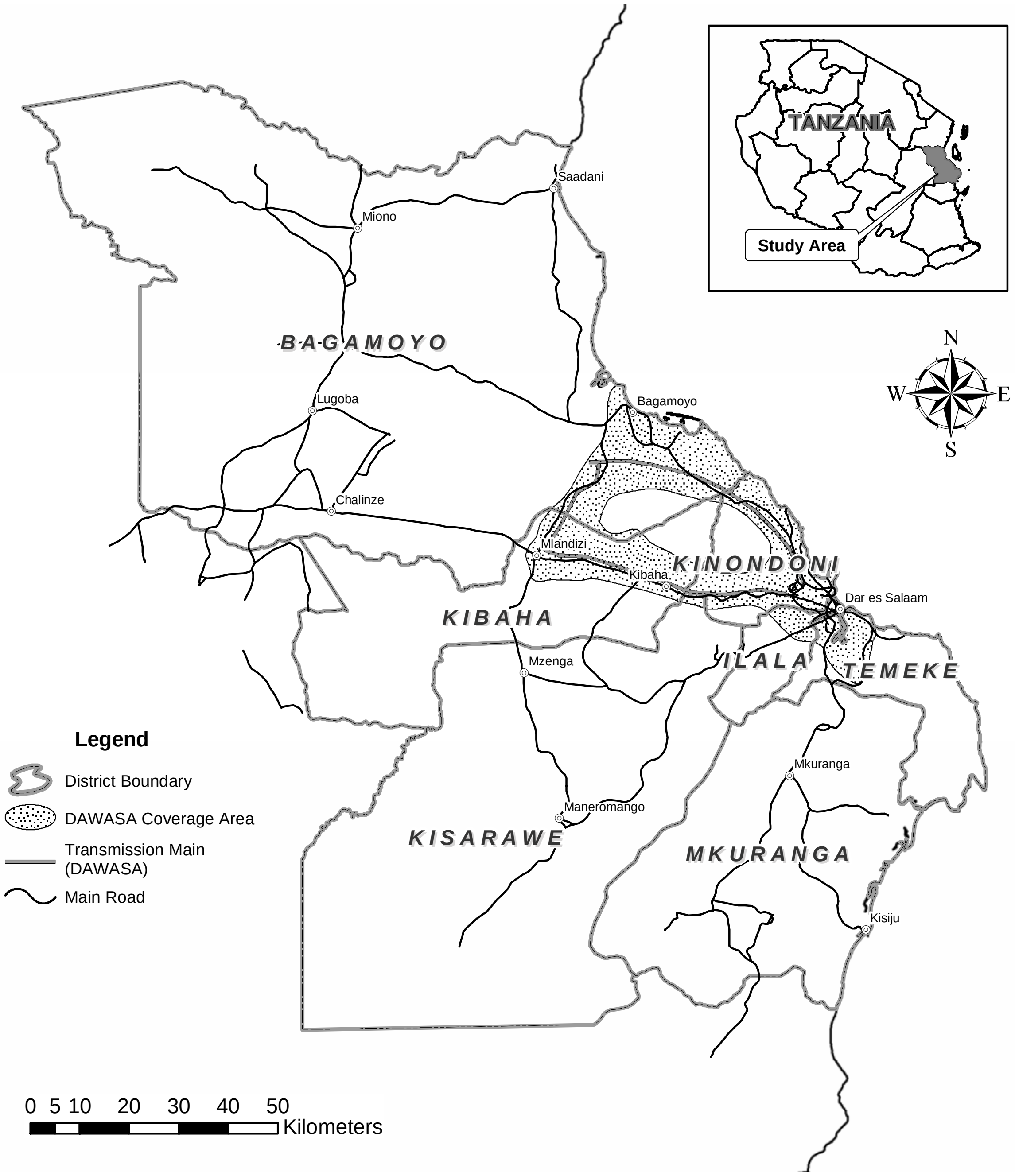


FIGURE 1.1 LOCATION MAP OF THE STUDY AREA

THE STUDY ON WATER SUPPLY IMPROVEMENT IN COAST & DAR ES SALAAM	JICA

1.3.2 TARGET MITAA/VILLAGES FOR THE STUDY

The number of target Mitaa and Villages (hereinafter, referred to as "Villages") of the Study were identified as 278 Villages based on the result of the "Village Inventory Survey" (Mitaa: An administrative unit in the urban area under the Municipality, equivalent to a Village in the rural area.). In Coast Region, most villages are sub-divided into Sub-Villages. In case of Dar es Salaam Peri-Urban, a few Villages are composed of Sub Villages. Total number of the Sub Villages in the Study target Villages is 884. Number of Villages and Sub Villages in each District/Municipality is shown in *Table 1.1*. Detailed list of Villages is presented in Chapter 1 of Supporting Report. Population used in this report is provisionally obtained through the Village Inventory Survey by interviewing at Ward and/or Village offices on the Census results of 2002, which was not yet officially reported. The compilation of Census results is still in process. Therefore, this provisional population is used in this report as the final population.

Table 1.1 Number of Study Target Mitaas/Villages and Population

District/Municipality	Total Population (2002)	Target Villages	
		No. of Village	Population served (2002)
Bagamoyo	228,967	45	104,264
Kibaha	131,242	24	40,334
Kisarawe	95,323	74	85,787
Mkuranga	186,927	74	161,263
Sub Total (Coast)	642,459	217	391,648
Ilala	634,924	24	217,358
Kinondoni	1,083,913	14	113,351
Temeke	768,451	23	142,137
Sub Total (Dar es Salaam)	2,487,288	61	473,246
Total	3,129,747	278	864,494

1.4 IMPLEMENTATION OF THE STUDY

The Division of Rural Water Supply of the Ministry of Water and Livestock Development (MoWLD) was assigned as the counterpart organization by the Government of Tanzania, while the Japan International Cooperation Agency (JICA) was assigned as the official agency responsible for the implementation of the technical cooperation program of the Government of Japan.

The Study was conducted by the Japanese study team, comprised of members from Pacific Consultants International and Japan Techno Co. Ltd, officially retained by JICA for the Study, and the counterpart staff provided by MoWLD.

The members involved in the Study are shown in *Table 1.2*

The total schedule of the Study is shown in the Flow Chart (See, *Figure 1.2*).

1.5 COMPOSITION OF THE REPORT

This report consists of four (4) volumes: Summary Report, Main Report, Supporting Reports and Data Book. The Main Report presents the summarized results of all the studies. In Chapter 2 through 4, the basic information on the Study is described. Water supply plan is described in Chapter 5. From Chapter 6 to Chapter 7, the priority projects are presented. Chapter 8 presents the Institution plan. Chapter 9 presents management, operation and Maintenance plans. Chapter 10 presents results of the evaluation of the priority projects. Chapter 11 deals with the conclusion and recommendations.

Detailed study results are described in the Supporting Report and Data Book. The contents of the Supporting Report are as follows;

Chapter 1: Village Inventory Survey
Chapter 2: Meteorology and Hydrology
Chapter 3: Topography and Geology
Chapter 4: Geophysical Exploration
Chapter 5: Socio-Economic survey
Chapter 6: Existing Well Inventory Survey
Chapter 7: Test Well Drilling
Chapter 8: Database System for Water Supply Planning
Chapter 9: Water Resources
Chapter 10: Preliminary Design of Priority Project
Chapter 11: Water Supply Development Plan
Chapter 12: Environmental and Social Consideration

1.6 MEMBERS INVOLVED IN THE STUDY

Members involved in the Study are listed in *Table 1.2*.

Table 1.2 List of Members involved in the Study

1) The JICA Study Team

The Team is composed of the following 10 experts.

Name	Assignment
Mr. Yasumasa YAMASAKI	Team Leader / Water Supply Planner (1)
Dr. Yuichi HATA	Deputy Team Leader / Hydrogeologist / Groundwater Development Planner
Ms. Mikiko AZUMA	Socio-Economist
Mr. Hiroyoshi YAMADA	Well Drilling Supervisor / GIS Specialist
Mr. Susumu ENDO	Geophysicist
Mr. Masahiro KAWACHI	Water Supply Facilities Planner / Cost Estimator / Water Supply planner (2)
Mr. Naoki MORI	Operation and Maintenance Planner
Ms. Hitomi TOMIZAWA	Environment and Social Consideration Specialist / Coordinator
Mr. Kenji MORITA	Meteorological and Hydrological Specialist
Ms. Yuka TAKAI	Coordinator

2) The Counterpart Team

The team is composed of following nine (9) members.

Name	Assignment
Mr. Benjamin CHAYAYI	Leader of Counterpart Team / Water Supply Planner
Mr. Peter L.L. MOLLEL	Hydrogeologist / Groundwater Development
Mr. Emmanuel MAUMBA	Sociologist Planning
Mr. H.M. KIMBANGA	Well Drilling Supervisor
Mr. Thomas Z. PACHO	Water Supply Facilities Designer / Cost Estimator
Mr. Johnson NDAMUGOBA	Operation and Management Planner
Mr. Walter W. MASANZA	Environmental and Social Consideration Specialist
Mr. Swalehe JONGO	Meteorological and Hydrological Specialist
Mr. Imani KASISI	GIS Specialist

3) Municipal/District Water Engineers

A total of seven (7) Municipal/District Water Engineers are involved in the Study.

Name	Assignment
Mr. Jason N. RAPHAEL	District Water Engineer (Bagamoyo)
Mr. Kassim Said MPUTE	District Water Engineer (Kibaha)
Mr. Omari JUMA	District Water Engineer (Kisarawe)
Mr. Abudi WAZIRI	District Water Engineer (Mkuranga)
Ms. Suzan S. KIDEKA	Municipal Water Engineer (Ilala)
Mr. Gonsalves RUTAKYAMIRWA	Municipal Water Engineer (Kinondoni)
Mr. Exaudi W.Z. MOSI	Municipal Water Engineer (Temeke)

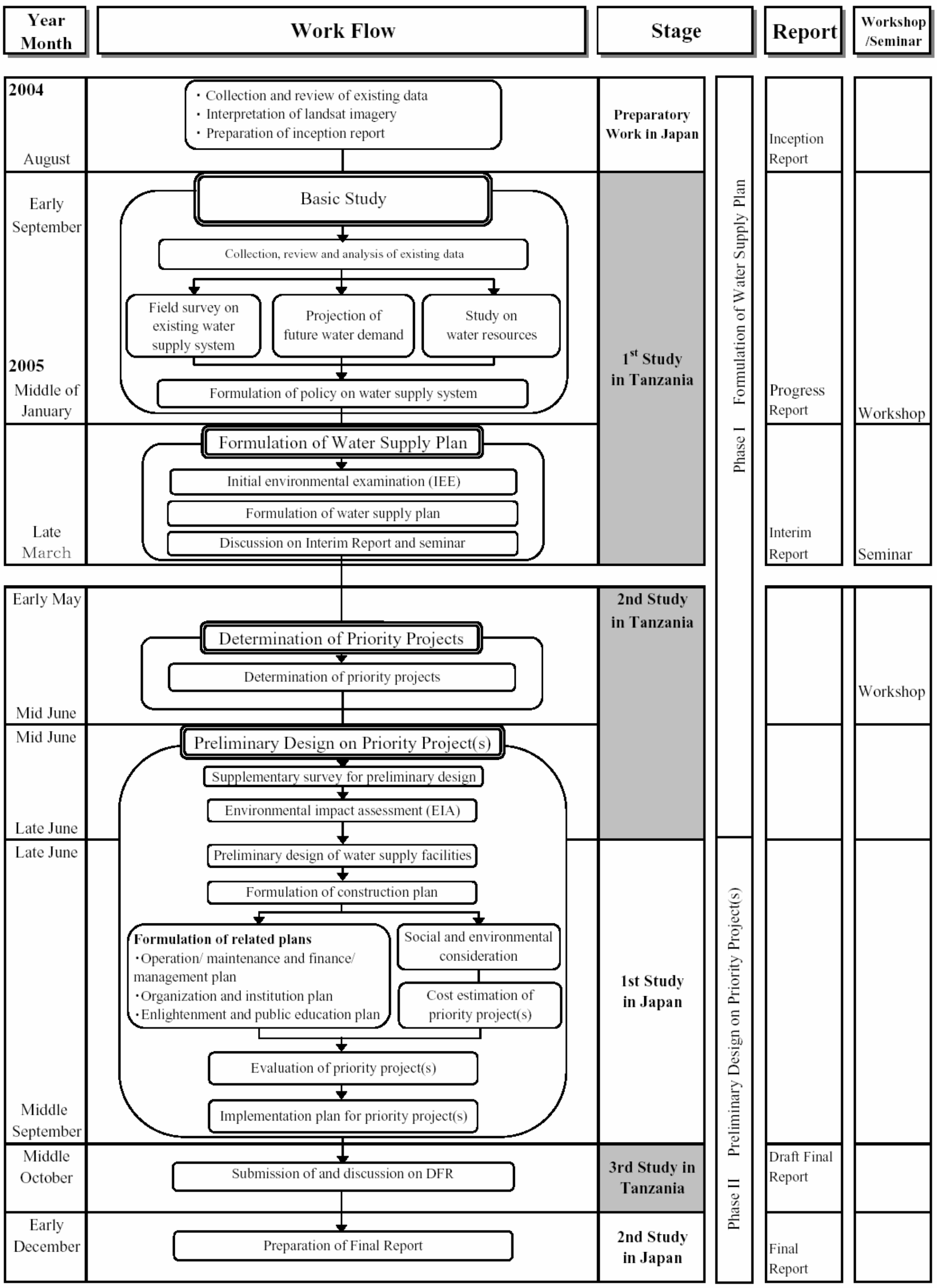


Figure 1.2 Flow Chart of the Study Work

Chapter 2

General Description of Study Area

CHAPTER 2 GENERAL DESCRIPTION OF STUDY AREA

2.1 GENERAL

Tanzania is located on the Indian Ocean coast, and the largest country in East Africa. Tanzania consist of the mainland plus the major islands of Zanzibar, Pemba and Mafia. The coast is protected by coral reef. A large central plateau and mountain ranges cover the mainland with Mt Kilimanjaro in the north being the highest mountain in Africa at 5,895 meters /19,340 feet. The Great Rift Valley runs through the centre of the country and contains many lakes. In the north the country borders Lake Victoria and in the west Lake Tanganyika.

The Study area is Coast and Dar es Salaam Regions, which lie in the Indian coast (See, *Figure 2.1*). Dar es Salaam Peir-Urban and Coast Region have acted as a receiver for demographic migration to the urban area. In these regions, shortage of domestic water has been caused by rapid expansion of population and water pollution due to inappropriate operation and management of existing water supply systems.

In this chapter, general description, which consists mainly of natural and socio-economic condition is presented.

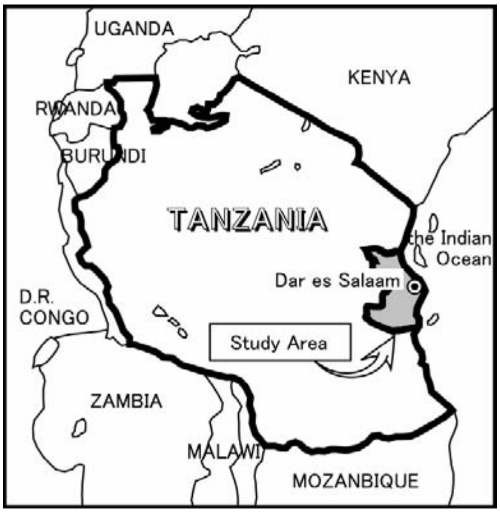


Figure 2.1 Location of Coast and Dar es Salaam Regions

2.2 METEOROLOGY AND HYDROLOGY

2.2.1 METEOROLOGY

In the mainland of Tanzania, generally two rainy seasons occur in a year; one is from March to May and the other is from November to December. Annual precipitation reaches 1,000mm.

There are 79 rainfall gauging stations in the Study Area, 57 in Coast region and 22 in Dar es Salaam region. Among them, seven stations measure temperature, and two stations measure temperature, humidity, radiation and wind in addition to rainfall.

(1) Annual Rainfall

Figure 2.2 shows the location of meteorological stations and distribution of annual rainfall. Average annual total rainfall is shown in *Table 2.1*. Annual total rainfall varies greatly by the station. It ranges from 849.7 mm in Utete Bomani to 1529.9 in Kisarawe even within the Study Area.

Table 2.1 Average Annual Total Rainfall

No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Station Name	Dar es Salaam International Airport	Kibaha agromat	Bagamoyo Salt mines	Ubena Prison	Ubena Zomozi	Kisarawa	Utete Bomani	Bagamoyo Bomani	Mandera Mission	Nghesse (Utari bridge)	Vikindu Forest	Mikula (Magogoni)	Mkuranga
Station Code	9639029	9638027	9638020	9638028	9638033	9639043	9838002	9638000	9638004	9738009	9739015	9738016	9739022
Annual Total Rainfall (mm)	1143.9	1002.3	942.4	1015.5	875.9	1529.9	849.7	983.2	992.2	921.8	1094.3	766.9	1141.3

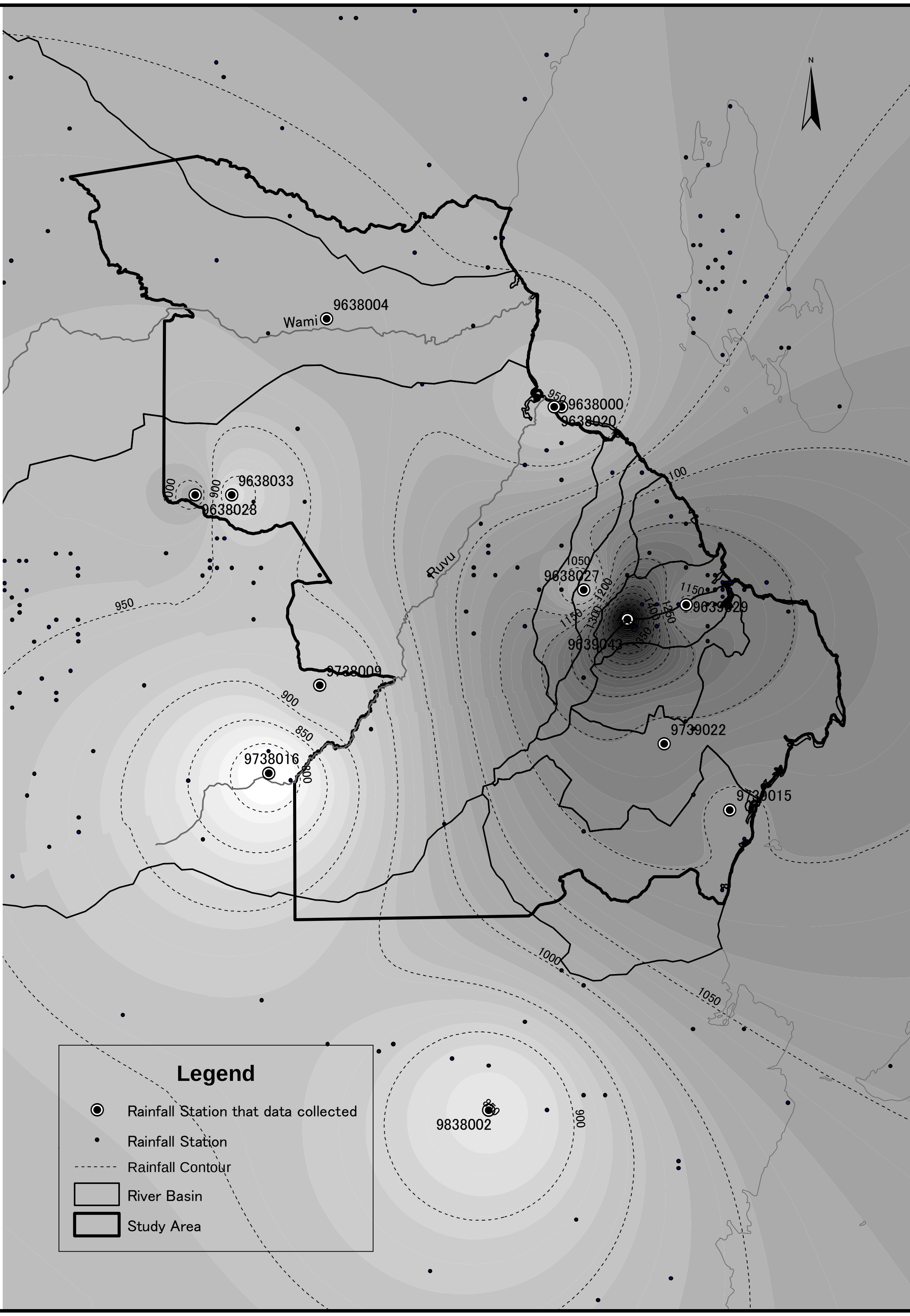


FIGURE 2.2 METEOROLOGICAL STATIONS AND ANNUAL RAINFALL DISTRIBUTION

THE STUDY ON WATER SUPPLY IMPROVEMENT IN COAST & DAR ES SALAAM | JICA

(2) Monthly Rainfall

In the study area, rainfall patterns are similar in all the stations though annual total rainfall varies by the station. Maximum rainfall occurs in the month of April in all stations, and minimum rainfall occurs in the month of September in nine stations, July in three stations and August in one station. *Figure 2.3* shows the monthly rainfall at Dar es Salaam International Airport.

