MINISTRY OF WATER
THE UNITED REPUBLIC OF TANZANIA

THE STUDY ON RURAL WATER SUPPLY IN TABORA REGION IN THE UNITED REPUBLIC OF TANZANIA

FINAL REPORT

MAIN REPORT

MAY 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

EARTH SYSTEM SCIENCE CO., LTD
JAPAN TECHNO CO., LTD.
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In this report, project costs are estimated based on prices as of November 2010 with an exchange rate of US$1.00 = Tanzania Shilling (Tsh) 1,434.66 = Japanese Yen ¥ 88.00.

EXECUTIVE SUMMARY

1. BACKGROUND OF THE PROJECT AND CURRENT SITUATION OF THE STUDY AREA

The government of Tanzania started the Rural Water Supply Project in 1971 aiming to provide safe and clean water to the entire nation within a 400m distance. The Ministry of Water (MoW) has been continuing efforts to improve water supply coverage formulating a "Poverty Reduction Strategy Paper (PRSP)" in 2000 and "MKUKUTA (National Strategy for Growth and Reduction of Poverty (NSGRP) in 2005. NSGRP targets are to improve water supply coverage from 53% to 65% in the rural area and from 73% to 100% in the urban area up to the year 2010. However, it is probably difficult to realize the target.

The Ministry of Water and Irrigation (MoWI) formulated the "Water Sector Development Programme (WSDP)" in 2006 to improve water supply coverage using the basket fund based on a Sector Wide Approach for Planning (SWAp). The WSDP intends to realize 74% of water supply coverage of the rural area in 2015 and 90% in 2025, and 95% in 2015 and 100% in 2025 for the urban area.

The water supply coverage of the Tabora Region, the Study Area, is low, 49.1% in 2008 against the national average of 58.3%. Its major reason is the hydrogeological difficulty of developing groundwater. Furthermore, many water supply schemes are left un-functioning due to improper operation and maintenance.

In order to overcome these situations, Tanzania requested Japan to implement a study in the Tabora Region on groundwater potential evaluation, construction of a database, formulation of rural water supply plan following the WSDP concept and feasibility study of priority projects to be formulated through the study.

In response to the request, Japan International Cooperation Agency (JICA) carried out a preparatory study in February 2009 and concluded the Scope of the Work of the Study. Accordingly, the Study is commenced in August 2009.

2. SOCIO-ECONOMY

The population in the rural area of the Tabora Region (547 villages) is about 1,884 thousand persons (as of November 2009) and is projected to increase to about 2,801 thousand persons in the target year, 2020. The population growth rate is high in Urambo District (5.0%), low in Nzega (2.5%) and 3.4-3.5% in other districts.

The GDP per capita in the Tabora Region in 2008 was Tsh 429,605 (US$ 340.0), the 14^{th} among the whole nation.

Fetching water is a role of women. The National Strategy for Growth and Reduction of Poverty (MKUKUTA) set the target time of fetching water from water facilities at 65 % of rural areas as less than 30 minutes by 2010. In the rainy season, more than 80% of the villages in all districts said that time for fetching water including queuing were less than 30 minutes. However, it decrease in the dry season. Especially, Igunga District faces the most difficult situation. More than 70% of the villages there stated that it took more than 90 minutes to fetch water.

3. METEOROLOGY AND HYDROLOGY

The climate of the Tabora Region is savannah. Precipitation is distinctly separated into rainy season (October to May) and dry season (June to September). The average annual precipitation is about 1,000mm. The maximum temperature (32.2 degrees Celsius) is observed in September and October and the minimum temperature (14.7 degrees Celsius) was observed in June and July.

The Tabora Region is a part of three (3) catchments: Internal Drainage Basin, Lake Lukwa Basin and the Lake Tanganyika Basin. However, there exists no perennial river. The river water is observed only in rainy season. The maximum flow rate (26.6 m^3/sec) was observed in 1978.

The annual groundwater recharge was estimated low (60 to70 mm/year) in the northern area and high (200 to 250 mm/year) in the southern area.

4. TOPOGRAPHY, GEOLOGY AND HYDROGEOLOGY

The plateaus with an altitude of 1,000 to1,300m are widely distributed in the Tabora Region. The inserbergs where the basement rocks crop out, and wetlands are distributed.