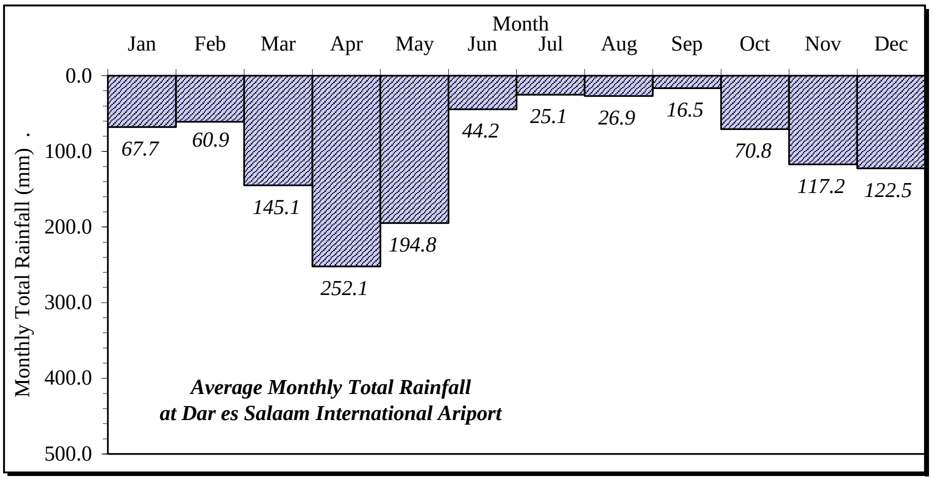
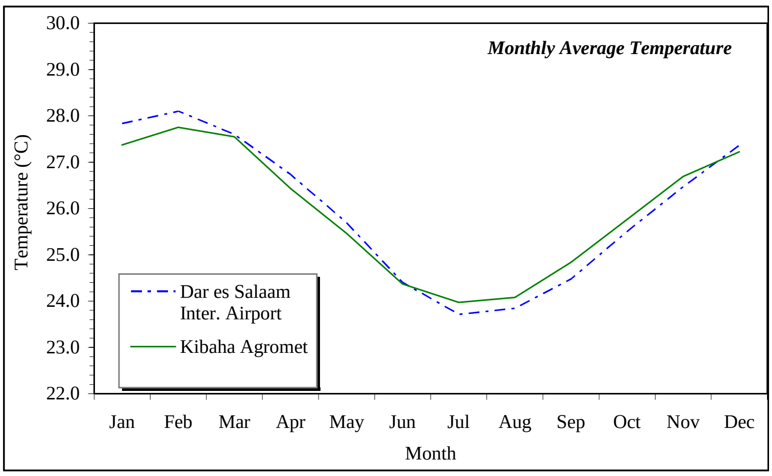


Figure 2.3 Monthly Rainfall in Dar es Salaam International Airport

(3) Monthly Temperature

Variation in monthly minimum, average and maximum temperature at Dar es Salaam International Airport and Kibaha Agromet stations averaged over the period 1981-2003 is shown in *Figure 2.4*. Average monthly minimum and maximum temperatures are observed in the months of August (18.3°C) and February (32.5°C) at Dar es Salaam International Airport, and in the months of August (18.9°C) and February (32.3°C) at Kibaha Agromet, respectively. Annual average temperature at Dar es Salaam International Airport and Kibaha Agromet are the same value of 26.0°C with small monthly variation (See, *Figure 2.4*).



Period: All the data is for period 1981-2003
Source: Tanzania Meteorological Agency

Figure 2.4 Monthly Average Temperature in Dar es Salaam International Airport

(4) Monthly Sunshine

Annual average sunshine at Dar es Salaam International Airport and Kibaha Agromet is 7.7 and 7.3 hours, respectively.

Radiation is measured only at Dar es Salaam International Airport Station. Annual average radiation averaged over the period 1983-1993 is calculated at 551.3 Mega joule/m^2.

2.2.2 RIVER SYSTEM

(1) River System in Tanzania

Tanzania is divided into nine major river basins as shown in *Figure 2.5* and as listed below:

- Lake Victoria basin
- Lake Tanganyika basin
- Internal drainage basin
- Pangani basin
- Wami and Ruvu basin
- Lake Rukwa Basin
- Rufiji basin
- Lake Nyasa basin
- Ruvuma river and the Southern coast basin

Almost all the Study Area is included in Wami and Ruvu basin.

(2) River System in the Study Area

Study Area contains three major river basins, Pangani, Wami and Ruvu, and Rufiji basin. Wami and Ruvu basin is divided into two river basins, namely Wami, and Ruvu basin. Moreover, Ruvu basin includes in addition to the basin that the Ruvu River itself flows, small river basins that are located in west side of Ruvu basin and along the ocean.

There are 38 stream gauging stations in the Study Area and Wami and Ruvu basin. Among them, eight stations are located in the Study Area. Almost all the station has not been maintained after economic collapse of 1980's and since then measurement has not been conducted. Location of the stations and basin are shown in *Figure 2.6*.

2.2.3 HYDROLOGICAL CHARACTERISTICS

Table 2.2 shows the characteristic of the river basins in the Study Area.

Table 2.2 Characteristics of the River Basins

Basin Name	River Name	Area (km^2)	Average Elevation (m)
Pangani	Tributary of Pangani	957	246.5
Wami	Wami	3749	285.1
Ruvu	Ruvu	8202	143.7
Coast R1	Mkuza, Kerege	518	140.7
Coast R2	Mpiji	489	168.6
Coast R3	Mbezi	312	77.7
Coast R4	Msimbo	319	115.4
Coast R5	Kizinga	249	88.9
Coast R6	Mzinga	615	109.5
Coast R7	Mbezi, Mbele, Ukooni	2128	80.5
Coast R8	Luhute, Luhule	1553	104.1
Rufiji	Tributary of Rufiji	723	150.0

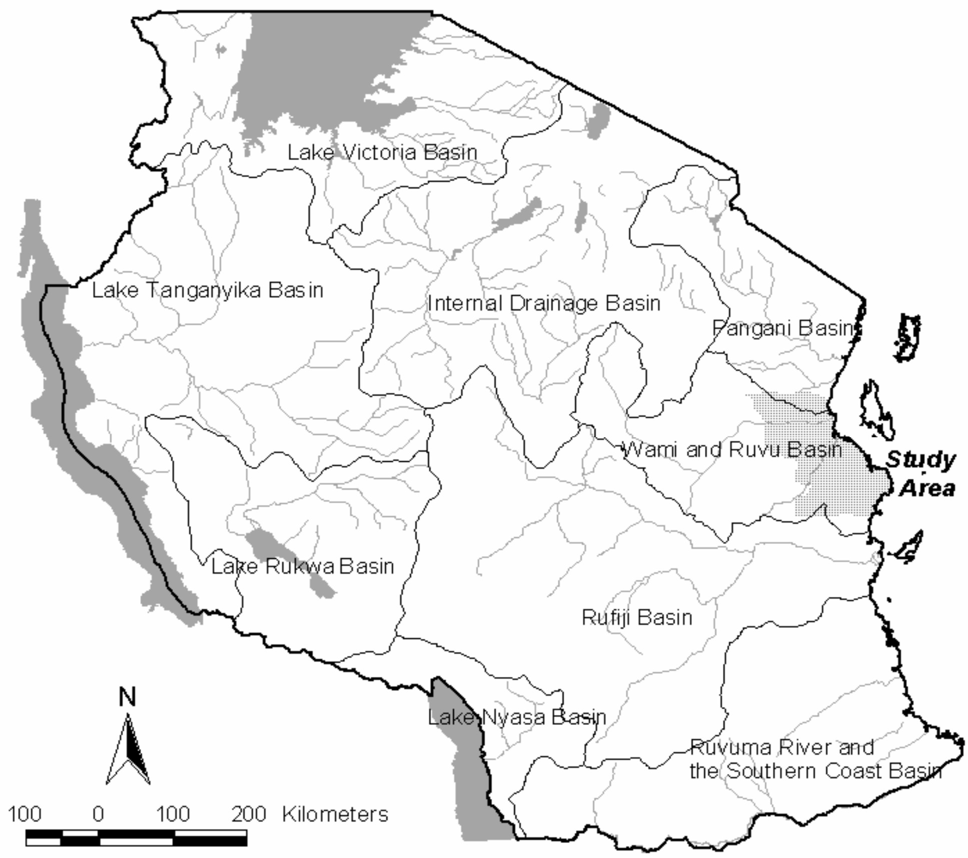


FIGURE 2.5 RIVER SYSTEM IN TANZANIA

THE STUDY ON WATER SUPPLY IMPROVEMENT IN COAST & DAR ES SALAAM | **JICA**

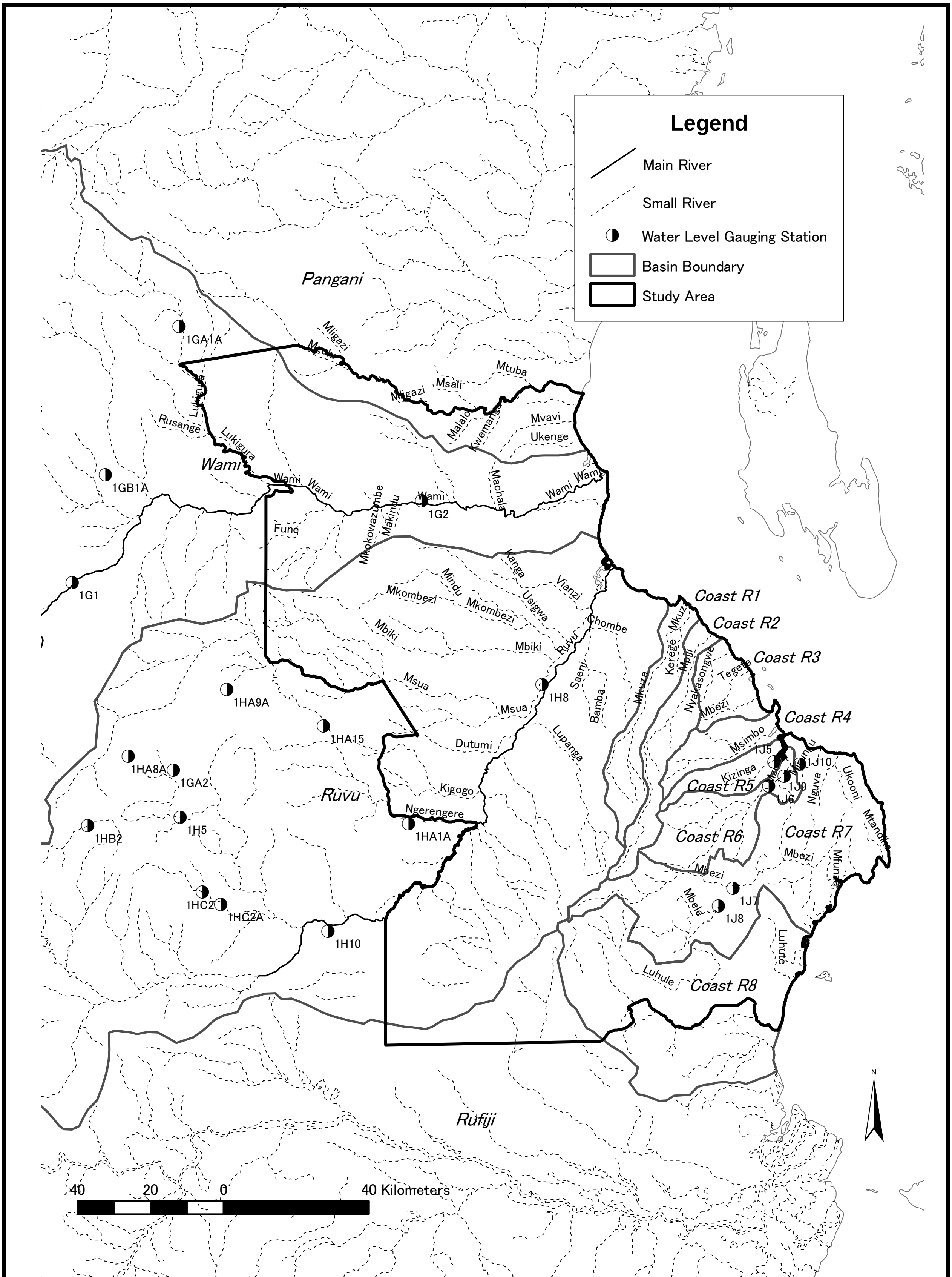


FIGURE 2.6 RIVER SYSTEM, BASIN AND HYDROLOGICAL STATIONS

THE STUDY ON WATER SUPPLY IMPROVEMENT IN COAST & DAR ES SALAAM | **JICA**

Based on the results of interview survey to related persons and investigation of the past discharge data, three rivers, namely the mainstream of Wami, Ruvu, and Kizinga are confirmed as perennial rivers in the Study Area.

2.3 TOPOGRAPHY AND GEOLOGY

2.3.1 GENERAL GEOLOGY OF TANZANIA

The geology of Tanzania comprises mainly the Precambrian (Archaean, Proterozoic) and Phanerozoic (Upper Palaeozoic, Mesozoic and Cenozoic). The Archaean rocks are characterized by a granite-greenstone terrain in which linear belts of greenstones are set in a field of predominantly granitic rocks. The Tanzanian Craton covers the central part of the Territory up to south and east part of Lake Victoria. Most of the granitic rocks are younger than the gereenstones, though a few of them may be older. The geological map of Tanzania is shown *Figure 2.7*.

2.3.2 TOPOGRAPHY AND GEOMORPHOLOGY OF THE STUDY AREA

Altitudes of the Study area are in a range from 0 m in the coast area along the Indian Ocean to approximately 600 m in the north-western hilly area in Bagamoyo District. The topography in general reflects the geological structure of the Study area. The north-western area, mainly in Bagamoyo District is characterized by the plateau with 200 to 600 m high. The eastern fringe of the plateau is surrounded by generally flat hills with height of approximately 100 to 300 m. The hilly topography is wide spread in the eastern half of the Study area. Two pairs of hills are recognized elongating in a NE-SW direction. River terraces and coastal terrace are recognized along the Wami River, the Ruvu River and the Indian Ocean.

Topographic map of the study area is shown in *Figure 2.8*. Three major plateau and hilly topographic features are recognized. This topography is dissected into three main blocks by the Ruvu River and the Kizinga-Lowland. Out of three blocks only Msanga-Pugu Hills has a topographical name. In this Study, they are provisionally called the Bagamoyo Plateau, the Msanga-Pugu Hills and the Mkuranga Hills from northwest to southeast.

Bagamoyo Plateau rises in the western part of the Study area. The Plateau is formed by the Precambrian rocks in the major part and by the Jurassic and Cretaceous rocks in the eastern marginal area. The Bagamoyo Plateau is sub-divided into two blocks by the Wami River, the Mbwewe Sub-Plateau and the Chalinze Sub-Plateau. The Mbwewe Sub-Plateau is characterized by mountainous features elongated in E-W direction. The highest point of 600m is near Kibindu Village that gradually decreases toward east reaching 300 m. The Chalinze Sub-Plateau shows rather gentle features with 200 to 400 m of height.

The eastern margin of the Bagamoyo Plateau is fringed with a hill gently inclined toward ESE direction. The Hill is called Ruvu Hills formed by the Neogene formation. Elevation of the Hill is from 150 to 200 m. The foot of the Hill is the gently inclined flood plain of the Ruvu River.

Along the Ruvu River, a trench like lowland is recognized. It is called geologically the Ruvu Graben, formed by down-faulting at both sides of the lowland. The Graben is approximately 2 km in width and extends in NNE-SSW direction.

The eastern side of the Ruvu River is characterized by wide spread hilly features of 100 to 300 m in height. There are two hills in parallel elongated in NNE-SSW direction. The north-western side of hill is called Msanga-Pugu Hills formed by the Neogene formation. Most of Kisarawe District lies in this area. The Hills has a ridge in the eastern margin with height of 200 to 400m. The eastern side of the ridge is steep slope and the western side is gentle slope to the Ruvu River. The Msanga-Pugu Hills seems to be tilted in the NW direction.

On the other hand, the southeastern side of the hill is generally flat. It is approximately 100 m in height. The hills are called the Mkuranga Hills. The eastern margin of the hill is fringed with the coastal terraces.

2.3.3 GEOLOGY OF THE STUDY AREA

Geological map of the study area is shown *Figure 2.9*. A total of five major geological formations of 1) Precambrian, 2) Jurassic, 3) Cretaceous, 4) Neogene and 5) Quaternary are identified.

(1) Precambrian

The Precambrian is distributed mainly in Bagamoyo Plateau. Miono, Kibindu, Mbwewe, Msata and Ubenazomoji Wards are main Ward included in this area. It consists mainly of gneiss and granulite in the lower part and crystalline limestone intercalated with schists and gneiss. Many faults and lineaments are recognized in the area. Due to weathering of formation, surface of Bagamoyo Plateau is generally dense covered by soils.

(2) Jurassic

The eastern edge of Bagamoyo Plateau is occupied by the Jurassic which unconformably overlies the Precambrian and overlain by the Cretaceous. Villages, Masuguru, Kisanga and Malivundo in Bagamoyo District are located in this area. The Jurassic is unmetamorphosed and comprised mainly of sandstone intercalated sometimes with shale, siltstone and conglomerate.

(3) Cretaceous

The Cretaceous crops out in narrow areas occupying the edge of Bagamoyo Plateau. It is underlain by the Jurassic and overlain by the Neogene. Only Talawanda Village, Bagamoyo District falls in this area. Another distribution area is in the southwestern foot of the Msanga-Pugu Hills; many villages in Kisarawe District located in the south from Masaki Village fall in this area. In this area, the Cretaceous Formation is distributed in the hillside and foot of hills underlying the Neogene Formation.

(4) Neogene

The Neogene strata occur widely in the eastern half of the Study area, covering most of areas in Ruvu Hill, Msanga-Pugu Hills and Mkuranga Hills.

Detailed discussion on the Neogene in the Study area was made by Tample (1970). The Neogene consists of less sorted intercalation of sandy clay and clayey sand accompanied by lenses of sand and clay.

(5) Quaternary

The Quaternary is distributed in a limited area, along the Ruvu River, near the river mouth of the Wami River and along the coast. These deposits consist of sand, gravel, silt and clay.

A fluvial deposit is distributed filling the Ruvu Graben along the Ruvu River. The thickness of this deposit has not been confirmed, but it is estimated more than 100m from the existing borehole data.

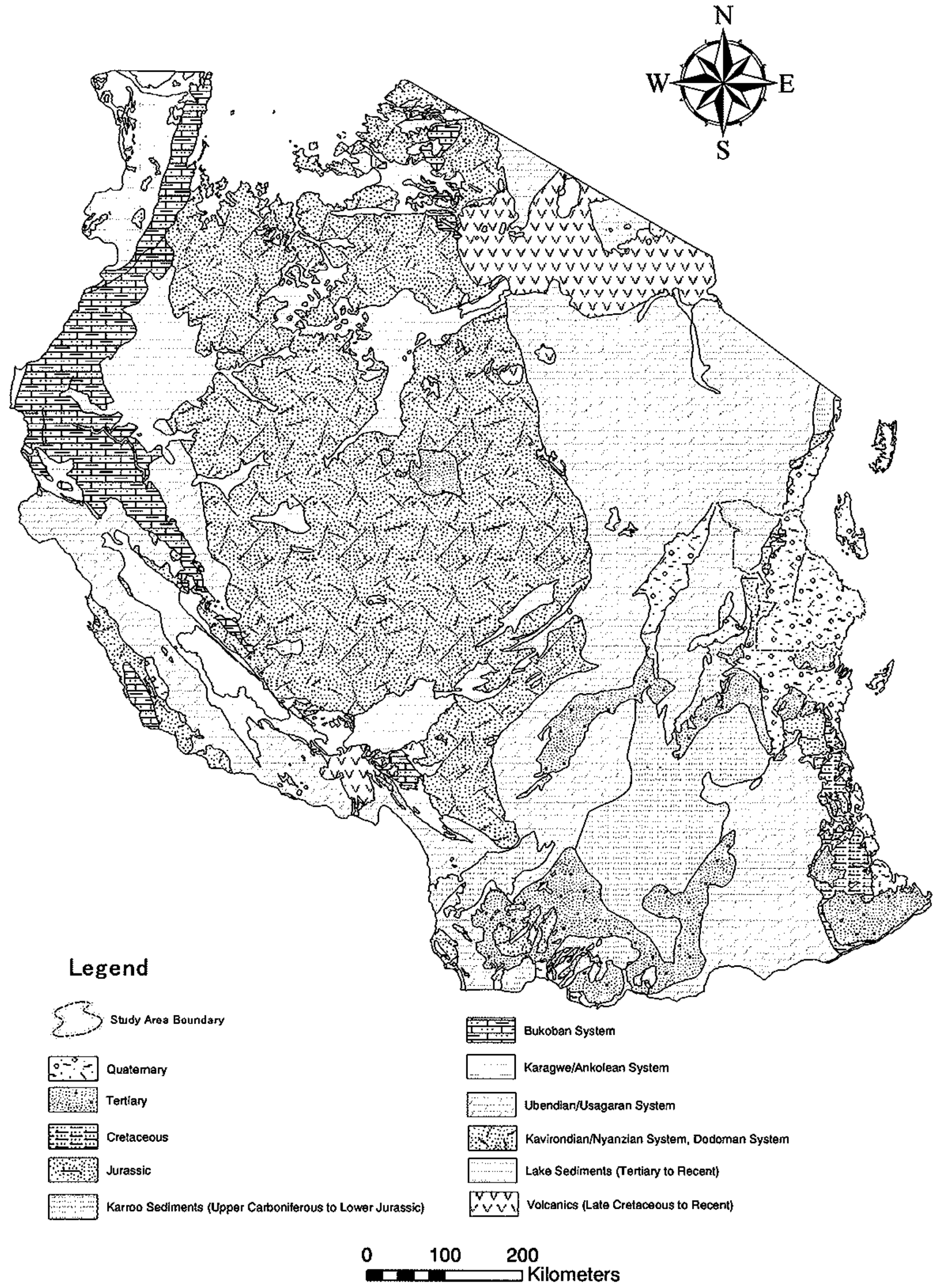


FIGURE 2.7 GEOLOGICAL MAP OF TANZANIA

THE STUDY ON WATER SUPPLY IMPROVEMENT IN COAST & DAR ES SALAAM	JICA

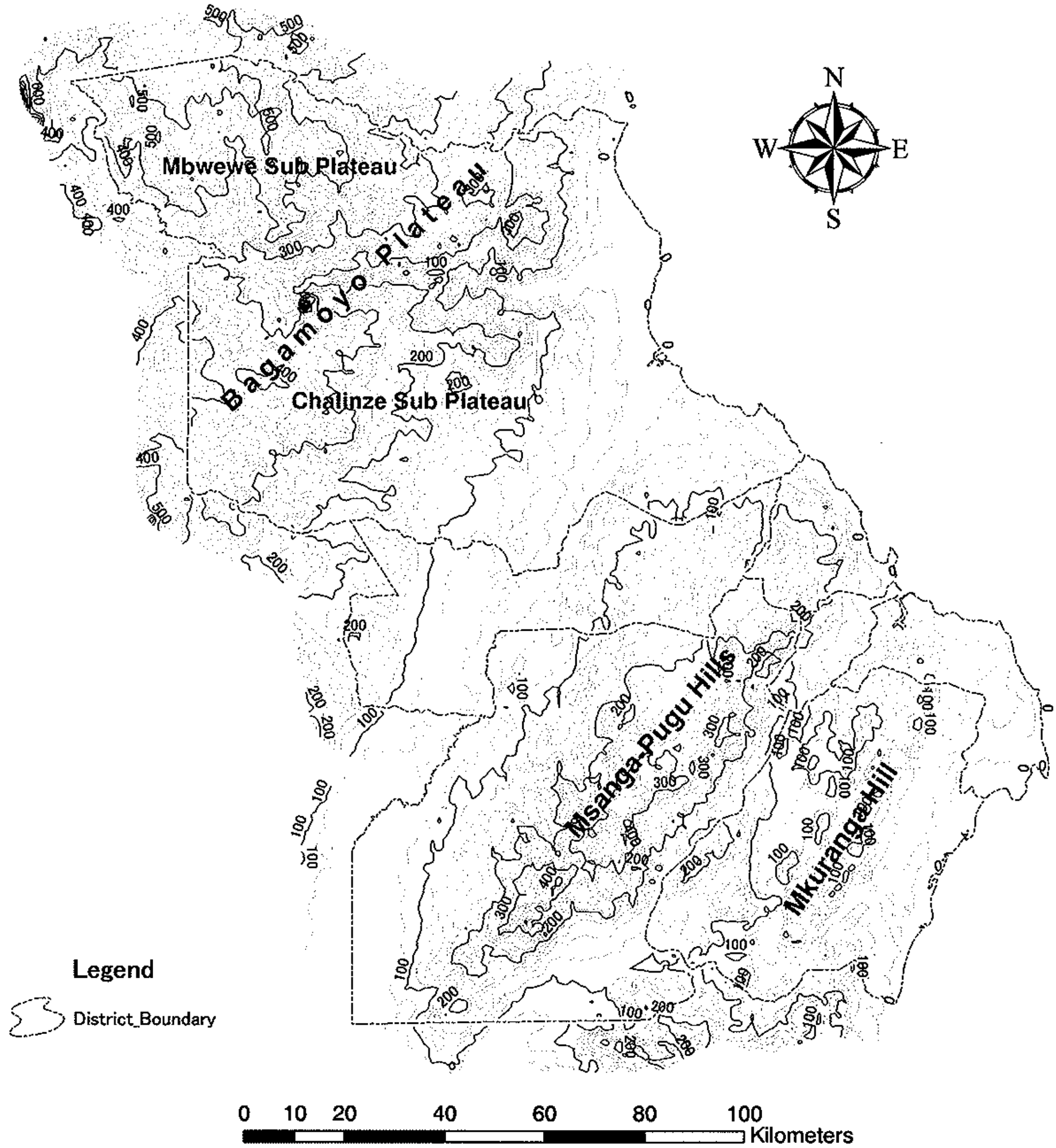


FIGURE 2.8 TOPOGRAPHIC MAP OF THE STUDY AREA

THE STUDY ON WATER SUPPLY IMPROVEMENT IN COAST & DAR ES SALAAM	JICA

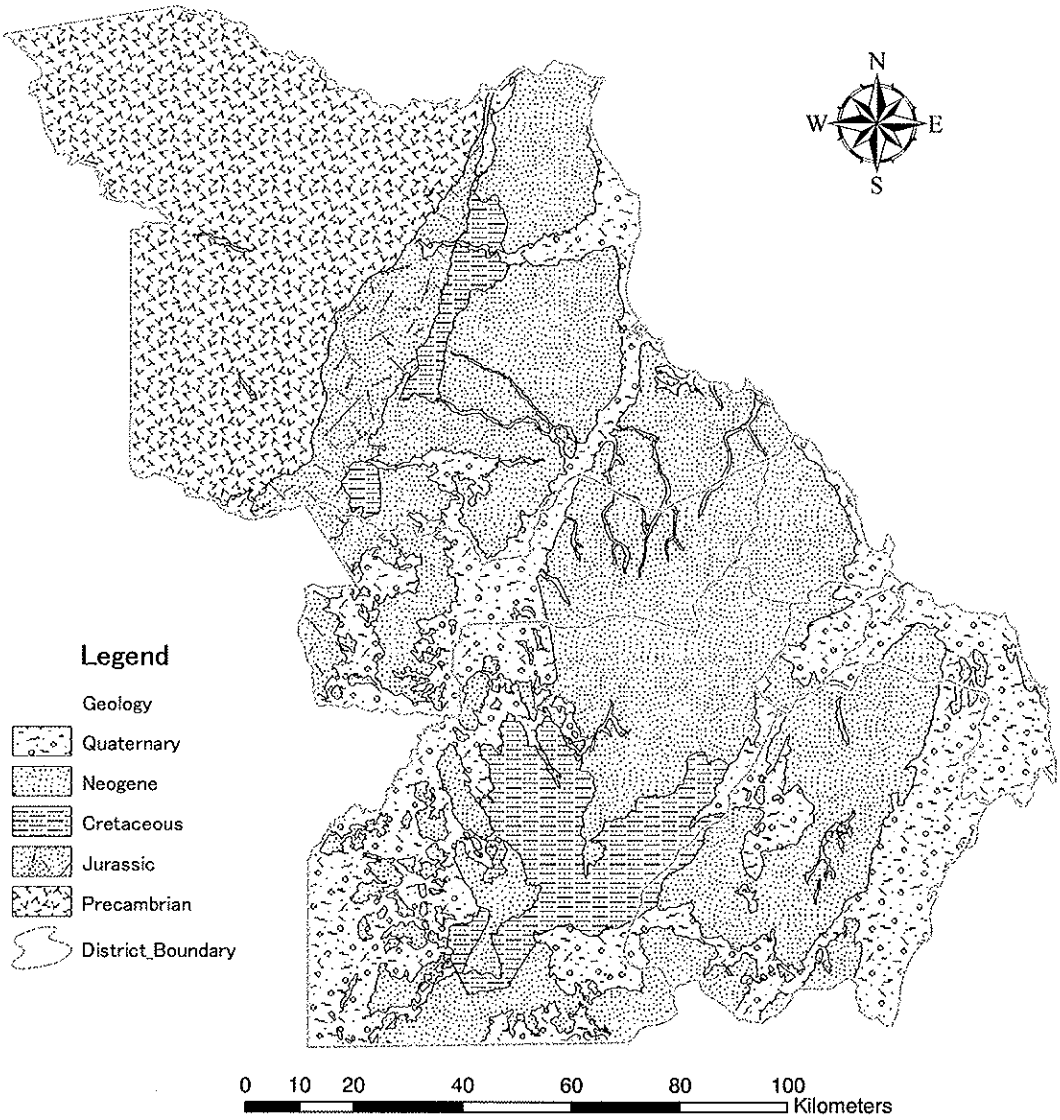


FIGURE 2.9 GEOLOGICAL MAP OF THE STUDY AREA

THE STUDY ON WATER SUPPLY IMPROVEMENT IN COAST & DAR ES SALAAM | **JICA**

2.4 SOCIO-ECONOMIC CONDITIONS

This section describes overall socio-economic conditions of the target regions and districts of the study.

2.4.1 ADMINISTRATIVE SETTINGS

Every district/ municipalities is subdivided into divisions which are further demarcated into wards. A ward consists of a certain number of villages or Mitaas which are administratively represented by the village/Mitaa councils. Kitongoji is the smallest unit of the administrative organ, which a village is subdivided into.

Coast Region presently consists of six districts, namely Bagamoyo, Kibaha, Kisarawe, Mkuranga, Rufiji and Mafia. The region was used to include present area of Dar es Salaam until 1972 when the former Coast Region, which headquarter was located in Dar es Salaam, was subdivided into two regions. The regional headquarters was shifted from Dar es Salaam to Kibaha District newly established in 1979 out of northern part of Kisarawe and small portion of southern part of Bagamoyo. In 1995, another new district, Mkuranga, was created out of eastern part and coastal area of Kisarawe.

Dasr es Salaam consists of three municipalities, namely Ilala, Kinondoni, and Temeke which were upgraded from district in 2000. The three Municipal Councils are responsible for primary education and partly secondary education especially where the community is involved, primary health care, city waste management and cleanliness, District roads, water supply, trade and informal sector development and management, cooperatives, agriculture and livestock development, forestry, fisheries, wildlife and parks. Dar es Salaam City Council performs a coordinating role and is responsible for cross-municipal issues.

Table 2.3 shows distribution of number of divisions, wards and Villages/Mitaas forming each target district in the two regions.

Table 2.3 Administrative Setup of the Study Area

District/Municipality		No. of Division	No. of Ward	No. of Village/Mitaa			
				District Total			Target Village/Mitaa of the Study
				Village	Mitaa	Total	
Coast	Bagamoyo	6	16	82	0	82	45
	Kibaha	3	9	25	0	25	24
	Kisarawe	4	15	74	0	74	74
	Mkuranga	4	15	101	0	101	74
	Sub-Total	17	55	282	0	282	217
DSM	Ilala	3	22	9	65	74	24
	Kinondoni	3	27	14	113	127	14
	Temeke	3	24	15	97	112	23
	Sub-Total	9	73	38	275	313	61
Total		26	128	320	275	595	278

Administrative setup of the regions and districts are defined by the laws of "The Local Government Act (1982)" and "The Regional Administration Act (1997)". The regional administration is governed by the Regional Commissioner's Office. The District Commissioner at the district level and Divisional Secretary are its subordinate bodies. These organizations belong to the central government. Meanwhile, the local authority represented by the District Council consists of members elected from each ward in the district. The District Executive Director is responsible for administration of the district council.

At the ward level, the Ward Development Committee (WDC) formed by the councilor representing the ward and chairpersons of the village councils within the ward deals with the development issues of the area. The Ward Executive Officer is appointed to administer the WDC.

At the village level, the village assembly consisting of residents in the village is the supreme authority to make decisions in relation with the general policies of the affairs of the village. It is also responsible for election of the village council which is mandated to govern daily administration of the village assembly and all the affairs and business of the village including social and economic development. Village Executive Officer employed by the village is responsible for operation of the village council while the Village Chairman represents the village politically and administratively.

2.4.2 POPULATION AND ETHNIC GROUPS

According to the population and housing census in 2002, national population of Tanzania is 34,443,603 of which 97% lives in the mainland. Coast Region has 885,017 population in total which is the second smallest region in population-wise in the mainland. Meanwhile, the regional population of Dar es Salaam is 2,487,288, third largest population in the mainland following Mwanza and Shinyanga regions.

Past trend of population growth of these target regions and districts is shown in *Table 2.4*. The population growth rate of Coast Region increased from 2.1% in the previous intercensal period (1978-1988) to 2.4% though it is below the growth rate of the national and mainland population. In the Coast Region, districts of Kibaha and Mkuranga show relatively high population growth rate compared to other districts in the region.

Regarding the population growth of Dar es Salaam Region, it has decreased from 4.8% in the last intercensal period (197-1988) to 4.3%. However, the rate still keeps high, which is mainly affected by the migration of rural population in urban areas.

Table 2.4 Past Trend of Regional and District Population

Region		Actual Population from the Censuses				Annual Average Intercensal Growth Rate		
District		1967	1978	1988	2002	1967-1978	1978-1988	1988-2002
Coast		428,041	516,586	636,103	885,017	1.7%	2.1%	2.4%
District	Bagamoyo		135,967	173,871	228,967		2.4%	2.0%
	Kibaha		-	81,952	131,242		1.8%	3.4%
	Kisarawe		222,172	193,263	95,323		-	1.4%
	Mkuranga		-	-	186,927		-	3.5%
	(Rufiji)		135,342	153,938	202,001		1.3%	1.9%
	(Mafia)		23,105	33,079	40,557		3.6%	1.5%
Dar es Salaam		356,286	843,090	1,360,865	2,487,288	7.8%	4.8%	4.3%
District	Ilala		218,426	331,663	634,924		4.1%	4.6%
	Kinondoni		366,159	627,416	1,083,913		5.0%	4.1%
	Temeke		258,505	401,786	768,451		4.3%	4.6%
Total, Mainland		11,958,654	17,036,499	22,485,625	33,461,849	3.2%	2.8%	2.9%
Total, Tanzania		12,313,469	17,512,610	23,057,922	34,443,603	3.2%	2.8%	2.9%

Source:

- Central Census Office, National Bureau of Statistics (2003), 2002 Population and Housing Census Vol. II Age and Sex Distribution, Dar es Salaam
- Central Census Office, National Bureau of Statistics (2003), 2002 Population and Housing Census,Volume IV District Profile
- President's Office-Planning Commission, Bureau of Statistics (1991), Tanzania Sensa 1988 Population Census National Profile, Dar es Salaam
- Bureau of Statistics, Ministry of Planning and Economic Affair (1982), 1978 Population Census Vol. IV. A Summary of Selected Statistics, Dar es Salaam

Note: 1. Population of Kisarawe at 1988 Census includes the one for Mkuranga which had been part of Kisarawe District until July 1995.

2. Population of Bagamoyo and Kisarawe at 1978 Census includes the one for Kibaha which was created from Bagamoyo and Kisarawe in 1979.

As shown in *Table 2.5* and Figure *2.10*, approximately 94% of population with population density of 1,786 persons/km2 lives in urban area in Dar es Salaam Region while nearly 80% with 27 persons/km2 is rural population in Coast Region.

Table 2.5 Distribution of Population by Rural/ Urban Areas

Region District	1988		2002	
	Rural	Urban	Rural	Urban
Coast	85.2%	14.8%	78.9%	21.1%
Bagamoyo	81.4%	18.6%	82.0%	18.0%
Kibaha	76.0%	24.0%	56.3%	43.7%
Kisarawe	93.5%	6.5%	84.8%	15.2%
Mkuranga	-	-	88.7%	11.3%
(Rufiji)	84.3%	15.7%	78.4%	21.6%
(Mafia)	82.7%	17.3%	77.8%	22.2%
Dar es Salaam	10.4%	89.6%	6.1%	93.9%
Ilala	9.0%	91.0%	7.2%	92.8%
Kinondoni	7.7%	92.3%	5.2%	94.8%
Temeke	14.7%	85.3%	6.3%	93.7%
Total, Mainland	81.7%	18.3%	77.4%	22.6%
Total, Tanzania	82.0%	18.0%	76.9%	23.1%

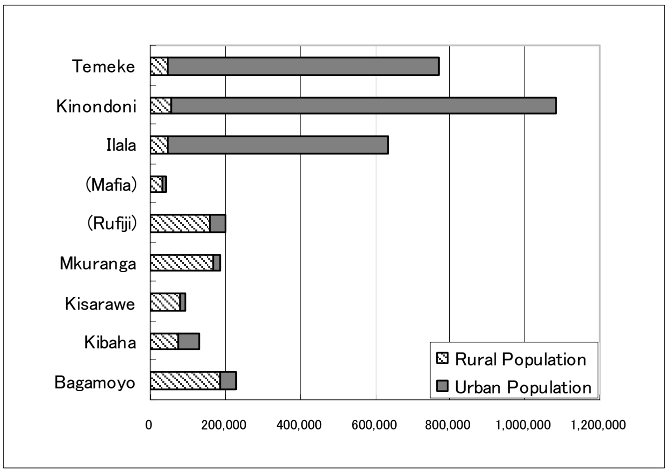


Figure 2.10 Population of Target Regions and Districts/ Municipalities (2002)

The main indigenous ethnic group in Coast Region are Wazaramo, who are dominant in all six districts of the region. Wadengereko are found mostly in Rufiji district and part of Mkuranga. Wakwere mostly reside in Bagamoyo and Wambwera and Wapokomu are found in Mafia. Apart from the dominant ethnic groups, Wamasai (Wakwavi) are mostly based in Kibaha and Bagamoyo, who migrated from other parts of the country and settled in the region are now counted among the list of ethnic groups in the region.

2.4.3 ECONOMIC CONDITIONS

Coast region predominantly relies on typical agricultural economy. More than 90 percent of its population is involved in agricultural sector. The agricultural sector alone contributes mote than 80 percent of the regional income while other sectors such as natural resources, livestock, industries and other together share the remaining portion.

Meanwhile, manufacturing accounts for 60 percent of GDP and a large proportion of the city labor force is engaged in informal sector activities. Only 35 percent of the labor force works in the formal sector in the region.

Table 2.6 shows average annual regional GDP contribution to the national GDP for the period of 1980-1994. Coast region is ranked as the lowest contribution among the regions in the mainland of Tanzania while Dar es Salaam accounts for 20 percent of contribution to the national GDP.

Table 2.6 Average Annual Regional GDP Contribution to the National GDP (1980-1994)

Region	Average Annual GDP contribution (%)	GDP Contribution Ranking
Coast	1.00	20
Dar es Salaam	20.33	1
Arusha	7.80	2
Mwanza	7.67	3
Mbeya	6.00	4
Shinyanga	5.80	5
Iringa	5.53	6
Tanga	5.52	7
Morogoro	4.67	8
Kagera	4.60	9
Kilimanjaro	3.67	10
Mara	3.47	11
Tabora	3.40	12
Ruvuma	3.33	13
Mtwara	3.27	14
Rukwa	3.13	15
Dodoma	3.07	16
Singida	2.87	17
Kigoma	2.53	18
Lindi	2.00	19
Total	10.00	-

(Source: Coast Region Socio-Economic Profile (1997))

Looking at the 1997 household income, Coast region has the lowest per capita income in the mainland. (See *Table 2.7*) The per capita income of Dar es Salaam is recorded as eight times of the one for Coast region.

Table 2.7 Annual Per Capita Income by Region (1994)

Rank	Name of Region	Per Capital Income/ Year (Tsh)
1.	Dar es Salaam	197,107
2.	Arusha	91,024
3.	Iringa	64,502
4.	Morogoro	59,370
5.	Kilimanjaro	55,716
6.	Singida	55,644
7.	Shinyanga	52,746
8.	Ruvuma	52,537
9.	Kagera	50,105
10.	Tanga	60,021
11.	Mbeya	48,737
12.	Mwanza	48,508
13.	Tabora	44,984
14.	Mara	43,748
15.	Rukwa	80,669
16.	Dodoma	39,604
17.	Mtwara	59,533
18.	Lindi	38,340
19.	Kigoma	30,103
20.	Coast	22,624

(Source: Coast Region Socio-Economic Profile (1997))

2.4.4 SOCIAL SERVICES

(1) Education

Table 2.8 shows distribution of schools in both Coast region and Dar es Salaam region as of 2005.

Table 2.8 Distribution of Schools in the Study Area

Region	District	Type of School	Pre-Primary		Primary				Secondary			
					Day School		Boarding School		Day School		Boarding School	
			No. of School	Total No. of Pupil	No. of School	Total No. of Pupil	No. of School	Total No. of Pupil	No. of School	No. of Pupil	No. of School	No. of Pupil
Coast[*1]	Bagamoyo	Public	61	947	108	47,720	0	0	2	2,754	2	1,010
	Kibaha	Public	51	1,889	66	29,781	0	0	3	8,756	2	1,241
	Kisarawe	Public	63	1,811	74	22,387	0	0	5	2,898	1	738
	Mkuranga	Public	57	495	88	43,956	0	0	4	720	0	0
Total (Coast Region)			232	5,142	336	143,844	0	0	14	15,128	5	2,989
DSM*[2]	Ilala	Public	39	862	100	109,799	0	0	12	2,678	0	0
		Private	26	2,430	25	3,390	0	0	16	2,428	0	0
	Kinondoni	Public	32	1,427	122	157,650	0	0	3	1,106	0	0
		Private	45	2,229	42	10,633	0	0	37	no record	16	no record
	Temeke	Public	23	1,204	95	135,185	0	0	3	1,596	0	0
		Private	15	681	6	1,857	2	520	11	7,977	10	3,068
Total (DSM Region)			180	8,833	390	418,514	2	520	82	15,785	26	3,068

(Source: *1 Regional Education Offices, *2 Municipal Education Offices)

Note:

*1: Only public schools are counted in the above table as the information on private school was not available.

*2: Number of pupils in boarding schools in Kinondoni is not included in the table above as the information was not available.

The enrolment rate in primary schools have been improved in both regions. The gross enrolment rate of Dar es Salaam has increased from 97.6 percent in 1999 to 110.1 percent in 2003 while 85.5 percent in 1999 to 114 percent in 2003 in Coast region. The net enrolment rate also shows improvement as 77.6 percent (1999) to 95 percent (2003) in Dar es Salaam and 63.5 percent (1999) to 94.2 percent (2003) in Coast Region. These figures are higher than the national average of the enrolment rate in primary schools. Furthermore, in Dar es Salaam region, female net enrolment rate (96.4 percent in 2003) in primary schools exceeds the one for male children (93.5 percent in 2003). In Coast region, male net enrolment rate in 2003 is 98.7 percent and female net enrolment rate is 89.8 percent.

Currently, the government of Tanzania is implementing the Primary Education Development Programme (PEDP) (2002-2006) to improve service delivery in primary education. As a part of its strategy, the school fees and other parental contributions were abolished from 2002. Also, rehabilitation and construction of classrooms and teachers' houses have been conducted.

With regard to the literacy rate of population aged 15 and above, Coast region records 54 percent which is far below the national average, 71 percent, in 2001. Difference of the literacy rates between male and female is large as 61 percent for male and 48 percent for female. In Dar es Salaam, the regional average of the literacy rate is 87 percent. The rate for male is 89 percent and the one for female is 84 percent.