The plutonic rocks and metamorphic rocks in the Precambrian period are widely distributed as the basement rocks against sedimentary rocks in Mesozoic and sediments in Miocene, Pleistocene and Holocene. Apparent lineament with N-S and NW-SE directions are observed in the basement rocks.

The aquifer in Tabora Region is divided into two (2) main parts as the stratum aquifers in sediments and the fractured aquifers in the basement rocks. Groundwater in Igunga District, the north-eastern part of the region and in Nzega, adjacent to Igunga District is deteriorated by high content of Fluoride.

The deep wells in Tabora Region are concentrated in three (3) districts, Igunga, Nzega and Urambo: It is about 84% of the total.

5. CURRENT CONDITIONS OF RURAL WATER SUPPLY

According to the Water Sector Performance Report (2009) prepared by MoW, the water supply coverage was 49.1% in the fiscal year 2007/2008. However, the inventory survey revealed that it was 11.8% in November 2009 in the rural area of Tabora Region.

There were 1,469 water supply schemes in the study area in 2009. Among them, 677 schemes (46.1%) were working and the remaining 792 schemes were not functioning.

The Water Sector Development Programme (WSDP) is the only national project by MoW in the water sector. A total of 74 villages were selected for the target of WSDP from five (5) districts and one (1) Municipality in the Tabora Region. Water Aid is actively supporting water supply in the region, however assistance by other organizations is not vigorous.

6. RURAL WATER SUPPLY PLAN AND SELECTION OF PRIORITY PROJECT

The Rural Water Supply Plan was formulated for 423 villages excluding 124villages of those in the Forest Reserves, Natural Reserves, other reserved areas, and the target villages of WSDP and other projects (Table 1). The target year of the project is 2020 as agreed in the Scope of Work of the Study. The target population in 2020 is projected to be about 2,062 x 10^3 persons. The water demand is estimated at about 51 x 10^3 m^3/day, considering the unit water demand, 25 L/capita/day.

Table 1 Number of Target Villages and Population for Rural Water Supply Plan

District/ Municipality	Target of Study			Excluded Vilalge			Target of Rural Water Supply Plan		
	Village	Population (2009)	Population (2020)	Village	Population (2009)	Population (2020)	Village	Population (2009)	Population (2020)
Igunga Dist.	97	363,188	524,687	15	71,122	102,746	82	292,066	421,941
Nzega Dist.	152	469,112	615,589	23	90,494	118,749	129	378,618	496,840
Sikonge Dist.	53	164,219	239,779	25	82,833	120,947	28	81,386	118,832
Tabora Rural Dist.	109	393,552	574,633	20	79,992	116,798	89	313,560	457,835
Tabora Mun.	24	58,842	101,710	11	32,933	56,923	13	25,909	44,787
Urambo Dist.	112	435,277	744,528	30	130,508	223,227	82	304,769	521,301
Total	547	1,884,190	2,800,926	124	487,882	739,390	423	1,396,308	2,061,536

The water source is groundwater. Alternatives for the water supply scheme are (1) piped water supply scheme with public water points (Level-2), (2) deep wells with hand pumps (Level-1), (3) rehabilitation of existing hand pumps and (4) rehabilitation of existing piped water supply schemes (only in the Igunga District). The formulated rural water supply plan is shown in Table 2.

Table 2 Summary of the Rural Water Supply Plan

District /Municipality	New Facility		Rehabilitation Well		Total
	Level-1	Level-2	Level-1	Level-2	
Igunga Dist.	0	117	4	17	138
Nzega Dist.	4	1,143	0	158	1,305
Sikonge Dist.	3	251	0	15	269
Tabora Rural Dist	6	1,135	0	48	1,189
Tabora Municipality	1	125	0	15	141
Uranbo Dist	4	1,368	0	79	1,451
Total	18	4,139	4	332	4,493

The service population will increase to 1,754 x 10^3 persons in 2020 from 2,68 x 10^3 persons in 2009, if the entire water supply plan is implemented. The implementation cost is about 281 x 10^6 US$.

Each village was given district/municipal wise priority based on the result of evaluation using the criteria: (1) urgency to provide water supply scheme, (2) groundwater development potential and (3) water quality.

A total of 20 villages were selected as the target villages for the priority project considering the criteria: (1) emergency to provide water supply scheme, (2) possibility of groundwater development and (3) appropriate scale of the project.

7. Operation And Maintenance For Rural Water Supply Schemes

The National Water Policy (NAWAPO) is the national basic policy for water resource management and water supply, of which principles in operation and maintenance for rural water supply system are to promote decentralization in implementation of water supply and sanitation projects to the lowest appropriate institutions, introduction of user-pay principle to recover the cost for operation and maintenance, and promotion of community-based management (CBM) to sustain the supply system. COWSOs are community-based organizations, which are vested with legal status by registering them under the Local Government Authorities (LGAs) and duly facilitate the community's sense of ownership. The roles and responsibilities of COWSO set out in the basic strategy and program can be summarized as follows:

- Own and manage water supply assets
- Operate and maintain water supply assets
- Determine consumer tariffs

- Collect revenue for the provision of services

District/Municipal Water and Sanitation Teams (DWST/MWST) are established under local government authorities (i.e. Municipal and District Council) in order to support and strengthen the capacity of local government authorities in planning, implementation, and monitoring of water supply services.

Although a total of 1,093 hand pumps were constructed, 475 hand pumps, 43% of the total, are not functioning. This fact means that it is an important issue to maintain and operate the schemes properly.

The Socio-Economic Condition Survey conducted under the Study, which was implemented in all the target villages (549 villages in total) in the Study area, revealed 38 villages (6.9% in the total number of villages) formed WUG, while only 16 villages established WUA (2.9% in the total number of villages). Otherwise, most of the villages (338-73.8% of the total number) own a conventional VWC. In the field survey under the Study, it was observed that VWCs cannot properly cope with breakdowns of supply facilities without collecting water fees for covering operation and maintenance costs.

The project operation and maintenance plan under the Study adopts the basic framework of; 1) facilitation of participatory model of community-based operation and maintenance through formation and capacity development of the community-based organization, and, 2) enhancement of preparedness in provision of technical guidance by local councils. Taking into consideration problems in operation and maintenance of the existing water supply scheme, the following issues shall be given significance in preparation of the project operation plan. Survey results and findings, gained through the Study and experiences of NGOs involved in the capacity development community in the Study area identify the training needs for the target communities and suggest provision of training for improvement of their capacity in the following concerns to assure sustainability in the community-based operation and management;

- Leadership skill
- Community communication skills
- Organizational/Institutional management skills
- Tariff setting and collection methods

User-Pay Principle (UPP) is introduced in the country for operation and maintenance of rural water supply facilities.

8. PUBLIC HEALTH AND HYGIENE

As for the outpatient department, malaria is the most common disease in the Tabora Region, followed by acute respiratory infection (ARI), pneumonia, diarrhoea, eye infections and intestinal worms. Malaria is also the most common in inpatient departments, followed by anaemia, pneumonia and diarrhoea. The composition of major diseases in the Tabora Region is not much different from that of the Tanzania Mainland.

According to a socio-economic survey by the JICA Study Team, 259 (82.7%) out of 313 cases utilised health facilities: 77.8% of diarrhoea cases, 88.1% of malaria cases and 79.3% of non-communicable Disease (NCD) cases. In all districts except Sikonge, more than 80% of the respondents regard "drinking contaminated water" as a cause of diarrhoea. However, community people have limited knowledge on causes of diseases. Although many of the community people have knowledge that using safe clean water will prevent diarrhoea, it does not lead to the proper behaviour to prevent diarrhoea such as washing hands.

In the frontline level, health education is done by VHW or Village Health Committees (VHC) in village level, while "Health Teachers" facilitate it at school level. Their activities are regularly supported and supervised by health workers at dispensaries or health centres and the Council Health Management Team (CHMT). The District Education Officer or District Community Development Officer also participates in supportive supervision in some districts. VHWs or VHCs cannot always perform well. As a tool for dissemination of knowledge on health, leaflets and posters are utilised at all districts, but it is not effective for illiterates. VHWs or VHCs are forced to provide health education depending on their memories and experiences due to the absence of teaching guides or educational aids.

There is room for improvement of health education at any phases of the cycle. In the planning stage it is necessary to review the current approach for health education to seek what is most effective. Reinforcement of the evaluation mechanism is a requisite. In the phase of implementation, it is essential for VHWs/VHCs and Health Teachers to have teaching guides and educational aids for health education. It is also necessary to seek a diversity of tools for health education and sensitisation. It can also be effective to share experiences regularly.