(2) Health

In the both regions, major causes of illness are malaria, upper respiratory tract infection, diarrhea which shows similar trend of national situation. Common causes of infant and under-5 mortality are malaria, upper respiratory tract infections, pneumonia, diarrhea, eye infections and skin infections. Coast region is ranked at eighth in terms of the highest infant mortality rate in the mainland followed by Dar es Salaam Region. Regarding under five mortality rate, Coast region has the eights highest rate while Dar es Salaam is ranked at tenth. (See *Table 2.9*)

Table 2.9 Infant and Under Five Mortality Rates by Regions

Region	Infant Mortality Rate			Under-5 Mortality Rate		
	1975	1985	1995	1975	1985	1995
Coast	121	113	105	204	189	174
Arusha	108	75	52	179	129	78
Dar es Salaam	108	105	102	179	173	168
Dodoma	133	132	130	225	222	220
Iringa	152	130	111	257	220	187
Kagera	133	130	127	225	219	212
Kigoma	163	115	81	269	192	137
Kilimanjaro	76	67	59	119	104	90
Lindi	151	140	129	255	236	218
Mara	140	125	112	236	211	189
Mbeya	161	124	96	267	209	163
Morogoro	140	125	112	236	211	189
Mtwara	161	138	119	267	233	202
Mwanza	139	115	95	233	192	157
Rukwa	170	131	101	283	221	172
Ruvuma	145	113	88	245	188	143
Shinyanga	150	110	81	252	183	131
Singida	137	96	67	231	157	106
Tabora	140	101	73	236	166	116
Tanga	112	106	100	187	176	166
Total	137	115	96	231	191	158

Source: Coast Region Socio-Economic Profile (1997)

For the health service delivery, three government hospitals and one parastatal hospital are operational in Coast Region. On the other hand, over 20 hospitals are presently run by government, private or voluntary organizations in Dar es Salaam. More than 85 percent of those hospitals are operated by private sector including NGOs and religious organizations in the region. Under the hospitals, health centers are established to cater for approximately 50,000 people which is almost the population size of one administrative division. Furthermore, dispensaries are supposed to serve for 6,000-10,000 people per facility according to the National Health Policy (1990). As the lowest level of the health service system, village health posts are established in the villages which do not have health facilities. *Table 2.10* shows distribution of health facilities in both regions.

Table 2.10 Distribution of Health Facilities in the Study Area

Region	District	Hospital								Health Center								Dispensary			
		No. of Facility				No. of Bed				No. of Facility				No. of Bed				No. of Facility			
		Govt	Parastatal	Private	Voluntary*	Govt	Parastatal	Private	Voluntary	Govt	Parastatal	Private	Voluntary	Govt	Parastatal	Private	Voluntary	Govt	Parastatal	Private	Voluntary
Coast*[1]	Bagamoyo	0	1	0	0	0	150	0	0	4	0	1	0	60	0	15	0	31	4	4	3
	Kibaha	1	0	0	0	213	0	0	0	3	0	0	0	45	0	0	0	24	2	7	3
	Kisarawe	1	0	0	0	130	0	0	0	2	0	0	0	30	0	0	0	11	3	1	2
	Mkuranga	1**	0	0	0	40	0	0	0	2	0	0	0	30	0	0	0	14	12	2	0
Sub-Total		3	1	0	0	383	150	0	0	11	0	1	0	165	0	15	0	80	21	14	8
DSM*[2]	Ilala	1	0	3	2	250	0	no record	no record	2	0	3	2	10	0	no record	no record	13	5	112	10
	Kinondoni	1	0	10	2	160	0	250	50	2	0	3	1	30	0	24	8	23	0	147	0
	Temeke	1	0	2	0	122	0	95	0	1	1	2	0	16	0	15	0	20	0	84	5
Sub-Total		3	0	15	4	532	0	345	50	5	1	8	3	56	0	39	8	56	5	343	15

Source
*1 Coast Region: Regional Health Office
*2 Dar es Salaam Region: Municipal Health Office in each Municipality
Note
* Voluntary: The facilities owned by NGOs or religious organizations
** The hospital is under construction though it is operating.

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Chapter 3

Existing Water Supply Condition and Water Supply Schemes

CHAPTER 3 EXISTING WATER SUPPLY CONDITION AND WATER SUPPLY SCHEMES

3.1 GENERAL

There are many types of water supply schemes in the Study area such as large scale piped water supply scheme, small scale piped water supply scheme and hand pump water supply scheme. In order to comprehend the water supply conditions in the Study area, current situation of existing water supply schemes were surveyed. In addition, water quality of existing water sources was surveyed.

3.2 GENERAL WATER SUPPLY CONDITION

3.2.1 NATIONWIDE WATER SUPPLY CONDITION

National Bureau of Statistics Tanzania (2000) reported that 40 % of population in Tanzania has access to piped water supply scheme with house connection or public tap. On the other hand, the poor water supply schemes in the rural areas have been obliged over 30 % of the Tanzanian people to fetch their drinking water from unprotected sources such as rivers, streams, reservoirs, charco dams or traditional wells (See. *Table 3.1*). Particularly, disparity in the water supply service between the Dar es Salaam Urban area and the rural area is remarkable.

Table 3.1 Existing Situation of Drinking Water Sources in Tanzania

	Type of water supply	Dar es Salaam	Other Urban	Rural	Nationwide
HBS	Piped water	92.2%	72.2%	24.2%	40.1%
	Protected water source	3.8%	10.9%	10.2%	10.0%
	Unprotected water source	4.0%	16.9%	65.6%	49.9%
HRDS	Piped water	94.6%	73.6%	22.6%	40.0%
	Protected water source	4.6%	19.5%	36.7%	30.4%
	Unprotected water source	0.8%	6.9%	40.7%	29.6%

Source: Household Budget Survey (HBS) 1991-1992
Human Resources Development Survey (HRDS) 1993-1994
National Bureau of Statistics Tanzania and Oxford Policy Management Ltd. United Kingdom (2000)

3.2.2 WATER SUPPLY CONDITION IN THE STUDY AREA

The drinking water sources in the Study area consist of three large scale piped water supply schemes, namely Upper Ruvu Water Supply and Lower Ruvu Water Supply under Dar es Salaam City Water Supply Scheme (DAWASA), Chalinze Water Supply Scheme, approximately 100 small scale piped water supply schemes, and large number of protected or unprotected sources.

Based on the results of Population and Housing Census (2002), the existing situation of drinking water sources in the Study area is summarized as follows (See, *Table 3.2*).

Table 3.2 Existing Situation of Drinking Water Sources in the Study Area

	District / Municipality	Piped water	Protected source	Sub-total	Unprotected source	Total
Coast Region	Bagamoyo	25.4%	5.8%	31.2%	68.8%	100.0%
	Kibaha	57.9%	2.0%	59.9%	40.1%	100.0%
	Kisarawe	13.9%	11.5%	25.4%	74.6%	100.0%
	Mkuranga	0.63%	8.07%	8.7%	91.3%	100.0%
	Average	32.4%	6.4%	**38.8%**	**61.2%**	100.0%
Dar es Salaam	Ilala	45.1%	40.5%	85.6%	14.4%	100.0%
	Kinondoni	91.2%	5.6%	96.8%	3.2%	100.0%
	Temeke	68.7%	21.9%	90.6%	9.4%	100.0%
	Average	68.3%	22.7%	**91.0%**	**9.0%**	100.0%

Source: Central Census Office, National Bureau of Statistics, President's Office, Planning and Privatisation, (2004) 2002 Population and Housing Census, Volume IV, District Profile Bagamoyo, Kibaha, Kisarawe, Mkuranga, Ilala, Kinondoni and Temeke.

Although Coast Region is the adjacent area to Dar es Salaam Region, about 60 % of people have no access to safe water and are obliged to fetch water from unprotected sources. In particular, water supply condition in Bagamoyo, Kisarawe and Mkuranga Districts is worse than national average.

3.3 EXISTING WATER SUPPLY SCHEMES

3.3.1 LARGE SCALE PIPED WATER SUPPLY SCHEMES

In the Study area there are three large scale piped water supply schemes: Upper Ruvu Water Supply, Lower Ruvu Water Supply (under DAWASA) and Chalinze Water Supply Scheme. Outline of thoese schemes are summarized as follows.

(1) DAWASA Water Supply Scheme

Dar es Salaam Water & Sewerage Authority (DAWASA) is currently responsible for provision of water supply and sewerage services in Dar es Salaam. The service area of DAWASA is the Dar es Salaam city area and the zonal areas in Bagamoyo and Kibaha Districts along the transmission lines from the Upper Ruvu and Lower Ruvu treatment plans to the city area (2 km width in both sides). Although no exact figure of service population of DAWASA is available, it is estimated at approximately 1.25 million (half of the present population in Dar es Salaam).

Main water source is the Ruvu River (Upper Ruvu and Lower Ruvu). Other sources are the Kizinga River and several wells in Dar es Salaam. Total capacity of water production (treatment capacity) of the Ruvu water treatment plants are 264 x 10^3 m^3/day (past results 245.3 x 10^3 m^3/day). Past result means average treated water volume in 11 months from August 2003 to June 2004.

(2) Chalinze Water Supply Scheme

The scheme has started the service in 2003 and its current service area is 19 villages in Bagamoyo District (as of November 2005). The scheme is planned for the extension up to 42 villages (38 villages in Bagamoyo and 4 villages in Kibaha). Water source is the Wami River and the capacity of water production is 9.35 x 10^3 m^3/day (Bagamoyo District, 2001).

3.3.2 SMALL SCALE PIPED WATER SUPPLY SCHEME

The survey on the small scale piped water supply schemes revealed that there are 20 schemes in Coast Region and 73 schemes in Dar es Salaam Region. The survey was aimed 1) to investigate the existing condition of water supply schems and 2) to acquire basic data for formulation of rehabilitation plan. Outline of survey results is shown in *Table 3.3*.

(1) Water Sources

In Coast Region, half of the water sources are surface water, such as rivers and small dams , and another half of the source is groundwater. Among the water source of groundwater, ring wells occupies 40 %, and the ratios of both borehole (tube well) and spring are 5 %.

In contrary to this situation, most of the source is groundwater in Dar es Salaam Peri-Urban. It reaches 90 %. Especially, Ilala and Temeke Municipalities depend heavily on groundwater.

These water sources are summarized in *Figure 3.1*.

Table 3.3 Summary of Existing Water Supply Schemes (1/2)

District Municipal	Ward	MTAA Village	Water Sources	Served Population (2002)	Operating Condition (Existing)	Year of Construction	Remarks (Reasons of suspension)
Bagamoyo	Chalinze	Mdaula / Matuli	Matuli dam	11,112	not working (2003)	1991	breakdown of diesel engine and pump
	Kibindu	Kibindu	Deep well	3,500	not working (1992)	1974	breakdown of diesel engine and pump
	Kiwangwa	Fukayosi	Lembo dam	3,700	not working (2003)	1976	breakdown of diesel engine and pump
	Kiwangwa	Kiwangwa	Shallow well	-	not working (1984)	1974	water source was shortage
	Lugoba	Mindutulieni	Mindutulieni earth dam	28,104	Working	1980's	The area is served by Chalinze WS-Phase I. Now the dam is used to supply water for livestock
	Mbwewe	Kwaruhombo	Ring well	100%	not working (2001)	1972	breakdown of diesel engine and pump
	Mkange	Saadani	Ring well	-	not working (1994)	1970's	breakdown of diesel engine and pump
	Vigwaza	Kidogozero	Ruvu river	75% of population (Migudeni, Seko, Kitonga)	Working	1997	
Kibaha	Kwala	Kwala / Mwembengozi	Mongomole nutural pond	2953	workng	1975	
	Ruvu	Ruvu	Ruvu river	3,100	not working (2000)	1970's	breakdown of diesel engine and pump
Kisarawe	Kisarawe	Kisarawe	Minaki dam	12,000	Working	1960's	-
	Kurui	Kurui / Mtakayo	Ring well (2 wells)	100%	Working	1973	-
	Mafizi	Gwata	Ruvu River	2,393	Working	1975	-
	Maneromango	Maneromango Sokoni / Kitonga / Msegamo	Kanga dam	100%	Working	1973	-
	Mzenga	Mzenga	Ruvu River	-	not working (1998)	1970's	breakdown of diesel engine and pump
Mkuranga	Kisiju	Kisiju Pwane	Ring well	2,416	not working (2002)	1981	breakdown of diesel engine
	Kisiju	Kalole	Shallow well	more than 2,000	not working (2002)	1994	breakdown of diesel engine
	Lukanga	Njopeka	Spring	6,000	not working (1998)	1976	diesel engine was stolen
	Magawa	Nasibugani	Mwinvya river	979	not working (2002)	1990	breakdown of diesel engine and pump
	Mkuranga	Mkuranga	Borehole Ring well	10,000	Working	1974	-
		Mkamba Kizapara	Shallow well	2,800	not working (1996)	1972	breakdown of diesel engine and pump
Kinondoni	Mbezi	Mpiji Magoe	DAWASA	50%	not working (1996)	1987	breakdown of pump
	Kibamba	Kibamba	DAWASA	100%	not working	1987	breakdown of pump
	Bunju	Mabwe Pande	DAWASA	50%	not working	1979	
	Goba	Goba	DAWASA	100%	not working	1978	
Ilala	Tabata	Msimbazi (1)	Deep well	100%	not working	1998 (2002)	breakdown of electric motor
		Msimbazi (2)	Deep well	100%	working	2000	
		Msimbazi (3)	Deep well	Dispensary, community (50%)	working	2002	
		Msimbazi (4)	Deep well	Mosque, community (2%)	working	2004	
		Mandela	Deep well	100%	working	2001	
	Ukonga	Mazizini	Deep well	30%	working	2002	
		Guluka Kwalala	Deep well	100%	working	2002	
		Mwembe Madafu	Deep well	80%	not working	2002	water source was shortage.
	Vingunguti	Mtakuja	Deep well	30%	working	2002	
		Miembeni	Shallow well	25%	working	1998	
		Yombo	Deep well	100%	working	2002	
	Kitunda	Kitunda Kati (1)	Deep well	100%	working	2002	
		Kitunda Kati (2)	Deep well	100%	working	2004	
		Kipunguni Machimbo	Deep well	100%	working	2003	
	Segerea	Migombani (1)	Deep well	100%	working	2000	
		Migombani (2)	Deep well	100%	working	2002	
		Segerea	Deep well	100%	working	2004	
		Liwiti	Deep well (depth= 48 m)	100%	working	2003	
		Kimanga (1)	Deep well (depth= 60 m)	25%	not working	2001	breakdown of pump
		Kimanga (2)	Deep well	5%	working	1999	

Table 3.3 Summary of Existing Water Supply Schemes (2/2)

District Municipal	Ward	MTAA Village	Water Sources	Served Population (2002)	Operating Condition (Existing)	Year of Construction	Remarks (Reasons of suspended scheme)
Ilala	Kinyerezi	Kinyerezi (1)	Deep well	25%	working (shortage of water source)	2002	
		Kinyerezi (2)	Deep well	School(100%), Dispensary(100%), Community(25%)	not working	2002	pump was stolen
	Pugu	Pugu Kajiungeni (1)	Deep well	25%	working (electric problem)	2002	
		Pugu Kajiungeni (2)	Deep well (depth= 50 m)	80%	working	2003	
	Chanika	Chanika (1)	Deep well	Primary School	working	2003	
		Chanika (2)	Deep well	60%	working	2002	
		Chanika (3)	Deep well	100%	working	2002	
	Kipawa	Kipunguni (1)	Deep well	100%	working	2002	
		Kipunguni (2)	Deep well	100%	working	2001	
		Kipunguni (3)	Deep well	100%	working	2001	
	Kipawa	Karakata (1)	Deep well	5%	not working	2000	water source was shortage
		Karakata (2)	Deep well	80%	working	2000	
		Karakata (3)	Deep well	20%	working	2004	
	Kipawa	Kipawa	Deep well	100%	working	1998	
	Kiwalani	Yombo (1)	Deep well	97%	working	2002	
		Yombo (2)	Deep well	3%	working	1999	
		Kiwalani	Deep well	25%, Market, Hospital, Mosque.	working	2002	
	Kiwalani	Minazi Mirefu (1)	Deep well	25%	working	2002	
		Minazi Mirefu (2)	Deep well	15%	working	-	
	Buguruni	Mnyamani	Deep well	45%	working	2002	
		Madenge	Deep well	50%	working	2002	
		Kisiwani	Deep well	30%	working	2004	
	Buguruni	Malapa	Deep well	75%	working	2004	
	Ilala	Kasulu	Deep well	10%	working	2002	
		Bungoni Mafuriko	Deep well	50%	working	2003	
		Sharif Shamba	Deep well	30%	working	2002	
	Msongola	Msongola	Deep well	100%	working	2003	
		Mvuti (1)	Deep well	60%	working	2002	
		Mvuti (2)	Spring	100%	not working	2002	water source was shortage
Temeke	Kisarawe II	Chekeni	B/H (16m)	50%	not working (1988)	1986	generator was stolen
	Somangira	Amani Gonvu	B/H (33m)	100%	not working (2004)	1970's	generator was stolen
	Mji Mwema	Ungindoni	B/H (21m)	50%	not working (2004)	2000	breakdown of pump
	Makangarawe	Buza	B/H	2%	working	1998	
	Makangarawe	Makangarawe	B/H (45m)	40%	not working (2004)	1997	water quality problem
	Kibada	Uvumba	B/H (42m)	5%	not working (2003)	1997	pump was stolen
	Kibada	Nyakwale	B/H (46m)	100%	working	2003	
	Kimbiji	Kizito Huonjwa	Spring	100%	not working	1997	breakdown of generator
	Kigamboni	Ferry	B/H	100%	working	1997	
	Kigamboni	Tuamoyo	B/H	25%	working	1997	
	Mbagala	Kichemchem	B/H (56m)	2%	working	1997	
	Kigamboni	Kigamboni	B/H (18m)	50%	not working	1999	breakdown of pump
	Mbagala Kuu	Kibonde Maji B	B/H (32m)	60%	working	1999	
	Mbagala Kuu	Mtoni Kijichi	B/H (50m)	25%	working	1999	
	Mjimwema	Mjimwema	B/H (18m)	35%	working	1997	
	Kurasini	Kurasini	B/H (40.5m)	70%	working	1997	
	Yombo vituka	Barabara ya mwinyi	B/H (36m)	40%	working	1997	
	Yombo vituka	Vituka	B/H (50m)	20%	working	2004	
	Mtoni	Sabasaba	B/H (32m)	60%	working	1997	
	Yombo vituka	Machimbo	B/H (52m)	30%	working	1997	

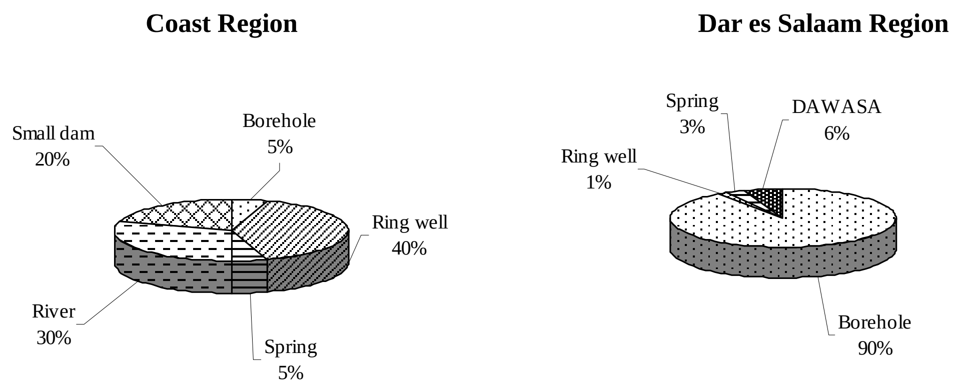


Figure 3.1 Water Sources of Water Supply Scheme

(2) Typical Components of Water Supply Scheme

The typical components of a water supply scheme consists of intake facilities, transmission line, storage tank, distribution lines and public water points (PWP) as shown in *Figure 3.2*. Water is extracted from various water sources by pumps and then sent to storage tanks by the pressure of the pump and then distributed by gravity from the storage tanks to public water points.

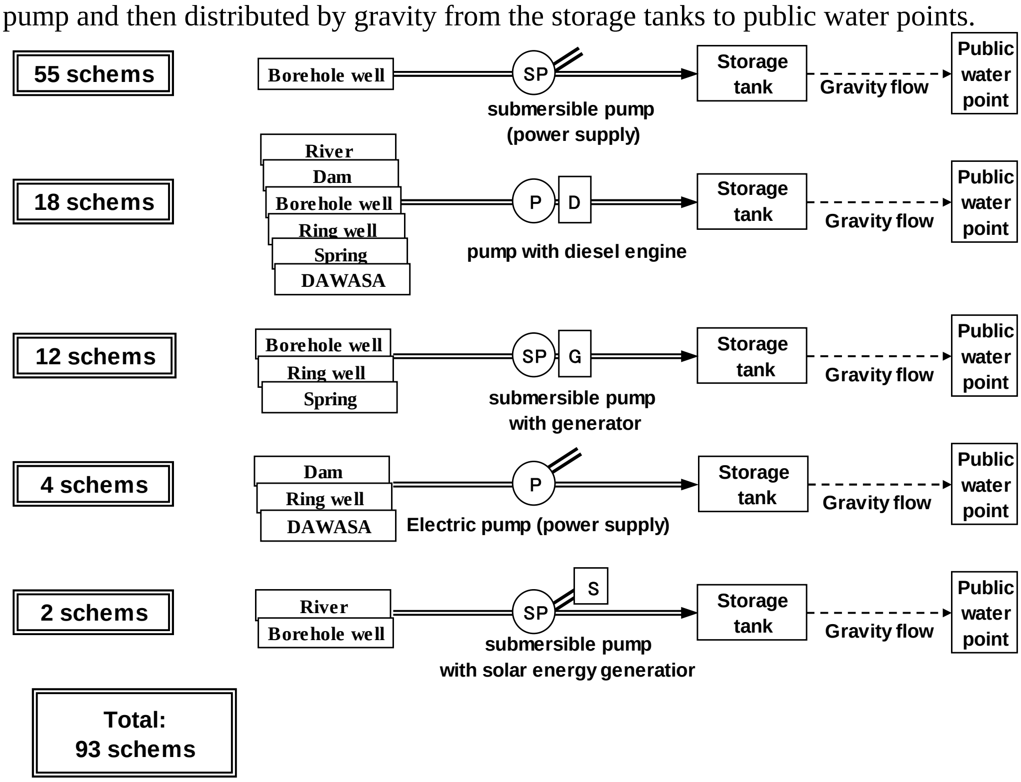


Figure 3.2 Components of Existing Water Supply Scheme

In the intake facility, submersible pump is mostly used since 1995. Power source is commercial power supply (TANESCO), diesel engine generator and solar energy. The commercial power supply is widely used in Ilala Municipality. Since it is not available in Coast Region, diesel engine generator and solar energy are used.

(3) Construction year

The construction year of existing water supply schemes is summarized in *Table 3.4*. As shown in the table, 75% of schemes were established in 1970's in Coast Region, while most in Dar es Salaam Region were constructed from the second half of 1990's to 2000's. Most schemes in Coast Region have been in operation for 20 years or more.

Table 3.4 Construction Year of Existing Water Supply Schemes

Construction Year	No. of Schemes and Rate (Coast Region)	No. of Schemes and Rate (Dar es Salaam Peri-Urban)
1970's	15 (75 %)	3 (4 %)
1980's	1 (5 %)	3 (4 %)
1990's	4 (20 %)	20 (27 %)
2000's	0 (0 %)	47 (65 %)
Total	20 (100 %)	73 (100 %)

(4) Current Condition of Water Supply Schemes

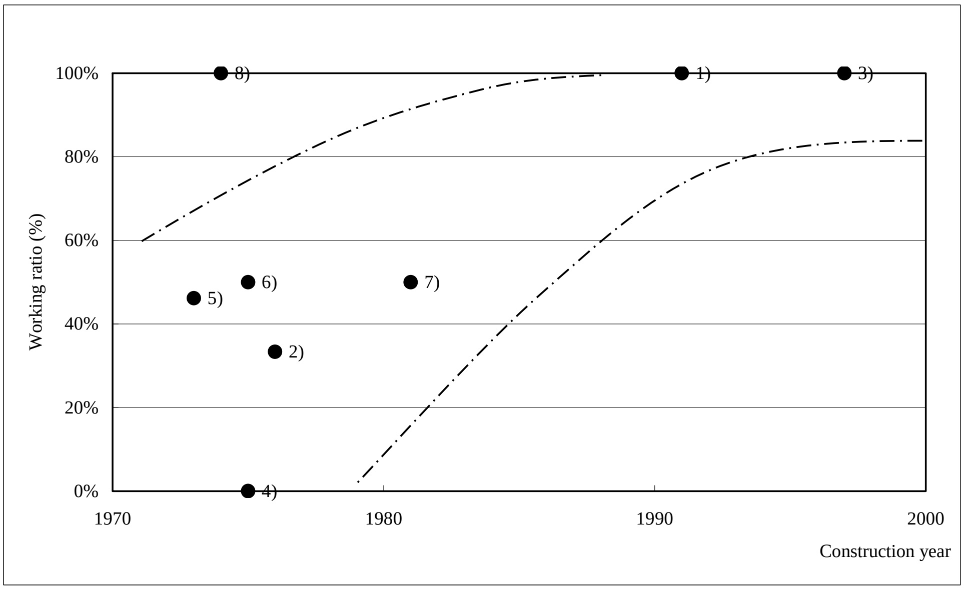
The operating condition of water supply schemes is summarized in *Table 3.5*.

Before 1990's a total of 22 schemes were constructed, however, 16 schemes (75 %) among them were already suspended. As for the schemes constructed in 2000's, 13 % were already suspended. Lifetime of machinery such as engine and pump is generally 10 to 15 years. Most of schemes in Coast Region have been in operation for 20 years or more, therefore these schemes are confronting overage.

Table 3.5 Operating Condition of Water Supply Schemes

		1970's	1980's	1990's	2000's	Total
Coast Region	Total	15	1	4	0	20
	Suspended	9 (60 %)	1 (100%)	3 (75 %)	0	13 (65 %)
Dar es Salaam	Total	3	3	20	47	73
	Suspended	3 (100%)	3 (100%)	5 (25%)	6 (13%)	17 (23%)
Total	Total	18	4	24	47	70
	Suspended	12 (67%)	4 (100%)	8 (33%)	6 (13%)	30 (32%)

Figure 3.3 shows current condition of public water points in Coast Region. Ratio of malfunction of public water points increases as operation year becomes longer. For example, Kwala/Mwembengozi water supply scheme was constructed in 1975. It is still operating, however, all the public water points were broken due to aging.



1) Mdaula/Matuli WSS
2) Fukayosi WSS
3) Kidogozero WSS
4) Kwala / Mwembengozi WSS
5) Kurui / Mtakayo WSS
6) Gwata WSS
7) Kisiju Pwane WSS
8) Mkuranga WSS

Figure 3.3 Condition of Public Water Point in Coast Region

(5) Reasons for Suspension of Water Supply Scheme

Reasons for suspension of schemes are classified into following four categories.

- Problem of intake facilities : engine, pump or generator trouble.
- Problem of water source : shortage of water source or water quality problem
- Theft of equipment : theft of engine, pump, generator, solar panel, etc
- Problem of pipe facilities : damage of pipe

These reasons are tabulated in *Table 3.6*. Major reason of suspension is trouble of intake facilities such as break-down of diesel engine, generator and pump, which makes up to 60 %. The other reasons are theft of equipment and water source problem. Although damages of pipes are frequent, problem with pipelines is minor reason for suspension.

Table 3.6 Number of Suspended Water Supply Schemes and Reasons

Reason of Suspended	1970's	1980's	1990's	2000's	Total
Problems of engine & pump	7	3	6	2	18 (60.0%)
Problems of water source	1	0	1	3	5 (16.7%)
Theft of equipment	1	1	1	1	5 (16.7%)
Problems of pipe facilities	2	0	0	0	2 (6.6%)
Total	12	4	8	6	30 (100%)

Main reason of suspension of intake facilities is aging in Coast Region as mentioned above. These troubles are also caused by frequent fluctuation of voltage of power supply in Dares Salaam Region.

The technical level and the efforts of operation staffs and engineers in existing water supply schemes are praiseworthy for the Tanzanian side, which have been operated for 20 years or more, and highly admired from the aspect of sustainability.

3.3.3 MAJOR FINDINGS

According to the results of existing water supply scheme investigation, following findings were observed.

- The total number of schemes in Coast Region and Dar es Salaam Region are 20 and 73, and their working ratios are 35 % and 77 %, respectively.
- The main reason of suspended facilities is trouble of intake facilities such as break-down of diesel engine, generator and pump that makes up 60% of all suspension.
- It takes too long time to repair the water schemes after breakdown.
- Some of the water supply schemes have been operated for about 30 years without replacement of equipment.
- Antitheft measure is insufficient.
- Pipeline damaged within limit of life and improper placement of pipes were observed.

These findings were taken into consideration for the formulation of water supply development and rehabilitation plans.

3.4 WATER QUALITY ON EXISTING WATER SOURCE

Water quality was analyzed aiming at 1) to grasp water quality condition of water source for the existing water supply schemes, 2) to understand the groundwater quality characteristics. Sampling was done in both dry and rainy seasons, however, groundwater sampling was done only in dry season. Location of sampling site is shown in *Figure 3.4*.

Total number of sampling locations is 77. Breakdown of water source of sampling is given below.

- 33 sampling locations for surface water including water from shallow wells (dry season and rainy season)
- 35 sampling locations for groundwater from tube wells (dry season only)
- 9 sampling locations for test wells of this Study

Thus, total number of 110 samples were analyzed.

Number of analyzed item is 50, breakdown of which is given below

- 2 items for Microbial aspects (Total Coliform bacteria and Escherishia Coli).
- 17 items related to Chemicals that are of health significance.
- 23 items related to Acceptability aspects.
- 8 items for evaluation of groundwater characteristics

Water samples were collected in October 2004 as the dry season and in January 2005 as the rainy season. Samples from groundwater were taken only in dry season in October 2004. The reasons why samples of groundwater were taken only once in dry season are as follows:

Water quality of deep groundwater is in general not influenced by seasonal changes and it is thought to be almost stable through the year. Even, if water quality of deep groundwater is influenced by rain fall, still it should be worse in dry season than rainy season.

In this Chapter, characteristics of surface and shallow ground water quality other than test well quality are discussed. The groundwater quality for the test wells drilled in the Study are discussed in Chapter 4.

3.4.1 WATER QUALITY STANDARDS FOR DRINKING WATER

For the evaluation of water quality, it was agreed between the Tanzanian side and the Study Team to apply the following guidelines and standards.

(1) Microbial Aspects: The Guidelines for Drinking-water Quality Third Edition (WHO, 2004) (hereinafter called “WHO Guidelines”)

(2) Chemicals that are of Health Significance: WHO Guidelines

(3) Acceptability Aspects: Temporary Standards of Quality of Domestic Water in Tanzania (Ministry of Water Development and Power, 1973) (hereinafter called “Tanzanian Standards”)

Comparative table of water quality standards for drinking water and their analysis method are shown in *Table 3.7* and *3.8,* respectively.

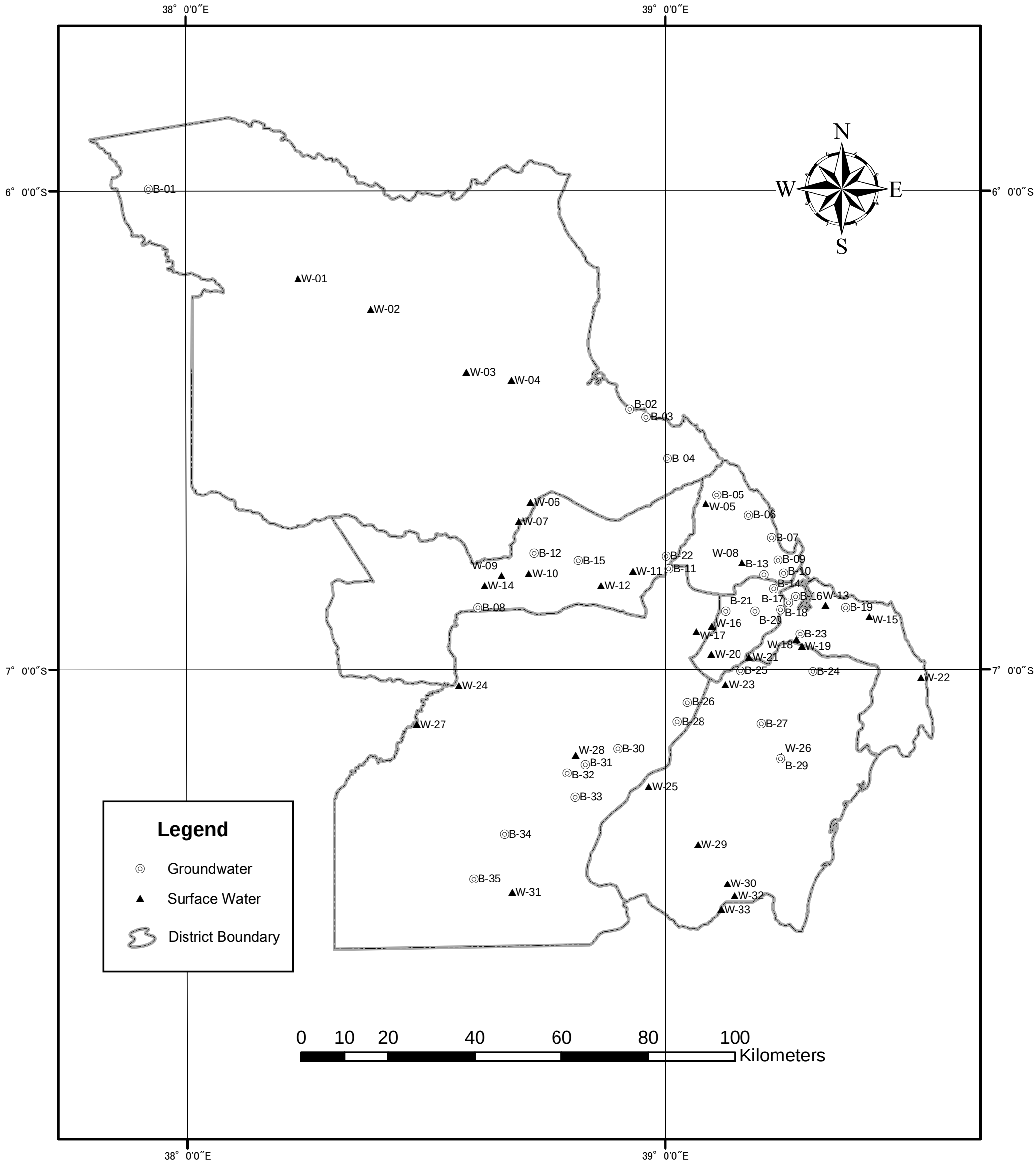


FIGURE 3.4 LOCATION OF SAMPLING POINT FOR WATER QUALITY ANALYSES

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Table 3.7 Comparative Table of Water Quality Standards for Drinking Water

Aspects and Items			Unit	Tanzanian Standard (1974) *1	WHO Guideline (2004) *2
Microbial aspects	1	Total coliform bacteria	count/100ml	0	-
	2	Escherichia Coli	count/100ml	0	0
Chemicals that are of health significance	3	Cadmium (Cd)	mg/l	0.05	0.003
	4	Cyanide (CN)	mg/l	0.20	0.07
	5	Lead (Pb)	mg/l	0.10	0.01
	6	Arsenic (As)	mg/l	0.05	0.01
	7	Mercury (Hg)	mg/l	-	0.001
	8	Selenium (Se)	mg/l	0.05	0.01
	9	Barium (Ba)	mg/l	1.00	0.7
	10	Fluoride (F)	mg/l	8.0	1.5
	11	Hexavalent-chromium (Cr^{6+})	mg/l	0.05	-
	12	Total chromium (T-Cr)	mg/l	-	0.05
	13	Nitrate (NO_3-N)	mg NO_3/l	100	50
	14	Nitrite (NO_2-N)	mg NO_2/l	-	3 / 0.2 *3
	15	Boron (B)	mg/l	-	0.5
	16	Nickel (Ni)	mg/l	-	0.02
	17	Antimony (Sb)	mg/l	-	0.020
	18	Molybdenum (Mo)	mg/l	-	0.07
	19	Manganese (Mn)	mg/l	0.5	0.4
	20	Organic Carbon (as carbon in Chloroform)	mg/l	0.5	-
Acceptability aspects	21	Hardness	mg/l	600	-
	22	Calcium (Ca)	mg/l	-	-
	23	Magnesium (Mg)	mg/l	-	-
	24	Iron (Fe)	mg/l	1.0	-
	25	Zinc (Zn)	mg/l	15.0	-
	26	Copper (Cu)	mg/l	3.0	2.0
	27	Chloride (Cl^-)	mg/l	800	-
	28	Residue*4	mg/l	-	-
	29	Total filterable residue*5	mg/l	2,000	-
	30	Anionic surface active agents (as ABS)	mg ABS/l	2.0	-
	31	Phenols	mg/l	0.002	-
	32	Hydrogen sulfide (H_2S)	mg/l	-	-
	33	Ammonium (NH_3+NH_4)	mg/l	-	1.5
	34	Total nitrogen (Excluding NO_3)	mg/l	1.0	-
	35	BOD	mg/l	6.0	-
	36	Potassium permanganate consumption	mg/l	20	-
	37	pH	-	6.5 - 9.2	
	38	Taste	dilution	not objectionable	-
	39	Odour	dilution	not objectionable	-
	40	Colour	mg Pt/l	50	15
	41	Turbidity (Tr)	NTU	30	5
	42	Temperature	℃	-	-
	43	Conductivity (EC)	mS/m	-	-
	44	Residual chlorine (Cl)	mg/l	-	-
	45	Sulfate (Mg+Na Salts)	mg/l	-	-
Water quality items related to the characteristics of groundwater	46	Sodium (Na)	mg/l	-	-
	47	Potassium (K)	mg/l	-	-
	48	Bicarbonate (HCO_3^-)	mg/l	-	-
	49	Total alkalinity	mg/l	-	-
	50	Sulfate (SO_4^{2-})	mg/l	600	-

*1: "Maji Review" Ministry of Water Development and Power vol. 1, No. 1, MoWDP, Dar es Salaam, 1974
*2: "WHO Guideline for Drinking Water Quality Third Edition", World Health Organization, Genova, 2004
*3: Short term / long term
*4: Residue is equal to [Total solids - Total dissolved solids]
*5: Total filterable residue is equal to Total dissolved solids (TDS).
[ ] Items adopted for water quality evaluation.

Table 3.8 Water Quality Analyses Method

Aspects and Items			Method of Analysis	Detection Limit
Microbial aspects	1	Total coliform bacteria	Membrane filtration	-
	2	Escherichia Coli		-
Chemicals that are of health significance	3	Cadmium (Cd)	Atomic Absorption Spectrometer	<0.001 mg/liter
	4	Cyanide (CN)	Atomic Absorption Spectrometer	<0.001 mg/liter
	5	Lead (Pb)	Atomic Absorption Spectrometer	<0.01 mg/liter
	6	Arsenic (As)	Atomic Absorption Spectrometer	<0.001 mg/liter
	7	Mercury (Hg)	Atomic Absorption Spectrometer	<0.00001 mg/liter
	8	Selenium (Se)	Atomic Absorption Spectrometer	<0.001 mg/liter
	9	Barium (Ba)	Atomic Absorption Spectrometer	<0.01 mg/liter
	10	Fluoride (F)	Potentiometric	<0.01 mg/liter
	11	Hexavalent-chromium (Cr^{6+})	Atomic Absorption Spectrometer	<0.001 mg/liter
	12	Total chromium (T-Cr)	Atomic Absorption Spectrometer	<0.001 mg/liter
	13	Nitrate (NO_3-N)	Cadmium reduction Spectrophotometric	<0.01 mg/liter
	14	Nitrite (NO_2-N)		<0.001 mg/liter
	15	Boron (B)	Carmine	<0.1 mg/liter
	16	Nickel (Ni)	Atomic Absorption Spectrometer	<0.001 mg/liter
	17	Antimony (Sb)	Atomic Absorption Spectrometer	<0.001 mg/liter
	18	Molybdenum (Mo)	Atomic Absorption Spectrometer	<0.0005 mg/liter
	19	Manganese (Mn)	Periodate Method	<0.01 mg/liter
	20	Organic Carbon (as carbon in Chloroform)	Dichromate	<0.001 mg/liter
Acceptability aspects	21	Hardness	EDTA Titrimetric	<0.1 mg/liter
	22	Calcium (Ca)	EDAT Titrimetric	<0.1 mg/liter
	23	Magnesium (Mg)		<0.1 mg/liter
	24	Iron (Fe)	Spectrophotometric	<0.01 mg/liter
	25	Zinc (Zn)	Atomic Absorption Spectrometer	<0.01 mg/liter
	26	Copper (Cu)	Atomic Absorption Spectrometer	<0.01 mg/liter
	27	Chloride (Cl^-)	Argentometric (titration)	<0.1 mg/liter
	28	Residue	Filtration (using GFC) and Drying at 105ºC	<0.1 mg/liter
	29	Total filterable residue	Gravimetric	<0.1 mg/liter
	30	Anionic surface active agents (as ABS)	MBAS Method	<0.001 mg/liter
	31	Phenols	4-Amino antipyrine	<0.001 mg/liter
	32	Hydrogen sulfide (H_2S)	Iodometric	<0.01 mg/liter
	33	Ammonium (NH_3+NH_4)	Nesler reagent	<0.01 mg/liter
	34	Total nitrogen (Excluding NO_3)	Titration	<0.01 mg/liter
	35	BOD	5-day BOD test	<0.1 mg/liter
	36	Potassium permanganate consumption	Oxidation reduction	<0.1 mg/liter
	37	pH	Potentiometric	<0.1
	38	Taste	-	-
	39	Odour	Threshold	-
	40	Colour	Platinum cobolt	1 mg Pt/liter
	41	Turbidity (Tr)	Nephelometric	<0.1 NTU
	42	Temperature	Thermometer	< 1 ^{o}C
	43	Conductivity (EC)	Conductivity meter	< 1 micro S/cm
	44	Residual chlorine (Cl)	DPD (No analysis)	<0.1 mg/liter
	45	Sulfate (Mg+Na Salts)	Spectrophotometric	<0.1 mg/liter
Water quality items related to the characteristics of groundwater	46	Sodium (Na)	Atomic Absorption Spectrometer	<0.1 mg/liter
	47	Potassium (K)	Atomic Absorption Spectrometer	<0.1 mg/liter
	48	Bicarbonate (HCO^{3-})	Titrimetric	<0.1 mg/liter
	49	Total alkalinity	Titration	<0.1 mg/liter
	50	Sulfate (SO_4^{2-})	Tubdimetric	<0.1 mg/liter

3.4.2 RESULTS OF WATER QUALITY ANALYSES

Number of samples that do not satisfy the relevant items (parameters) of the Guidelines (WHO, 2004) or the Standards (Ministry of Water Development and Power, 1973) is summarized in *Table 3.9* below.

Table 3.9 Number of Samples with Items exceeding the Guidelines and Standards

Aspects and Items		Test well	Existing well	Surface water (Dry season)		Surface water (Rainy season)	
				River and Dam	Shallow well and Spring	River and Dam	Shallow well and Spring
Total Number of Sample		9	35	17	16	16	17
Microbial aspects	Escherichia coli	6	10	17	14	16	17
Chemicals that are of health significance	Cadmium (Cd)	0	1	0	0	0	0
	Cadmium (Cd)	0	0	0	0	0	0
	Cyanide (CN)	0	0	0	0	0	0
	Lead (Pb)	1	0	0	0	0	0
	Arsenic (As)	0	0	4	4	9	11
	Mercury (Hg)	0	0	2	1	6	4
	Selenium (Se)	0	0	11	9	8	7
	Barium (Ba)	0	0	12	11	10	5
	Fluoride (F)	0	0	0	0	0	0
	Hexavalent-chromium (Cr^{6+})	0	0	0	0	0	0
	Total chromium (T-Cr)	-	-	-	-	-	-
	Nitrate (NO_3-N)	0	3	1	3	1	3
	Nitrite (NO_2-N)	0	0	0	0	0	0
	Boron (B)	0	0	1	4	0	0
	Nickel (Ni)	1	1	1	0	4	1
	Antimony (Sb)	0	0	0	0	0	0
	Molybdenum (Mo)	0	0	0	0	0	0
	Manganese (Mn)	2	0	0	3	1	2
	Organic Carbon (as carbon in Chloroform)	0	0	0	0	0	0
Acceptability aspects	Total Hardness	4	5	0	0	1	0
	Hardness	0	1	2	3	4	5
	Calcium (Ca)	-	-	-	-	-	-
	Magnesium (Mg)	-	-	-	-	-	-
	Iron (Fe)	2	0	2	3	2	1
	Zinc (Zn)	0	0	0	0	0	0
	Copper (Cu)	1	0	0	0	1	0
	Chloride (Cl)	4	5	1	1	1	0
	Residue	-	-	-	-	-	-
	Total filterable residue	4	2	1	0	1	0
	Anionic surface active agents (as ABS)	0	0	0	0	0	0
	Phenols	0	0	0	0	0	0
	Hydrogen sulfide (H_2S)	-	-	-	-	-	-
	Ammonium (NH_3+NH_4)	0	0	0	1	2	6
	Total nitrogen (Excluding NO_3)	0	0	0	0	2	6
	BOD	0	0	4	3	8	9
	Potassium permanganate consumption	0	0	2	2	4	4
	pH	0	17	3	7	3	10
	Taste	5	7	2	2	1	2
	Odour	0	8	3	5	0	0
	Colour	0	2	9	8	5	9
	Turbidity	3	2	5	6	8	10
	Temperature	-	-	-	-	-	-
	Conductivity (EC)	-	-	-	-	-	-
	Residual chlorine (Cl)	-	-	-	-	-	-
	Sulfate (Mg+Na Salts)	-	-	-	-	-	-
Water quality items related to the characteristics of groundwater	Sodium (Na)	-	-	-	-	-	-
	Potassium (K)	-	-	-	-	-	-
	Bicarbonate (HCO^{3-})	-	-	-	-	-	-
	Total alkalinity	-	-	-	-	-	-
	Sulphate (SO_4)	1	0	0	0	0	0

Itemized results of water quality analyses are summarized in *Table 3.10*.