As for monitoring and supportive supervision of health education, it is necessary to reschedule involving other relevant sectors. The District Water and Sanitation Team (DWST), a district inter-sectoral body, is a good opportunity to enable such collective approaches.

9. DETAILED SURVEY AND OUTLINE DESIGN OF PRIORITY PROJECT

Test well drilling was carried out in the target villages for construction of the piped scheme to evaluate the availability of deep groundwater sources. Water quality was evaluated applying the WHO Guideline (2008) for "Items related to Health Significance" except for Fluoride contents and the Tanzania Health Standard (2008) for Fluoride contents and others. As a result, a suitable water source from view points of yield and water quality was obtained at four (4) villages: Isanga village in Nzega District, Mpumbuli and Mabama Villages in Tabora Rural District, and Kakola Village in Tabora Municipality.

A piped water supply scheme (Level-2) is not necessarily capable to cover the entire area of the village, some Sub-villages are not covered by the scheme judging from the results of the field survey and the facility layout plan.. Such Sub-Villages will be covered by hand pump schemes (Level-1),

The field survey was carried out on the target villages for the hand pump schemes (Level-1) to evaluate topographical, geological, and hydrogeological conditions, and the dwelling type of the community. The water supply plan shown in Table-4 was formulated considering the results of the field survey.

It will take about 35 months for implementation starting from the detailed design study to the completion of the construction of the water supply schemes.

Operation and maintenance costs for the water supply schemes were estimated as shown in Table 4.

Table-4 Operation and Maintenance Costs for Level-2 and Level-1

Type	Village	O&M Cost/Year ($x10^3$ Tsh)	O&M Cost (Tsh /capita/month)
Level-2	Isanga	21,944	935
Level-2	Mpumbuli	42,281	1,326
(continued)	Mabama	37,655	574
	Kakola	45,930	1,400
Level-1	Each scheme	841	280

Table-3 Water Supply Plan for the Priority Project

District /Municipality	Ward	Village	Population 2009	Population 2020	Population served by existing WSS (2009)	Coverage by existing WSS (2009) (%)	Coverage by existing WSS (2020) (%)	To be served by the project (2020)	Number of Level-2 Sub-projects	Population served by Level-2 (2020)	Number of Level-1 Sub-projects	Population served by Level-1 (2020)	Population served by the Project (2020)	Total Population served (2020)	Coverage (by the Project: (2020) (%)	Coverage* (Target Population: (2020) (%)
Igunga	Mwisi	Busomeke	3,618	5,227	250	7	5	4,977	0	0	7	1,750	1,750	2,000	34	38
	Mwisi	Kalemala	2,429	3,509	0	0	0	3,509	0	0	5	1,250	1,250	1,250	36	36
Nzega	Ijanija	Makomelo	1,005	1,319	250	25	19	1,069	0	0	6	1,069	1,069	1,319	81	100
	Lusu	Isanga	1,491	1,956	0	0	0	1,956	1	1,956	0	0	1,956	1,956	100	100
	Miguwa	Kitangili	2,664	3,496	0	0	0	3,496	0	0	10	2,500	2,500	2,500	72	72
	Wela	Wela	1,753	2,301	500	29	22	1,801	0	0	7	1,750	1,750	2,250	76	98
Sikonge	Igigwa	Kasandalala	2,282	3,332	250	11	8	3,082	0	0	7	1,750	1,750	2,000	53	60
	Kipanga	Usunga	1,894	2,766	250	13	9	2,516	0	0	5	1,250	1,250	1,500	45	54
	Pangale	Mpombwe	3,435	5,015	250	7	5	4,765	0	0	8	2,000	2,000	2,250	40	45
Tabora Rural	Kizengi	Mpumbuli	2,157	3,148	0	0	0	3,148	1	2,658	3	490	3,148	3,148	100	100
	Mabama	Mabama	4,329	6,321	500	12	8	5,821	1	5,471	2	350	5,821	6,321	92	100
	Ufuluma	Ufuluma	5,741	8,382	250	4	3	8,132	0	0	7	1,750	1,750	2,000	21	24
Tabora Urban	Kakola	Kakola	2,015	3,483	0	0	0	3,483	1	2,983	2	500	3,483	3,483	100	100
	Misha	Misha	759	1,312	0	0	0	1,312	0	0	5	1,250	1,250	1,250	95	95
	Uyui	Uyui	3,138	5,424	250	8	5	5,174	0	0	8	2,000	2,000	2,250	37	42
Urambo	Imalamakoye	Imalamakoye	2,509	4,292	1,000	40	23	3,292	0	0	4	1,000	1,000	2,000	23	47
	Kapilula	Kapilula	1,568	2,682	0	0	0	2,682	0	0	5	1,250	1,250	1,250	47	47
	Kiloleni	Kalembela	3,131	5,356	0	0	0	5,356	0	0	7	1,750	1,750	1,750	33	33
	Kiloleni	Kiloleni	1,653	2,828	250	15	9	2,578	0	0	6	1,500	1,500	1,750	53	62
	Uyowa	Nsungwa	6,911	11,821	250	4	2	11,571	0	0	10	2,500	2,500	2,750	21	23
Total			54,482	83,970	4,250	7.8	5.1	79,720	4	13,068	114	27,659	40,727	44,977	48.5	53.6