Most items of water quality do not show any regional characteristics other than for Electric Conductivity (EC). Distribution of EC is shown in *Figure 3.5.* Relatively high EC (more than 1,000 micro-S/cm) is observed in the areas of Kinondoni, Kibaha and the southeastern area of Bagamoyo. On the one hand, relatively low EC (less than 1,000 micro-S/cm) are measured in the areas of Ilala, western half of Temeke, northern part of Mkuranga and in the hilly areas of Kisarawe.

Table 3.10 Results and Evaluation of Water Quality Analyses (1/4)

Aspects and Items		Test Well (9 sites)	Existing Well (35 sites)	Surface Water (River, Dam) (17 sites)	Surface Water (Shallow well, spring) (16 sites)
Microbial Aspects	1. Microbial Aspects				
	Escherichia coli	Although Microbial aspects is generally not detected in deep groundwater, it was unlikely detected in more than two third of samples. Therefore, chlorination is necessary in using as the water sources.	Although Microbial aspects is generally not detected in deep groundwater, it was detected in many samples. It might be caused due to intrusion of deteriorated water through the aged casing pipe.	It is common to detect Microbial aspectss in the samples collected from surface water of rivers and dams.	Since even deep wells are deteriorated with Microbial aspects, much more shallow wells are also deteriorated.
Chemicals that are of Health Significance	2. Chemicals that are of health significance				
	Arsenic (As)	Among the chemicals that are of health significance (CHS), the values more than Guidelines were detected for Ni, Mn and Pb. Contents of other chemicals were lower than the Guidelines. Therefore, significant level of CHS is not expected from new wells to be drilled for the Priority Project.	Cd, Ni and N_3 were independently detected from different wells. Other items were lower than the Guidelines. Significant detection of items of CHS is not expected in deep wells.	Content of As is lower than the Guidelines in deep wells, contamination source is not geological origin. It is likely artificial source, but there are no factories or mines related to As. Fertilizer and agrichemical may be possible sources. However, the contamination source is not clear. Content of As is lower than the Guidelines in the Wami River, therefore, the water is suitable as the water source for the Priority Project in Matipwili.	As content is lower than Guidelines in deep wells. It is considered that contamination source of surface water is not geological origin. In addition, there exist no artificial contamination sources like drained water from chemical factories or mines. Therefore, contamination might be caused by agrichemicals, but it is not clear. No contamination by As was confirmed in the Njopeka spring, therefore, the water is suitable as the sources of the Priority Project in Njopeka.
	Mercury (Hg)			Content of Hg is lower than the Guidelines in deep wells. Contamination source is not geological origin. There is no factory where Hg is used. Agrichemicals containing Hg are prohibited to use. Therefore, the contamination source is unclear. Content of Hg is lower than the Guidelines in the Wami River, therefore, the water is suitable as the water source for the Priority Project in Matipwili.	Hg content is lower than Guidelines in deep wells. It is considered that contamination source of surface water is not geological origin. In addition, there exist no artificial contamination sources like chemical factories where a large quantity of Hg is used. And it is prohibited to use agrichemicals which contain Hg. Therefore, contamination source is not clear. No contamination by Hg was confirmed in the Njopeka spring, therefore, the water is suitable as the sources of the Priority Project in Njopeka.
	Selenium (Se)			Content of Se is lower than the Guidelines in deep wells. Contamination source is not geological origin. There is no factory where Se is used. Agrichemicals containing Se are prohibited to use. Therefore, the contamination source is unclear. The water is suitable as the water source for the Priority Project in Matipwili.	Se content is lower than Guidelines in deep wells. It is considered that contamination source of surface water is not geological origin. In addition, there exist no artificial contamination sources like drained water from chemical factories or mines. Therefore, contamination might be caused by agrichemicals, but it is not clear. No contamination by Se was confirmed in the Njopeka spring, therefore, the water is suitable as the sources of the Priority Project in Njopeka.
	Barium (Ba)			Content of Ba is lower than the Guidelines in deep wells. Contamination source is not geological origin. There is no factory where Ba is used. Therefore, the contamination source is unclear. The water is suitable as the water source for the Priority Project in Matipwili.	Content of Ba is lower than the Guidelines in deep wells. Contamination source is not geological origin. There is no factory where Ba is used. Therefore, the contamination source is unclear. The water is suitable as the water source for the Priority Project in Njopeka.

Table 3.10 Results and Evaluation of Water Quality Analyses (2/4)

Aspects and Items		Test Well (9 sites)	Existing Well (35 sites)	Surface Water (River, Dam) (17 sites)	Surface Water (Shallow well, spring) (16 sites)
Chemicals that are of Health Significance (Cont'd)	Fluoride (F)			Although content of F is sometimes more than Guidelines in the river water, it is lower than the Guidelines in deep wells. Contamination source is not geological origin. There is no factory where F is used. Therefore, the contamination source is unclear. The water is suitable as the water source for the Priority Project in Matipwili.	Although content of F is sometimes more than Guidelines in shallow wells, it is lower than the Guidelines in deep wells. Contamination source is not geological origin. There is no factory where F is used. Therefore, the contamination source is unclear. The water is suitable as the water source for the Priority Project in Njopeka.
	Chromium (Cr)			Cr is not detected in deep wells, therefore it is not geological origin. The contamination source is not clear because there are no factories related to Cr. The water of the Wami River is suitable as the source for the Priority Project in Matipwili.	Cr is not detected in deep wells, therefore it is not geological origin. The contamination source is not clear because there are no factories related to Cr. The water of Njopeka spring is suitable as the water source for the Priority Project in Njopeka.
	Nitrate (NO_3)		Elements of fertilizer might intrude into wells through aged casing pipes and deteriorate groundwater.	Elements of fertilizer might intrude into the well through aged casing pipes and deteriorate groundwater.. The water of the Wami River is suitable as the water source for the Priority Project in Matipwili.	Elements of fertilizer might intrude into the well through aged casing pipes and deteriorate groundwater. The water of Njopeka spring is suitable as the water source for the Priority Project in Njopeka.
	Nitrite (NO_2) (long/short term)			Deterioration might be progressed through aged casing pipes. The water of the Wami River is suitable as the water source for the Priority Project in Matipwili.	Deterioration might be progressed through aged casing pipes. Because NO_2 content is lower than Guidelines in both dry and rainy seasons in the Njopeka spring, the water is suitable as the water source for the Priority Project in Njopeka.
	Boron (B)			Content of B is lower than the Guidelines in deep wells. Contamination source is not geological origin. It is not likely to be deteriorated by artificial contamination sources. The water is suitable as the water source for the Priority Project in Matipwili.	Content of B is lower than the Guidelines in deep wells. Contamination source is not geological origin. It is not likely to be deteriorated by artificial contamination sources. Because B content is lower than Guidelines in both dry and rainy seasons in the Njopeka spring and the water is suitable as the water source for the Priority Project in Njopeka.
	Nickel (Ni)	Ni was detected from only one well content of which was 0.03 mg/L.	Ni was detected from only one well content of which was 0.23 mg/L. It was not detected from other wells. Therefore, a contamination source is not likely of geological origin. Probable sources are Ni contained in the pipes, or elution from the coated metal or instrument. However, contamination source is not clear.	Content of Ni is lower than the Guidelines in deep wells. Contamination source is not geological origin. There are no artificial contamination sources such as plating factories and mines. Contamination source is not clear. The water is suitable as the water source for the Priority Project in Matipwili.	Content of Ni is lower than the Guidelines in deep wells. Contamination source is not geological origin. There are no artificial contamination sources such as plating factories and mines. Contamination source is not clear. Because Ni content is lower than Guidelines in both dry and rainy seasons in the Njopeka spring and the water is suitable as the water source for the Priority Project in Njopeka.
	Antimony (Sb)		-	-	Content of Sb is lower than the Guidelines in deep wells. Contamination source is not geological origin. There are no artificial contamination sources such as plating factories and mines. Contamination source is not clear. The water is suitable as the water source for the Priority Project in Njopeka.
	Manganese (Mn)	Content of Mn is sometimes more than 0.5 mg/L. When Mn content is high, EC is also high. Groundwater in such aquifer is not suitable as water source of water supply schemes.		-	It is considered that origin of contamination source of Mn is geological origin. Mn content is lower than Guidelines in both dry and rainy seasons in the Njopeka spring, the water is suitable as the water source for the Priority Project in Njopeka.

Table 3.10 Results and Evaluation of Water Quality Analyses (3/4)

Aspects and Items		Test Well (9 sites)	Existing Well (35 sites)	Surface Water (River, Dam) (17 sites)	Surface Water (Shallow well, spring) (16 sites)
Acceptability aspects	3. Acceptability aspects				
	Total Hardness	Hardness of deep groundwater is divided into three orders: about 150, about 500 and about 1,000. If hardness is high, values of other items such as TDS, EC and Cl are also high. Such water with high hardness is not suitable for potable use.	Hardness of groundwater is divided into three orders: about 150, about 500 and about 1,000. If hardness is high, values of other items such as TDS, EC and Cl are also high. Such water is with high hardness not suitable for the source of water supply scheme.	Hardness of surface water is generally low. It is lower than Standards in the Wami River, therefore, the water is suitable as the sources of the Priority Project in Matipwili.	
	Iron (Fe)	It seems to be of geological origin. Iron in deep groundwater is Fe^{2+} and is divided into two groups contents of which are about 0.5 mg/L and more than 5 mg/L. The latter will cause metallic odour or rust-coloured water, therefore, it is not suitable for potable use.		It seems to be of geological origin. Iron in surface of waters in rivers or dams is Fe^{3+} and insoluble. It will not generate metallic odour or rust-coloured. Fe content in the Wami River is lower than Standards, therefore, it is suitable as the source of the Priority Project in Matipwili.	It seems to be of geological origin. Iron in shallow groundwater is Fe^{2+}. If the content is high, it will generate metallic odour or rust-coloured water. Fe content in the Njopeka spring is lower than Standards, therefore, it is suitable as the sources of the Priority Project in Njopeka.
	Copper (Cu)	Content of Cu of more than 5 mg/L was detected at Msumi in Kinondoni.		Content of Cu more than Standards was not detected in the deep groundwater, it is not of geological origin. There are no drained water from the mines and factories related to metals, the contamination source is unclear. The water of the Wami river is also less than Standards and the water is suitable for the Priority Project in Matipwili.	
	Total filterable residue (TDS)	TDS values are lower than Standards in five wells. Although those of three wells out of remaining four wells, are more than Standards, but they are less than 3,000. TDS value in Matipwili is extremely high, 6,170. TDS values more than Standards are distributed in eastern and southern part of Bagamoyo, and southern part of Kibaha and Mkuranga. In such area, no Priority Project is planned, therefore, those results will not affect to the Priority Project.	TDS values are in a range between 70 and 5,990. TDS values are more than Standards in only two wells. They are located near the coast line. High TDS values are derived from intruded sea water.	TDS values are in a range from 37.3 to 2,280. Only one value is higer than Standards It is the water of small stream in Kise, Kisarawe. Still the Wami River is suitable as the source of the water supply scheme in Matipwili.	All the TDS values are lower than Standards. So the spring is suitable as the source of the water supply scheme in Njopeka.
	Ammonia (NH_4)			It might be deteriorated by fertilizer, wastewater and night soil. Still the water of the Wami River is less than Standards.	It might be deteriorated by fertilizer, wastewater and night soil. Still the water of Njopeka Spring is less than Standards.
	BOD			It might be deteriorated by fertilizer, wastewater and night soil. Although the water of the Wami River is less than Standards, it is high, 5.0 mg/L in dry season and 4.0 mg/L in rainy season.	It might be deteriorated by fertilizer, wastewater and night soil. Although the water of Njopeka Spring is less than Standards, it is high, 5.0 mg/L in dry season and 5.2 mg/L in rainy season.
	PV Oxygen abs. $KMnO_4$)			It might be deteriorated by fertilizer, wastewater and night soil. Although the water of the Wami River is less than Standards, it is high, 8.6 mg/L in dry season and 6.8 mg/L in rainy season.	It might be deteriorated by fertiliser, wastewater and night soil. Although the water of Njopeka Spring is less than Standards, it is high, 8.2 mg/L in dry season and 8.8 mg/L in rainy season.
	pH		In case of test wells pH values are 7 in average and no sample shows less than lower limit of Standards. But, pH values in existing wells are often less than 6 and sometimes 5. The water of low pH is not suitable for the source of water supply scheme because metallic materials of wells will be corroded by such water.	The water in rivers and dams shows neutral pH. Some dam water is weak-acidic. Still the water of the Wami River is within the Standards, therefore, it is suitable for source of water supply scheme.	Some water in shallow wells are weak-acidic. The water of Njopeka Spring is within the Standards, therefore, it is suitable as the source of the Priority Project in Njopeka.

Table 3.10 Results and Evaluation of Water Quality Analyses (4/4)

Aspects and Items		Test Well (9 sites)	Existing Well (35 sites)	Surface Water (River, Dam) (17 sites)	Surface Water (Shallow well, spring) (16 sites)
	Taste	Evaluation results are "sweet" and "salty". "Sweet" includes insipidity. "Salty" has a relationship with high TDS and Cl content.	Evaluation results are "sweet" and "salty". "Sweet" includes insipidity. "Salty" has a relationship with high TDS and Cl content.	Evaluation results are "sweet" and "salty". "Sweet" includes insipidity. "Salty" has a relationship with high TDS and Cl content. The water of the Wami River is within the Standards, therefore, it is suitable for source of water supply scheme.	Evaluation results are "sweet" and "salty". "Sweet" includes insipidity. "Salty" has a relationship with high TDS and Cl content. The water of Njopeka spring contains high content of Cl in dry season, therefore, taste is salty.
Acceptability aspects (Cont'd)	Odour	No water is "Objectionable" in test wells.	Water in many wells are "Objectionable". Odour seems to be generated by deterioration.	Odour seems to be generated by deterioration. The water of the Wami River is within the Standards, therefore, it is suitable for source of water supply scheme.	Odour seems to be generated by deterioration. The water in Njopeka spring is "Objectionable" in dry season.
	Colour	No samples of Test wells are "Objectionable".	Many samples are "Objectionable". Colour is milky white, it is derived from material of geological layers. It is remarkable in Chole.	The water in rivers and dams are remarkably coloured. Some of samples have more than 500 unit. The water of the Wami River is more than the Standards, therefore, it is necessary to check the effectiveness of the sedimentation tank in the implementation of the project for reduction in colour.	The water in rivers and dams are remarkably coloured. Some of samples have more than 300 unit. The water of Njopeka Spring is within the Standards, therefore, it is suitable for source of water supply scheme.
	Turbidity	Most of Turbidity is lower than 30 of Standards. But, it is sometimes extremely high, more than 500. The latter includes high content of Fe and TDS. Such water is not suitable as the source of water supply scheme.	Turbidity is high only in Chole, Kisarawe. Others are generally low.	Turbidity is high in the Ruvu and Wami Rivers. However, it is unavoidable. The water of the Wami River is more than the Standards in rainy season, therefore, it is necessary to check the effectiveness of the sedimentation tank in the implementation of the project for reduction in turbidity.	Turbidity is generally low in wells. But it is sometimes extremely high. In such case, colour is also high. The water of Njopeka Spring is within the Standards, therefore, it is suitable as source of water supply scheme.
	Chloride (Cl)	Cl in deep groundwater is of geological origin. Contents are divided into four levels: less than 100, 500, 1000 and 2000. The water of which Cl content is high, is not suitable as the source of water supply scheme.	Cl in deep groundwater is of geological origin or is derived from sea water intrusion along the coast of the Indian Ocean. Contents are divided into four levels: less than 100, 500, 1000 and 2000. The water of which Cl content is high, is not suitable for the source of water supply scheme.	Content of Cl is less than 100 mg/L in many samples. Some samples have more than 500 mg/L. The water of the Wami River is within the Standards, therefore, it is suitable as source of water supply scheme.	Content of Cl is less than 100 mg/L in many samples. Some samples have more than 500 mg/L. The water of the Njopeka Spring has 650 but still it is within the Standards. Therefore, it is suitable as source of water supply scheme.
Evaluation		Microbial aspects were unexpectedly detected in two third of newly drilled test wells. No problem was found on the Chemicals that are of health significance. The areas having no suitable water source are Matipwili and Magindu in Bagamoyo, Kipangege in Kibaha and Kise in Mkuranga.	Microbial aspects were detected from one third of existing wells. Deterioration might be caused through aged casing and screen pipes. Almost no problem was found on the Chemicals that are of health significance. The numbers of wells unsuitable for potable use due to Acceptable aspects are 5 in test wells and 35 in existing wells. Although no pH values are less than 6.5 in test wells, 17 wells (about 50%) in existing wells have pH value less than 6.5. Such low pH will affect the well structures like casing and screen pipes. Proper selection of material for those wells are required.	Although many items of Chemicals that are of health significance have contents more than Guidelines, they are lower than Guidelines in deep wells. Therefore, such sources are of no geological origin. Since there are no artificial contamination sources like industrial waste water, the contamination source is not clear. If the water in rivers and dams is used as the sources of potable water supply, attentions shall be paid on the water quality, because many items of Acceptable aspects are more than Standards. Still the water of the Wami River satisfy both Guidelines and Standards. But it is required to check removal of turbidity and colour in the implementation stage.	Although many items of Chemicals that are of health significance have contents more than Guidelines, they are lower than Guidelines in deep wells. Therefore, such sources are of no geological origin. Since there are no artificial contamination sources like industrial waste water, the contamination source is not clear. If the water in rivers and dams is used as the sources of potable water supply, attentions shall be paid on the water quality, because many items of Acceptable aspects are more than Standards. Some items of the water of Njopeka Spring are more than Guidelines and Standards. Therefore, it is required to check such items in the implementation stage.

Note : CHS means chemicals that are of health significance.
: Guidelines means Guidelines for Drinking –water Quality Third Edition (WHO, 2004).
: Standards means Tanzanian Proposed Temporary Standards for Rural Water Supply (Rural Water Supply Health Standards Committee, 1973).

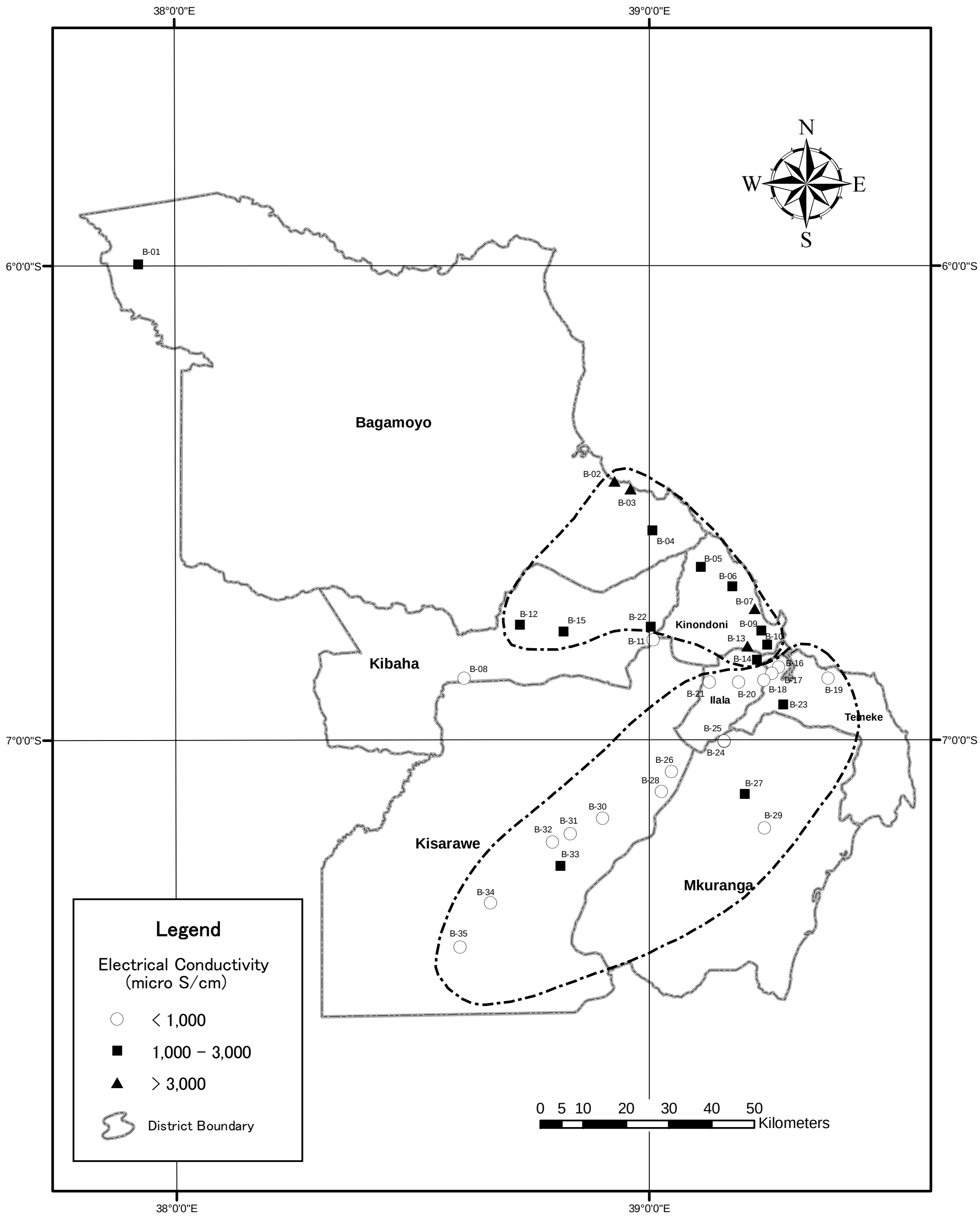

FIGURE 3.5 DISTRIBUTION OF ELECTRIC CONDUCTIVITY (EC)

THE STUDY ON WATER SUPPLY IMPROVEMENT IN COAST & DAR ES SALAAM	JICA

3.5 CURRENT STATUS OF OPERATION AND MAINTENANCE OF EXISTING SCHEME

3.5.1 OVERVIEWS OF CURRENT INSTITUTIONAL FRAMEWORK

The current institutional framework for the provision of water supply and sanitation services are established and developed, separating between urban water supply with sewerage service, and rural water supply services. In particular, in the current institutional framework in rural and peri-urban water supply services the ultimate responsibility for the provision of those services rests largely with the Ministry of Water and Livestock Development (MoWLD). Moreover, regulation of the water supply sector effectively remains under MoWLD. In rural and peri-urban water supply sector, the Government has also been the owner and operator of number of supply installations. Thus, the current institutional framework has a central focus in MoWLD but is still complex, both in law and practice.