10. SOCIO-ECONOMY IN TARGET VILLAGES OF PRIORITY PROJECT

The primary income source of the target villages of the priority project is agriculture (96.3%). Other income sources such as livestock rising (1.0%), waged income (1.0%), or small business (0.7%) are minor. In Nsungwa village in Urambo District, there is a gold mine and workers work for wages.

The median household income was categorised as 150,001 - 200,000 Tsh/month, with a share of 22.6%, followed by 200,001 - 300,000 Tsh/month comprising 16.9%. Differences among districts reveal Urambo as the wealthiest district with 200,001 - 300,000 Tsh/month, followed by Igunga, Tabora Rural and Tabora Municipality with 150,001 - 200,000 Tsh/month, and Nzega and Sikonge with 60,001 - 100,000 Tsh/month, respectively.

Fetching water is primarily work for adult women (93.3%). A minority of males (3.3%) take charge of the task. Water is fetched on foot by more than 60% of women, while 30% are allowed to use a bicycle. With regards to queuing time at water points, as shown in Figure 10.5, waiting time in the rainy season was less than 10 minutes (79.7%), while the proportion decreased to 29.4% in the dry season. 46% of people wait for more than 30 minutes. The mean time required for fetching the water, including time for travelling and queuing, was 20 minutes during the rainy season and 63 minutes during the dry season respectively.

11. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

The National Environmental Management Council (NEMC) developed "Tanzania Environmental Impact Assessment Procedure and Guidelines (2002) for EIA processes. However, in 2008, a water sector guideline was promulgated for projects by MoW under WSDP.

The PEA report was submitted through the EIA division of MoW at the end of November 2010. NEMC reviewed the PEA report, and evaluated the project as "Category C". Since "Category C" projects do not require the EIA process under NEMC, further evaluation of environmental impact assessment in Tanzania was waived.

12. EVALUATION OF PRIORITY PROJECT

Results of the economic and the financial evaluation were summarized in Table-6.

Table-6 Summary of Economic and Financial Analyses

Item	NPV	B/C Ratio	EIRR	FIRR
Economic Analysis	US$ 3,762,466	1.77	18%	—
Financial Analysis	US$ 239,423	1.26	—	—

As summarized in Table-6, the economic benefit will exceed the cost in case the project is implemented. The priority project could generate a financial surplus, thus financially viable, in running and management of the scheme with a realistic revenue collection ratio.

The institutional framework, and the operation and maintenance system proposed in the Study was evaluated to meet the strategy of the water sector. The implementation of the priority project will contribute to attain the target of WSDP and realize the policy of MoW.

The construction works of the Priority Project require no special techniques. These will be carried out by conventional methods and machinery widely applied in Tanzania. Equipment and materials required for the Priority Project are generally procured in Tanzania, although some of them are imported from abroad such as EU countries, South Africa and Japan. Therefore the technique and materials applied to the project are considered as appropriate.

13. GIS AND DATABASE

The basic data collected by the Study Team were integrated into the database using MS-Excel.

The ArcGIS was applied for the data analyses. The list of analyzed maps are shown in Table-7.

Table-7 List of Base Maps, Database, Survey Results and Analyzed Maps

No.	Base Map and Database	Survey Result	Analyzed Map
1	Regional boundary	Village location	Lineament and dyke
2	District boundary	Location of water supply facility	Main lineament
3	Ward boundary	Distribution of water quality	Interpreted fault
4	Cities in Tabora		Intepreted dyke
5	Geological map		Drainage system
6	Vegetation map		Drainage boundaries
7	National forest map		Water body
8	Water body		River system
9			Lithology
10			Well data
11			Hydrogeology

14. URBAN WATER SUPPLY PLAN

Tabora Municipality and small township, the centres of the districts, were receiving service of water supply and sewerage by the Urban Water Authorities (UWSAs). The summary of each UWSA is shown in Table-8.

Table-8 Outline of UWSAs

Service Item	IGUWASA	NZUWASA	SUWASA	TUWASA	UUWASA
Population of town	18,000	32,075	11,411	175,557	30,104
Served population	6,900	18,000	3,800	151,000	4,800
Ratio of served population	38%	56%	33%	86%	16%

Improvement of water supply facilities and management system are on-going under WSDP and SECO project assisted by the Swiss government.

15. REPAIRING OF EXISTING HAND PUMP

The inventory survey of the existing water supply schemes carried out in the Study revealed that there exist 1,431 hand pumps in the rural area of Tabora (Study area) and 765 hand pumps were not functioning (November 2009). Then, the survey for repairing of hand pumps was carried out and it was confirmed that 27 Afridev type and 19 Tanira type hand pumps among the malfunctioned hand pumps would recover their function by simple repairing (March 2010).

Repairing was carried out by the Study Team targeting those hand pumps. In addition, guidance to the community people on the importance of collection of water tariffs, and operation and maintenance of the facilities.

Location Map of the Study Area

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ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
AMO	Assistant Medical Officer
ARI	Acute Respiratory Infection
ATP	Affordability-to-Pay
B/C Ratio	Benefit/Cost Ratio
CBM	Community-Based Management
CBO	Community-Based Organization
CBRC	Community Based Resources Centre
CCHP	Council Comprehensive Health Plan
CHMT	Council Health Management Team
CI	Cast Iron
CLTS	Community-Led Total Sanitation
CO	Clinical Officer
COWSO	Community-Owned Water Supply Organization
CWSD	Community Water Supply Division
DDCA	Drilling & Dam Construction Agency
DED	District Executive Officer
DEM	Digital Elevation Model
DEO	District Education Officer
DHIS	District Health Information System
DHO	District Health Officer
DI	Ductile Iron
DN	Digital Number
DOM	District Operational Manual
DP	Development Partner
DSM	Dar es Salaam
DTH	Down The Hole Hammer
DWE	District Water Engineer
DWSP	District Water Sanitation Plan
DWST	District Water and Sanitation Team
EC	Electric Conductivity
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EIS	Environmental Impact Statement
E/N	Exchange of Notes
ESAs	External Support Agencies
ESMF	Environmental and Social Management Framework

EWURA	Energy and Water Utilities Regulation Authority
FBO	Faith-Based Organization
FIRR	Financial Internal Rate of Return
FY	Fiscal Year
GDP	Gross Domestic Product
GIS	Geographic Information System
G.L	Ground Level
GNP	Gross National Product
GPS	Global Positioning System
GSP	Galvanized Steel Pipe
HDPE	High Density Polyethylene
HIV	Human Immunodeficiency Virus
HMIS	Health Management Information System
HSSP	Health Sector Strategic Plan
IBRD	International Bank for Reconstruction and Development
IEE	Initial Environmental Examination
IGUWASA	Igunga Urban Water Supply Authority
IPD	Inpatient Department
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
JPY	Japanese yen
JWSR	Joint Water Sector Review
JWWA	Japan Water Works Association
LGA	Local Governmental Authority
L.W.L	Low Water Level
MDG	Millennium Development Goals
MKUKUTA	Mkakati wa Kukuza Uchumi na Kupunguza Umaskini Tanzania
MMAM	Mpango wa Maendeleo wa Afya ya Msingi
MoHSW	Ministry of Health and Social Welfare
MoNRT	Ministry of Natural Resource and Tourism
MoW	Ministry of Water
MoWI	Ministry of Water and Irrigation
MoWLD	Ministry of Water and livestock Development
MWE	Municipal Water Engineer
MWST	Municipal Water and Sanitation Team
NAWAPO	National Water Policy
NBS	National Bureau of Statistics
NCD	Non-Communicable Disease
NDVI	Normalized Difference Vegetation Index
NEMC	National Environmental Management Council