These interlocking relations have led to a lack of commitment by the users to safeguard the facilities, and reluctance to contribute to the cost of operation and maintenance. Furthermore, Draft National Water Sector Development Strategy 2005-2015 (NWSDS) points out ‘overlapping responsibilities, duplication and omissions’ as well as ‘inefficiency of the mechanism for effective consultation and consensus building, and participation of stakeholders in the decision-making process’. The NWSDS made further analysis on the consequences of the lack of active participation and effective institutional framework, as given below:

The lack of participation of beneficiaries in the execution of water scheme in rural areas, has led to:

- Poor performance of the schemes;
- Lack of proper management of the schemes;
- Lack of ownership; and
- Poor delivery of the service

The lack of an effective institutional framework for water supply and sanitation has led to:

- Overlapping roles and responsibilities between various institutions leading to inefficient use of human and financial resources, duplication of effort, and gaps in effective provision of services;
- Inadequate co-ordination between various government institutions;
- Inadequate communication and awareness building between these institutions and local organizations and water users; and
- Responsibility for regulation and performance monitoring of the provision of WSS services is being vested in the same organization that is responsible for service delivery and investment financing, thus creating a potential conflict of interest.

The consequences for inadequate participation and ineffective institutional framework are widely observed and well recognized in the Study Area. The effects are negligence of communities’ responsibilities in operation and maintenance and not repairing system breakdown as observed in the previous sections.

3.5.2 CURRENT COMMUNITY ORGANIZATION OPTIONS

In reorganized current institutional framework, executing functions in rural/peri-urban water supply sector development are considerably decentralized to Municipal/District Councils, while autonomous entities, such as Water Supply and Sanitation Authorities (WSSAs) and Community-Owned Water Supply Organizations (COWSOs) are responsible for service provision. Particularly in rural and peri-urban water supply sector, COWSOs are expected to provide supply services, by owning, managing, operating and maintaining the supply schemes. Therefore, clear responsibility is given for effective and efficient service provision that these COWSOs are vested with efficiency and competency and guarantee proper management, operation and maintenance of water supply schemes of varying technical choices.

COWSOs are currently taking various organizational forms. This section overviews the current operation and maintenance arrangements under each COWSO options, along with their characteristics of institutional set-up and degree of efficiency and expertise in the scheme management, operation and maintenance.

(1) Village Water Committees (VWCs)

Village Water Committees (VWCs) are the most usual and conventional arrangement for community-based operation and maintenance since 1970s. It is also the most common arrangement among the communities in the Study Area.

Committee members are appointed by the Village Government in the most cases, and the VWCs are placed under the Village Councils. Thus, they are considerably less autonomous, without any legal status provided. The efficiency of VWC is often hindered by Village Council interference and sometime misappropriation of water funds.

The roles of the VWCs are collection of user fee, and operation and maintenance of the water supply scheme. However, VWCs are often formed without necessary capacity building and provision of training on operation and maintenance of the scheme. Thus, the schemes are often managed in incompetent manners. In this arrangement, VWCs are service providers, but, as well as consumers. In the circumstances with no clear separation is made between service provider and consumers, the awareness and expertise of VWC as service provider is often lacking.

(2) Water Users Groups (WUGs)

Although the definition of Water User Groups (WUGs) is elusive, it becomes one of common organizational arrangements in rural and peri-urban water supply and sanitation service delivery. It is similar to the Village Water Committee, but, a single WUG is formed by the community at each and every Domestic Water Point (DWP). In the formation of WUGs, gender balance in membership is often emphasized. WUGs are responsible for daily operation and maintenance of designated DWPs and user fee collection.

A number of WUGs are registered either under Ministry of Water and Livestock (MoWLD) or local government framework and provided with legal entity, while others are not registered. Those registered seems to be more promising in management of the scheme than those not registered, defining their roles and responsibilities in their memorandum of understandings or by-laws.

WUGs are often associated with more elaborated Community-Owned Water Supply Organizations (COWSOs) such as Water Users Associations (WUAs) and Water Company. In those cases, WUGs are functioning as link between communities and COWSOs management.

WUGs are one of viable models, provided that proper registration process is taken and their management is strengthened with the provision of capacity building in operation and maintenance. However, limited expertise in rural communities and WUG members, and lack of contracting-out arrangement for the service provision requiring managerial and technical know-how is a great risk for the sustainability of the scheme.

(3) Water Users Associations (WUAs)

Water Users Associations (WUAs) are a currently evolving arrangement in rural and peri-urban water supply and sanitation services. WUAs are given autonomy and legal status, by registering itself either under Ministry of Water and Livestock (MoWLD) or local government framework. Executive members of WUA are elected among the registered users. Its regulation and by-law are often developed in a participatory manner with users and other stakeholders such as District staff, Ward and Village officers. Through this process, risks of negative intervention by the Village Council are reduced and their relationship becomes rather mutually interactive.

Establishment of WUAs is often associated with capacity building in its management, operation and maintenance of the supply scheme through provision of trainings by District/Municipal council, Non-Governmental Organizations (NGOs), and External Support Agencies (ESAs). Provided with these capacity building, competence and efficiency in management, and operation and maintenance are relatively enhanced. Furthermore, their autonomous and legal status enables contractual arrangements to achieve efficiency and competence in management of the scheme. In many cases, WUAs have service agreement/contract with Domestic Water Point (DWP) attendants, security guards, and pump operators. This contractual arrangement can be further extended to more elaborate service contract such as regular pump maintenance and the entire management contract with private agents, company, and local NGOs having expertise in scheme management.

(4) Water User Trust / Co-operative

A Water User Trust is constituted by deed and should be approved by the Attorney General according to the Tanzanian Trustee Incorporation Ordinance. In a trust, specified properties are legally placed under the custody, management and care of specified persons for the benefits of the beneficiaries. In this arrangement, a few specified persons hold on trust the property on behalf of the users who have little say in management.

Water Co-operative society is similar arrangement to the Water User Trust. Co-operatives are formed and constituted under the Society Act. Members of Water Co-operative shall make equitable contributions to the Co-operatives, while the Government maintains control over their activities and management.

In both cases, however, these organizational arrangements are less placed in practice in Tanzania, though they might have potential and viability in management and operation and maintenance of the scheme, if their capacity and setting contract-out arrangement are enhanced.

(5) Water Company by Guarantee

This is a unique arrangement emerged in Morogoro Region, that the water users themselves organize and manage Water Company by guarantee. Water Company is registered under Company Acts (Cap. 381), with submission of its articles and memorandum of association, and managed in an autonomous manner by a Board made of elected representatives of users from Domestic Water Points (DWPs). The leaders of the company are the elected Chairperson, Secretary and Treasurer. They seek the advice of water users' representative for critical matters. In a few cases and depending on the financial capability, Water Company by guarantee may have contracting-out arrangement for the provision of particular services or entire management and operation and maintenance services to private/individual agents, which can possibly enhance guarantee and competency in service provision and scheme management. Water users have elected committees on each DWP that serves an average of 250 water consumers.

One of the characteristics of the Water Company by guarantee is that its articles and memorandum of association stipulate that the company cannot do anything else than pursuing the objectives stated, in this case rural water supply services. Water users pay monthly water fee, clean the surroundings of the water points, and hold regular meetings to discuss water issues and to solve problems. Water Company by guarantee has started to show that they own their schemes and that they are capable of managing independently their water supply systems (SMET 2002), provided that support in capacity building is ensured.

(6) Water Company by Share

This is an arrangement similar to the usual commercial company where members buy shares from their company. In such arrangement, water users are shareholders and a team of executive manages the company. Kilimanjaro Water Supply Company Ltd (KILIWATER) in Northern Tanzania is a typical example of such arrangement. The company was registered in 1995; it has 44 employees including a general manager, 127 shareholders and provide services to 3,000 households disseminated in 70 villages. The company uses Area Water Committee to link with individual users. Women are involved in the company management that enables it to run with quite efficiency a large systems of 27 intakes, 112 storage tanks, 1070 public taps provided along a 800 km long pipeline. This arrangement has chances to perform much better when users are sufficiently motivated and used to its functioning.

Water Company by share requires much expertise, therefore, this arrangement is the most competent in the scheme management. However, application of this model seems to be difficult in rural and peri-urban communities, since it requires a larger scale merit of economics for scheme to operate in a profitable manner.

Reviewing the characteristics of those current COWSO management options ranging from the simplest form of conventional VWCs (Village Water Committees) to the most comprehensive one of Water Company by Share, competency, effectiveness and degree of expertise and guarantee in the scheme management, operation and maintenance are further assessed in the later chapter (Refer to Chapter 8).

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Chapter 4

Water Resources

CHAPTER 4 WATER RESOURCES

4.1 GENERAL

Availability of the water resources and its development potential are the important elements to decide the optimum alternative of water supply plan. In this study, water resources for both surface water and groundwater were investigated. The details on the investigation carried out and results of those investigations were presented in Chapter 2 and Chapter 8 of Supporting Report. Consequently, this chapter describes the evaluated development potential of water resources of both surface water and groundwater. Realization of proposed water supply scheme of piped water supply system (level 2) mostly depends on the availability of groundwater sources. Therefore, the study put emphasis on consideration of groundwater development potential.

However, if groundwater development potential is not adequate as the source of water supply system in a certain village, alternative water source should be selected. In such case, potential availability of surface water shall be examined. Potential amount and area of surface water source was examined from the viewpoint of discharge and actual intake amount. As a result, basic information for the surface water development plan as a source of water supply was formulated.

4.2 SURFACE WATER POTENTIAL

4.2.1 SELECTION OF THE RIVER

As the result of interview survey to related persons and investigation of the past discharge data, three rivers, namely the mainstream of Wami and Ruvu, and Kizinga are confirmed as perennial rivers in the Study Area. Actually there are intakes from some other rivers as well. However, they are not suited as for stable water supply sources because they are dried up seasonally.

4.2.2 INTAKE AMOUNT OF SELECTED RIVER

When calculate the actual intake amount, the amount which water right was permitted is considered to be equivalent of actual intake amount so that the data for actual intake amount could not be obtained.

Table 4.1 summarizes existing intake amount including water rights sorted and integrated in upstream and downstream of specified gauging station of selected three rivers.

Table 4.1 Intake Amount from Selected Rivers

River Name	Station Code	Total Intake Amount of Upstream (m^3/s)	Total Intake Amount of Downstream (m^3/s)
Ruvu	1H8	0.017* (0.007)	4.866
Wami	1G2	9.002 (9.002)	0.167
Kizinga	1J5	0	0.104

Note *: This figure includes only intake amount from the mainstream of Ruvu river.
( ): This figure shows total intake amount outside of the Study Area out of total intake amount of upstream of the station

4.2.3 POTENTIAL AMOUNT AND AREA OF SURFACE WATER DEVELOPMENT

In making the balance of river discharge, actual intake amount and potential amount for surface water development, the river maintenance flow constitutes key component of estimation of potential amount for surface water development. Although the maintenance flow of a river needs to be determined normally taking into account various aspects such as navigation, fishing, aesthetic scenery, salt water intrusion, clogging of river mouth, riparian structures, groundwater table, flora and fauna, and river water quality, the maintenance flow is examined based on the following aspects in this Study:

1. Droughty-water discharge

Daily natural discharge with a probability of exceedance of 97% is defined as droughty-water discharge, and droughty-water discharge of each year is found from the past discharge data at the gauging stations of target rivers of Wami, Ruvu and Kizinga.

2. Available discharge

Average droughty-water discharge over all the observed period is calculated, and it is defined as available discharge.

3. Maintenance flow

Droughty-water discharge of 10-year return period is calculated by probability analysis, and the total value of the droughty-water discharge of 10-year return period and actual net intake amount at downstream of gauging station is defined as maintenance flow.

4. Potential amount of surface water development

Potential amount of surface water development is calculated using above investigation results.

Table 4.2 shows the result of the analysis.

Table 4.2 Potential Amount of Surface Water Development

Unit: m^3/s

River	Station Code	Available Discharge (Average Droughty-Water Discharge) A	Droughty-Water Discharge of 10-year Return Period B	Actual Total Intake Amount at Downstream of the Station C	Maintenance Flow Discharge D=B+C	Potential Amount of Surface Water Development E=A-D
Ruvu	1H8	7.073	3.260	4.866	8.126	-1.053
Wami	1G2	6.781	1.611	0.167	1.778	5.003
Kizinga	1J5	0.074	0.015	0.104	0.119	-0.045

Conclusion of the analysis of potential amount of surface water development is summarized as follows:

- The Wami River has adequate potential for development. As shown in *Table 4.2*, any intake isn't conducted in the upstream of 1G2 within the Study Area. Therefore, total amount of 5.003 m^3/s is considered as a potential amount of surface water development.
- Since the actual intake amount is more than the available discharge, the Kizinga River is impossible for new surface water development.
- As for the Ruvu River, available discharge is less than the maintenance flow discharge. Still, since the actual total intake amount is less than available discharge, however, surface water development is possible if priority is given to surface water development than securement of maintenance flow. In such case, total amount of 2.197 and 2.207 m^3/s is considered as a potential amount of surface water development of upstream and downstream of 1H8, respectively, taking into account of actual intake amount within the Study Area. At the same time, further surface water development is not recommended at the view of securing river maintenance flow.

4.2.4 POTENTIAL AREA FOR SURFACE WATER DEVELOPMENT

In the result of the above investigation, a river at which surface water development is possible is only the mainstream of the Wami River. Taking into account the accessibility of the river as a water source, potential area for location of intake is classified by distance of 5, 10 and 15 km from the mainstream of Wami River.

Taking into account the capacity of water supply facility, potential area of intake location by distance is evaluated using the vertical drop of 100 m from the river as an index. As the result of the analysis using GIS, the area within 5km from the Wami River is selected as a potential area for intake of surface water development.

Figure 4.1 shows the potential area as a result of the above analyses.

4.3 GROUNDWATER OF STUDY AREA

4.3.1 AQUIFER CATEGORY

(1) Quaternary Aquifer

Geological unit of Quaternary formation exists throughout the study area, mainly the coastal plain from Dar es Salaam to west part of Mkuranga district, along the main rivers of Ruvu and Wami and their branches and lowland between Mkuranga and Msanga-Pugu hills.

In the Quaternary formation, the groundwater have been developing very actively, accordingly the number of well are the highest. Almost 50% of the wells in the Study area are tapped from Quaternary aquifer. The yield of these well is generally high, especially in Dar es Salaam region.

(2) Neogene Aquifer

Neogene formation covers the study area extensively, and form three major hills of Mkuranga, Msanga-Pugu and western part of Bagamoyo plateau.

Neogene sediments consist of interbedded sandy clays and clayey sands with minor lenses of pure sand or clay (Temple, 1970). The gravel of mostly quartz, some feldspar and some Precambrian gneiss, is scattered throughout still always in a clay matrix.

Since the formation is distributed extensively in the study area, large number of wells has been drilling into the Neogene aquifer. It covers about 40% of the total wells in the two regions. The yield of wells differs by area; this phenomenon is due to the rapid change in facies and clay matrix.

(3) Aquifer in the Basement Rocks

The geological units of Precambrian, Jurassic and Cretaceous are relevant to the basement of the study area. The Precambrian formation is distributed in the eastern part of Bagamoyo; and forms Mbwewe and Chalinze Sub Plateau. The Cretaceous formation is distributed at south of Kisarawe district, and forms Msanga-Pugu Hills.

The geology of these basement rocks is metamorphic rocks, mainly of gneiss, schist and crystalline limestone in Precambrian formation, and sedimentary rocks, mainly of sandstone and/or calcareous sandstone in Jurassic and Cretaceous formations.

Basically, the groundwater is not developed well in these basement rock areas, mainly due to high elevation and difficulty of the occurrence of groundwater in the geological formations. The numbers of wells having its data recorded in such basement rocks region are very few. Most of the wells are abandoned because of no water, or very low yield.

(4) Classification of the Aquifer Type

The geological units of Quaternary and Neogene are classified as stratum aquifer. The stratum aquifer is the aquifer in which intergranular flow is significant. The geological units of Precambrian, Jurassic and Cretaceous are classified as fractured aquifer. The fractured aquifer is the aquifer in which flow is dominantly in fissure, fracture zone and other geological discontinuities.

The aquifer in the Study area, therefore, is categorised into two parts: namely, the fractured aquifer and the stratum aquifer.

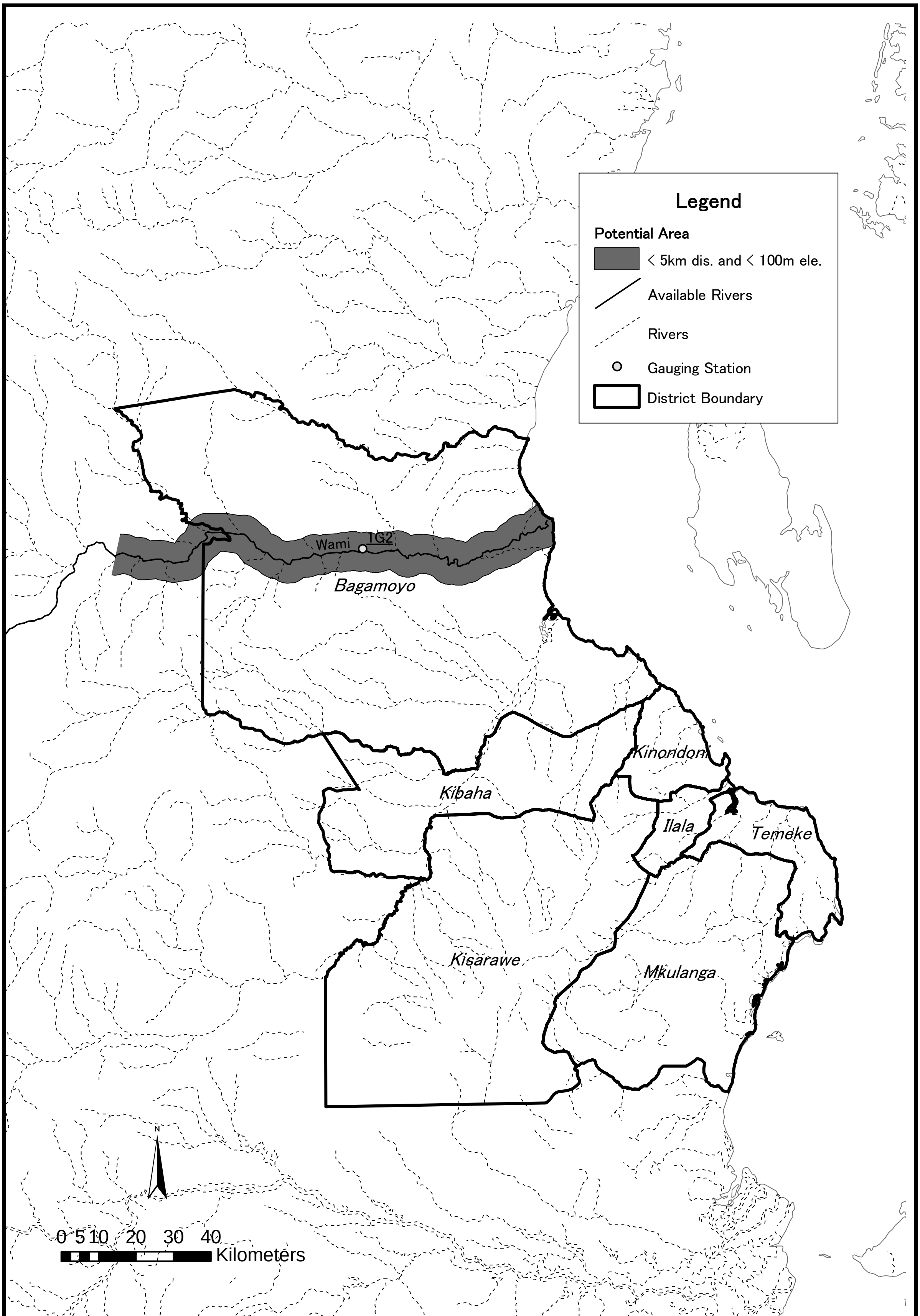

FIGURE 4.1 POTENTIAL AREA OF SURFACE WATER DEVELOPMENT

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4.3.2 WELL YIELD AND WATER QUALITY

The well yields and water qualities by the geological formation is graphically shown in *Figure 4.2*. A line graph indicates water quality (EC: μ S/cm) and the number of wells. Bar charts indicate average and median yield from wells classified by depths.

For the geological formation of Precambrian, Cretaceous and Jurassic, which is fractured aquifer, the number of samples (wells) are too small for evaluation. However, the yield of these fractured aquifers is generally very low only about 10 liter/min in average, which is almost 0 liter/min as median yield.