NEP	National Environmental Policy
NGO	Non-Governmental Organization
NOx	Nitrogen Oxide
NPV	Net Present Value
NSGRP	National Strategy for Growth and Reduction of Poverty
NWP	National Water Policy
NWSDS	National Water Sector Development Strategy
NZUWASA	Nzega Urban Water Supply Authority
O&M	Operation and Maintenance
OPD	Outpatient Department
PAP	Project Affected Person
PE	Polyethylene Pipe
PEA	Preliminary Environmental Assessment
PEDP	Primary Education Development Programme
PHAST	Participatory Health and Sanitation Transformation
PHSDP	Primary Health Services Development Programme
PIM	Program Implementation Manual
POM	Programme Operational Manual
PP	Progect Proponent
PPP	Public Private Partnership
PRSP	Poverty Reduction Strategy Paper
PVC	Polyvinyl Chloride
PWP	Public Water Point
PWSS	Piped Water Supply Schemes
RAP	Resettlement Action Plan
RHMT	Regional Health Management Team
RPF	Resettlement Policy Framework
RWST	Regional Water and Sanitation Team
SC	Specific Capacity
SEAMIC	Southern and Eastern African Mineral Centre
SECO	Swiss State Secretariat for Economic Affairs
SEDP	Secondary Education Development Programme
SMS	Short Message
SOx	Sulfur Oxide
SR	Scoping Report
SRTM	Shuttle Radar Terrain Model
SUWASA	Sikonge Urban Water Supply Authority
S/W	Scope of Work
SWAP	Sector Wide Approach to Planning
TAC	Technical Advisory Committee

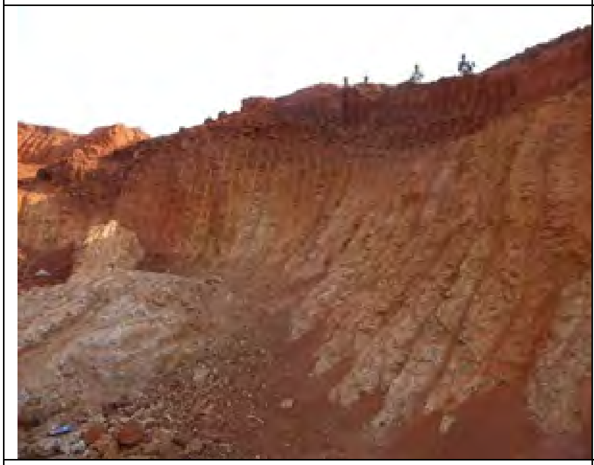
TANESCO	Tanzania Electric Supply Company
TASAF	Tanzania Social Action Fund
TDS	Total Dissolved Solid
ToR	Terms of Reference
TRC	Technical Review Committee
Tsh	Tanzania shilling
T.T.S	Tanzania Temporary Standards
TUWASA	Tabora Urban Water Supply and Sewerage Authority
UfW	Unaccounted-for water
UNDP	United Nations Development Programme
UPP	User-Pay Principle
USD	US Dollar
UTM	Universal Transverse Mercator System
UUWASA	Urambo Urban Water Supply Authority
UWSA	Urban Water Supply Authority
UWSS	Urban Water Supply and Sewarage
UWSSP	Urban Water Supply and Sewerage Programme
VEO	Village Executive Officer
VHC	Village Health Committee
VHW	Village Health Worker
V.I.P	Ventilation Improved Pit latrine
VWC	Village Water Committee
WATSAN	Water and Sanitation
WHO	World Health Organization
WSDP	Water Sector Development Programme
WSPR	Water Sector Performance Report
WSSA	Water Supply and Sanitation Authority
WTP	Willingness-to-Pay
WUA	Water User Association
WUG	Water User Group
cm	centimeter
kWh	kilowatt hour
L	liter
m	meter
masl	meter above sea level
mbgl	meter below ground level
mg	milligram
mH	meter Head
min	minute
ml	milliliter

mS	millisiemense
m^2	square meter
m^3	cubic meter
sec	second

PHOTOGRAPHS IN THE STUDY AREA

1: Inserberg of the basement rock (Tabora Municipality)