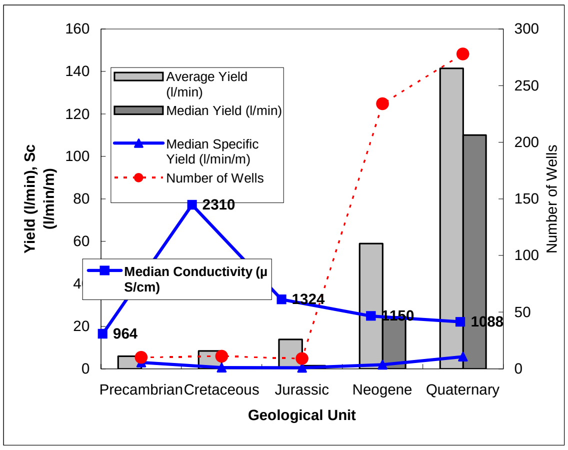

Figure 4.2 Yield and Water Quality by Geological Formation

Quaternary aquifer shows very high yield of more than 100 liter/min in median value. Next to Quaternary aquifer, Neogene aquifer shows relatively higher yield. However, the difference between the two aquifers is large. In Neogene aquifer, median yield is only 24.5 liter/min. Specific yield also shows high value in Quaternary aquifer.

As for the water quality, electric conductivity (EC) shows relatively low value in Neogene and Quaternary aquifers. It is 1150 μ S/cm in Neogene aquifer, and 1088 μ S/cm in Quaternary aquifer.

4.4 AQUIFER EVALUATION

4.4.1 TRANSMISSIVITY

The *Table 4.3* shows the general guidelines of the evaluation of well potential by transmissivity and specific capacity. In the table, the transmissivity of 10 m^2/day means good potential for domestic water use. The withdrawals, or productivity, are expected to be used for a water supply system of a small to moderate size rural area, which is nearly same scale of the villages in the Study area.

Table 4.3 Comparison of Transmissivity, Specific Capacity and Well Potential

Transimissivity m^3/day/m			Specific Capacity (litres/min/m)	Groundwater Supply Potential	
	Irrigation	Good	1000	Very High	Withdrawals of great regional importance
1000	Irrigation	Fair	100	High	Withdrawals of lesser regional importance
	Irrigation	Poor			
100	Domestic	Good	10	Intermediate	Withdrawals for local water supply
10	Domestic	Fair	1	Low	Smaller withdrawals for local water supply
1	Domestic	Poor	0.1	Very Low	Withdrawals for local water supply with limited consumption
0.1		Infeasible	0.01	Interceptible	Source for local water supply are difficult (if possible) to ensure

after U.S Bureau of Reclamation, Groundwater Manual U.S. Department of Interior, Washington, 1997 (Kashef A. Ismail, Groundwater Engineering P. 366)

after Krasmy, Jiri 1993. GROUND WATER. Vol 31, no2,pp 231

The level of infeasible or imperceptible, which is below the transmissivity of 0.1 m^2/day, means that groundwater cannot be practically extracted. Poor to fair or very low to low, means that groundwater can possibly be pumped out by a hand pump. Good, or intermediate, means that groundwater may be withdrawn using a submersible pump for small scale water supply.

The result of the test well drilling and existing wells for the Study was evaluated using the above table and also the yield from each existing well. Based on the results of pumping tests of both Test and Existing wells, the distributions of Transmissivity are examined as shown in *Figure 4.3.*

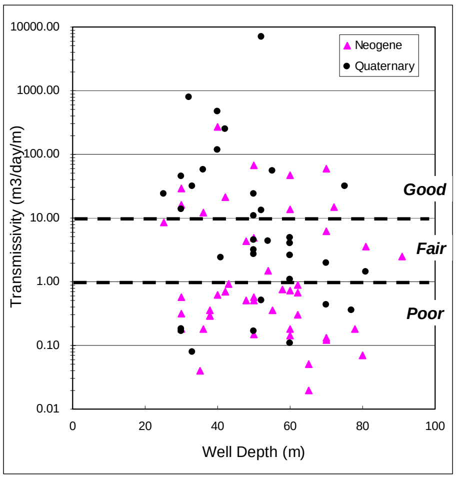

Figure 4.3 Distribution and Evaluation of Transmissivity

4.4.2 HYDRAULIC CONDUCTIVITY

The hydraulic Conductivity of the aquifer can be evaluated by the permeability. Based on the results of pumping tests of both Test and Existing wells, the distributions of Permeability, are evaluated as shown in *Figure 4.4.*

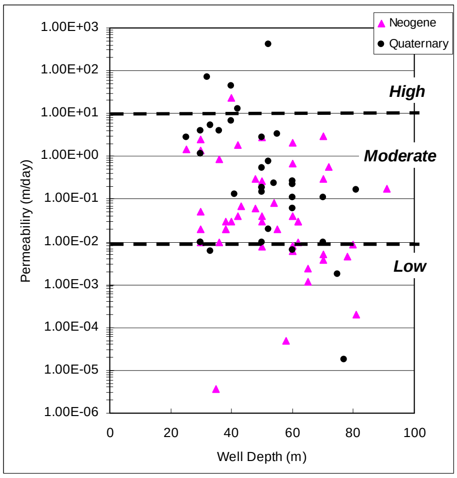

Figure 4.4 Evaluation of Hydraulic Conductivity

The *Table 4.4* shows the general ranges of hydraulic conductivity for soils and rocks. The values of massive to fractured basement rocks vary from 10^{-5} to 10^{1} m/day, and soil vary from 10^{-2} to 10^{4} m/day. The foremost range of the obtained values for each geological unit in the Study area was also shown in the table.

The results suggested that for the two major aquifers of both Quaternary and Neogene in the study area, hydraulic conductivity largely varies from "Very Low" to "High". The Quaternary is still slightly in a higher range of Hydraulic Conductivity than the Neogene aquifer. For the Cretaceous, Jurassic and Precambrian aquifers, since the number of sample is very low, scattered result is observed.

Table 4.4 Evaluation of Hydraulic Conductivity of Aquifers

(m/day)

Scale: 10^{4} | 10^{3} | 10^{2} | 10^{1} | 1 | 10^{-1} | 10^{-2} | 10^{-3} | 10^{-4} | 10^{-5} | 10^{-6}

Aquifer	Upper value	Median Value	Lower value
Quaternary	4.07×10^{2}	2.05×10^{-1}	1.80×10^{-5}
Neogene	2.30×10^{1}	3.00×10^{-2}	3.67×10^{-6}
Cretaceous	1.27		7.00×10^{-2}
Jurassic		▲ 6.21×10^{-6}	
Precambrian	2.20×10^{-1}		5.48×10^{-4}

Relative permeability

Very high	**High**	**Moderate**	**Low**	**Very low**
Clean gravel	Clean sand and sand and gravel	Fine sand	Silt, clay and mixture of sand, silt and clay	Massive clay
Vesicular and scorioceous basalt and covernous limestone and dolomite	Clean sandstone and fractured igneous and metam orphic rocks		Laminated sandstone shale, and mudstone	Massive igneous and meramorphic rocks

Remarks : ● *Median Value*
: ▲ *Only one sampls*

After Kashef, A.I GROUNDWATER ENGINEERING, 1987

U.S. Bureau of Reclamation, Groundwater Manual, U.S. Department of Interior, Washington, 1977.

4.5 GROUNDWATER POTENTIAL EVALUATION

4.5.1 POTENTIAL EVALUATION

(1) Yield

As for the yield, groundwater potential is classified into following three categories;

1) Highly Productive Aquifer

To provide the water supply conforming the Evaluation of Technical Appropriateness of Water Supply Plans for a population of 2,500 under the 10 to 12 hours operation, the yield of 100 liter/min is required. Therefore, the rank of “Highly Productive Aquifer” is given to the yield of more than 100 liter/min is required.

2) Low Yielding Aquifer

The yield of 10 liter/min is a marginal yield, since a minimum yield of 6 liter/min is required for hand pump operation. Therefore, the rank of “Low Yielding Aquifer” is given when the yield of less than 10 liter/min is achieved.

3) Moderately Productive Aquifer

Consequently, the range of yield from 10 to 100 liter/min is ranked as “Moderately Productive Aquifer”.

(2) Water Quality

According to the water quality standards for drinking water in Tanzania, the value of EC is divided into following three classes;

- EC under 1,000 μS/cm, which is the maximum desirable level, is good for drinking.
- EC between 1,000 and 3,000 μS/cm, which is the maximum permissible level, is fair for drinking.
- EC of 3,000 μS/cm and over is poor, or not satisfactory, for drinking.

The hydrogeological map shows these boundary lines for EC. The value of EC is useful as the practical indicator of water quality; therefore the above classification is used to make the groundwater resources evaluation map. As a matter of cause, there are other considerable elements such as fluoride and heavy metals; therefore a detailed chemical analysis is necessary during the implementation stage of development plan.

(3) Depth to Groundwater

Depth to groundwater usually relates to pumping cost, or operation cost, of a production well. The isobaths of groundwater depth are shown in the hydrogeological map. As shown in the hydrogeological map, however, the depth to groundwater is mostly 40 mbgl and above. Practically, this means that the depth to groundwater is a less important factor for groundwater development for the study area. Therefore this factor was not used to make the evaluation map.

(4) Geological Structure

As described in the Chapter 4 on Topography and Geology of the Supporting Report, some geological structures such as a lineament and a fault zone affect the productivity of groundwater in basement rock region. The classification of the area yielding groundwater was modified from the viewpoint of this geological structure.

4.5.2 Preparation of Hydrogeological and Groundwater Evaluation Maps

The aquifer in the Study area was categorised into two segments: namely, the fractured aquifer and the stratum aquifer. The stratum aquifer is the aquifer in which intergranular flow is significant. The geological units of Quaternary and Neogene are relevant to this aquifer type. The aquifers of Quaternary and Neogene are already developed and utilized in the study area. The fractured aquifer is the aquifer in which flow is dominantly in fissure, fracture zone and other geological discontinuities. The geological units of Precambrian, Jurassic and Cretaceous are relevant to this aquifer type. Since the number of wells in these geological regions are very few, there is still little information about the aquifer at present.

The hydrogeological map has been prepared as shown in *Figure 4.5*. It is recommended that the map be revised in future with further accumulation of hydrogeological data. The map contains the information on groundwater yield, quality (EC), depth to groundwater, existing well location, geological structure and physiographic information such as surface water and contour lines. Naturally, groundwater yield, or productivity, is one of the most important factors for groundwater exploitation. The quality of groundwater is another essential factor. Pumping and maintenance costs depend on the depth to groundwater. The analyses using GIS show the regional characteristics in the area. Finally, the groundwater resources evaluation map was prepared based on the hydrogeological map to contribute to the groundwater development plan. The groundwater resources evaluation map is shown in *Figure 4.6.*

4.5.3 Promising Area for Groundwater Development

(1) Area Evaluation

After the preparation of the hydrogeological map, the groundwater resources evaluation map was prepared based on it. The evaluation map was drawn in accordance with the distribution of groundwater yield and quality (EC). The *Figure 4.7* shows the combination of factors used in the evaluation map.

			Estimated Yield (liters/min)		
			100 <	10 - 100	< 10
Water Quality EC (µS/m)		Allotment Points	Good	Fair	Poor
			4	2	1
< 1000	Good	3	**12**	**6**	**3**
1000 - 3000	Fair	2	**8**	**4**	**2**
3000 <	Poor	0	**0**	**0**	**0**
			Weighting		

Evaluation of Groundwater Resources

Weighting	Evaluation
12, 8	Promising water source for the Piped Scheme to serve more than 2,500 population with single well
6, 4	Fairer water source for the Piped Scheme to serve 2,500 population with multi-well system
3, 2	Can be utilized for Hand Pump
0	Not suitable for drinking water

Figure 4.7 Matrix of the Classification for Groundwater Evaluation

The evaluation is described as follows.

Weighting: 12 and 8 Good

– Promising water source for the Piped Scheme of more than 2,500 population with single well. EC is good for drinking for weighting point 12, and fair for weighting point 8, and besides the yield expected is 100 liter/min and more.

Weighting: 6 and 4 Fair

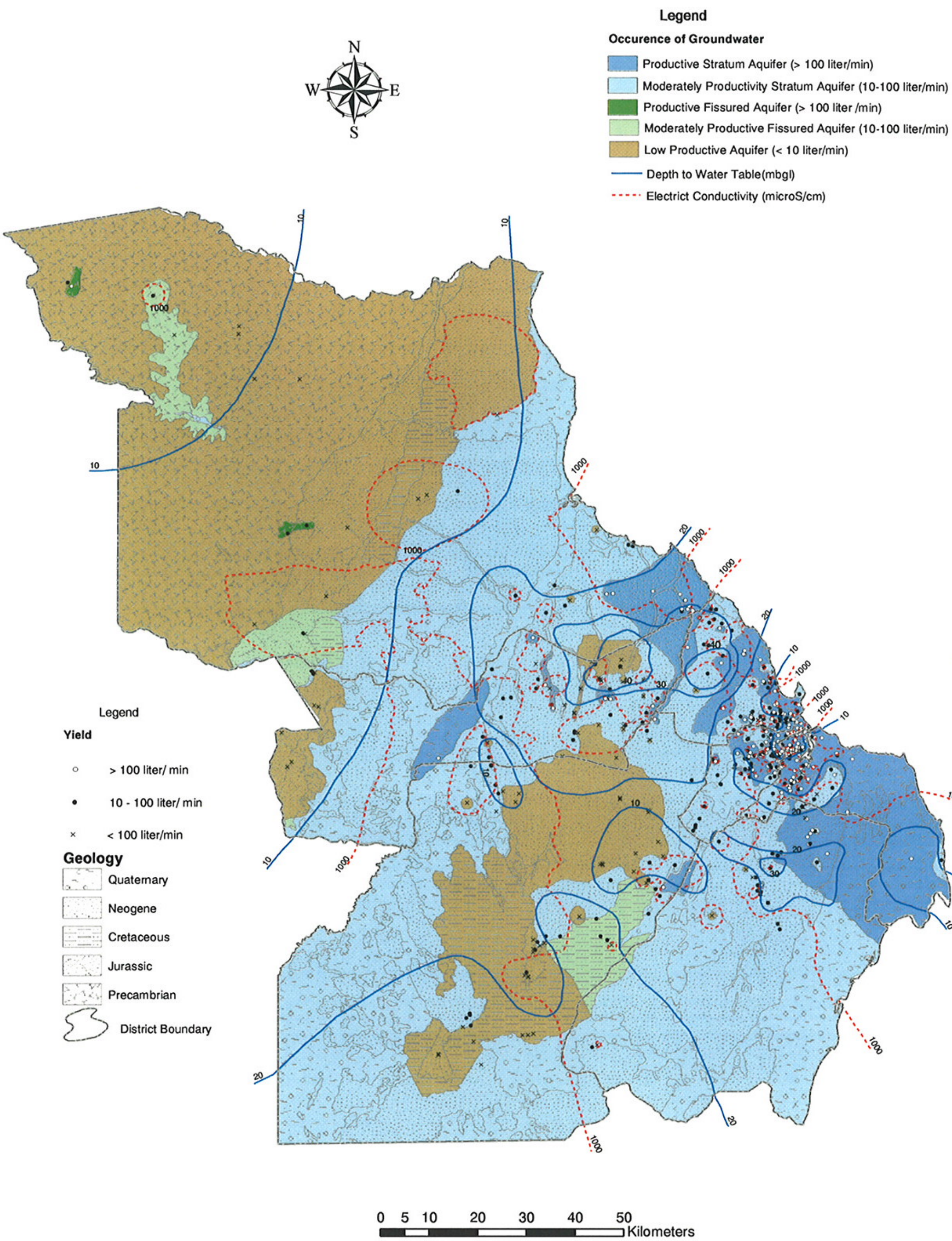

FIGURE 4.5 HYDROGEOLOGICAL MAP

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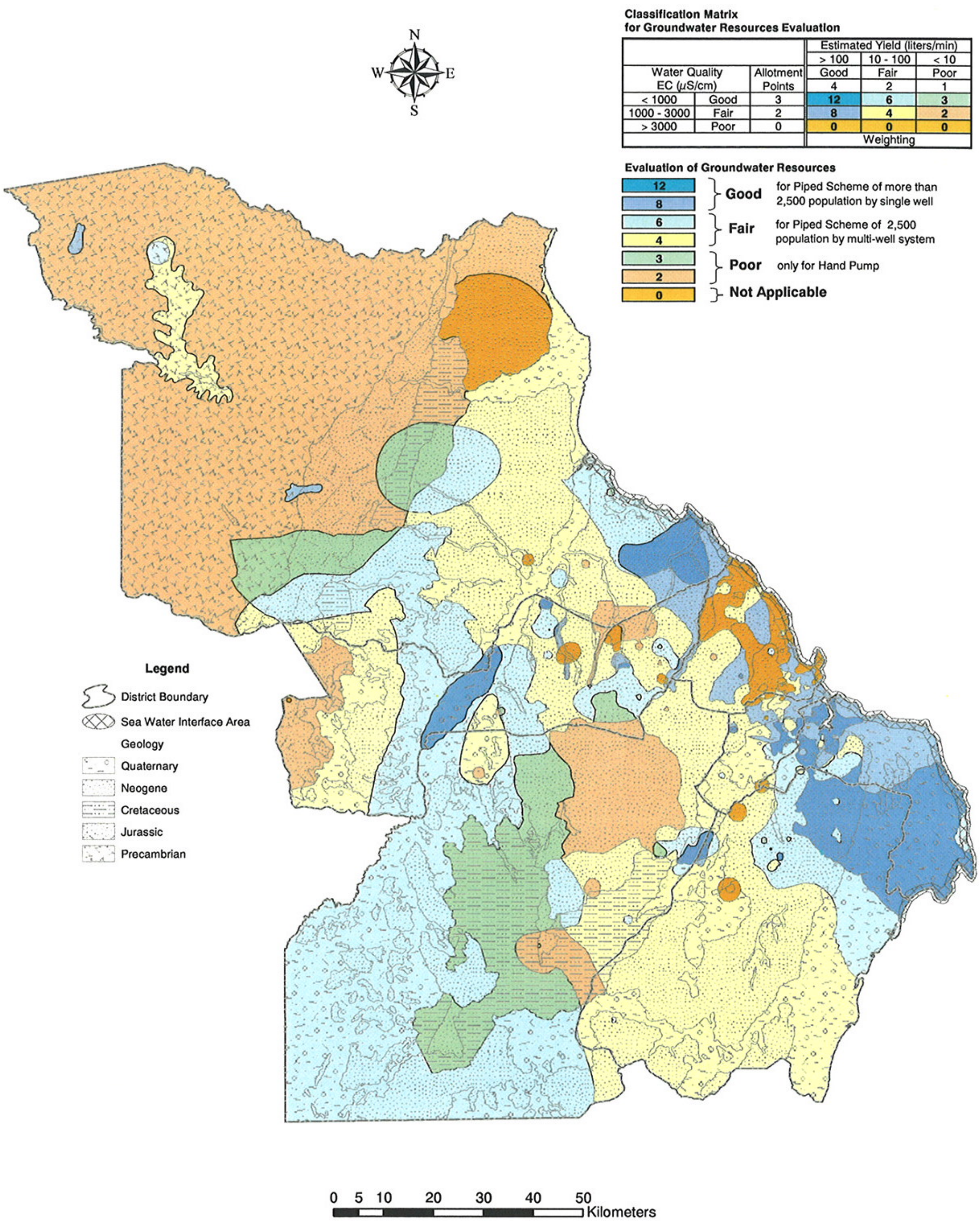

FIGURE 4.6 GROUNDWATER RESOURCES EVALUATION MAP

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- Promising water source for the Piped Scheme of more than 2,500 populations with multi-well system. EC is good for drinking for weighting point 6, and fair for weighting point 4, and the yield expected is from 10 to 100 liter/min. This volume is exploitable using small submersible pumps.

Weighting: 3 and 2 Poor

- The yield is fair to exploit for hand pump water supply scheme. EC is good for drinking for weighting point 3 and fair for drinking for weighting point 2.

Weighting: 0 Not Applicable

- EC is poor for drinking. As shown in *Figure 4.20*, an area classified to this class may have a groundwater potential yielding 100 liter/min or more. It may be possible to use as a source for small scale industrial water or livestock water, otherwise elaborate water treatment facility is necessary for drinking water use.

(2) Promising Area for Groundwater evaluation

The area evaluated as Good on the evaluation map is the promising area for the development of Piped Scheme (Level-2). It is the dark blue and blue coloured area in the map (*Figure 4.6*).

In Dar es Salaam, especially in Temeke, northern part of Mkuranga and coastal area of Bagamoyo, the promising area for Level-2 is fairly large. The Quaternary aquifer distributed along the Ruvu River in Kibaha area also expected as promising area. In general, the area where Quaternary formation is distributed is expected to be promising area.

The area evaluated as Fair on the evaluation map is the potential area for the development of Piped Scheme (Level-2) by the multiple well systems. It is the light blue and yellow coloured area in the map. In Mkuranga, Kisarawe, Kibaha and eastern part of Bagamoyo, this potential area for the development is extensively distributed.

The area evaluated as Poor on the evaluation map is the possible area for the hand pump water supply only. It is the green and orange coloured area in the map. In general, the areas where geological unit of Precambrian, Jurassic and Cretaceous are distributed are relevant for this area. These are the band of Jurassic formation and Precambrian formation of Bagamoyo Plateau, and Cretaceous formation of Msanga-Pugu Hills.

The area evaluated as Not Applicable is the red coloured area in the map. In Kinondoni district, this area is fairly distributed. This is mainly due to the poor water quality.

It should be noted that, however, geological investigation, especially geophysical survey is very important, even in the promising area. This is due to the fact that Neogene aquifer is unevenly distributed even in the promising area.

4.5.4 Groundwater Development Plan

The area of influence is estimated, under the condition that the influenced drawdown is 1 mm within the pumping time from one hour to 10 hours. Most aquifers show the area of influence within 50m radius. It is concluded that, in most cases, area of influence is negligible, as long as a minimum 100m spacing between wells is provided.

The potential groundwater recharge from rainfall by basin was estimated in Chapter 2 of this Supporting Report. Annual potential recharge amount and current extraction ratio was estimated using the pumping data of existing wells. The estimation was made by basin. As the result it was revealed that the current extraction ratio against potential recharge amount is generally low, mostly less than 1%. Therefore, from the point of view of macro water balance, it is concluded that the area has considerable margin for the groundwater exploitation.

However, in the urban area of Dar es Salaam Region, there are many existing wells that are concentrated. So it is not recommended to drill all wells as calculated by demand. In the plan, therefore, the criteria to restrict the number of wells to be actually drilled are provided, based on macro water balance consideration by comparing recharge area with pumping rate. The detail of the criteria is shown in Chapter 9 of the Supporting Report.

Accordingly, the exploitable number of the wells for each proposed schemes are determined. The numbers determined are presented in Table 5.4 of Chapter 5 on Water Supply Plan.

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