2: Typical residence form in Tabora region (residences are scattered around a hill) (Tabora Municipality)



3: Weathering of a bedrock (Urambo District)

4: A woman fetching water from a hole dug near a river (Igunga District)

5: A piped water supply water supply scheme under repairing (Level-2) (Nzega District)

6: A girl fetching water from unprotected traditional water source (Sikonge District)

7: A woman fetching deteriorated water (Tabora Rural District)

8: A girl pumping water from a shallow well with a hand pump (Tabora Municipality)

9: The water source in Igunga District (Bulenya Dam) (Igunga District)

10: The Office of NZUWASA, operated by private sector (Nzega District)

11: An abandoned distribution tank (Sikonge District)

12: A functioning piped water supply scheme (Tabora Rural District)

13: Water venders (Tabora Municipality)

14: A malfunctioned piped water supply scheme (Urambo District)

15: The water source of SUWASA (Mtyatya Dam) (Sikonge District)

16: Girls fetching water from a shallow well (hand pump was stolen soon after the installation) (Tabora Municipality)

17: Socio-economic survey at a village

18: The weather observation site at Tabora airport (Tabora Municipality)

19: Geophysical Survey (Radon method)

20: Two-dimensional resistivity survey

21: Test well drilling (development work)

22: Repairing of a hand pump
(Nata village, Nzega District)

23: A malfunctioned hand pump
(Isanga village, Nzega Distrit)

24: Mpumbuli village (Tabora Rural District)

25: People fetching water from a shallow well (Mabama village, Tabora Rural District)

26: Kakola village (Nzega District)

27: Busomeke village (Igunga District)

28: Makomelo village (Nzega District)

29: Kasandalala village (Sikonge District)

30: Imalamakoye village (Urambo District)

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The United Republic of Tanzania (hereinafter referred to as "Tanzania") is located in the eastern part of Africa covering 884,000km^2. The total population reaches 33.58 million according to the result of census in 2002. GNP is US$330/capita in 2004 (estimation). The Study Area, Tabora Region lies in the central part of Tanzania and occupies 76,700km^2 of area. Population is projected as 2,140 x 10^3 in 2008. Annual precipitation is 952.3mm (average between 1999 and 2008). There observed a rainy season from November to April and a dry season from May to October.

The Government of Tanzania started Rural Water Supply Project in 1971 aiming to provide safe and clean water to the entire nation within a 400m of distance. The Ministry of Water[1] (MoW) has been continued the efforts to improve the water supply coverage formulating "Poverty Reduction Strategy Paper (PRSP)" in 2000 and "MKUKUTA (National Strategy for Growth and Reduction of Poverty (NSGRP))" in 2005. NSGRP targets to improve water supply coverage from 53% to 65% in the rural area and from 73% to 100% in the urban area up to the year 2010. However, it is likely difficult to realize the target.

Ministry of Water and Irrigation (MoWI) formulated the "Water Sector Development Programme (WSDP)" in 2006 to improve the water supply coverage using the basket fund based on the Sector Wide Approach for Planning (SWAp). The WSDP intends to realize the 74% of water supply coverage of the rural area in 2015 and 90% in 2025, and 95% in 2015 and 100% in 2025 for the urban area.

The water supply coverage of Tabora Region, the Study Area, is low, 49.1% in 2008 against the national average of 58.3%. Its major reason is hydrogeological difficulty of developing groundwater. Furthermore, many water supply schemes are left un-functioning due to improper operation and maintenance.

Many people are using deteriorated water sources without using safe and clean water sources. It is said a lot of community people suffered from water borne diseases. Therefore, it is requested to develop water supply schemes as well as to improve people's awareness of public health and hygiene.

In order to overcome these situations, Tanzania requested to Japan to implement a study in Tabora Region on groundwater potential evaluation, construction of database, formulation of rural water supply plan following the WSDP concept and feasibility study of priority projects to be formulated through the study.

In response to the request, Japan International Cooperation Agency (JICA) carried out a preparatory study in February 2009 and concluded the Scope of Work of the Study. Accordingly, the Study is commenced in August 2009.

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[1] Ministry of Water changed its name from Ministry of Water and Irrigation (MoWI) in November 2010.

1.2 OBJECTIVES OF THE STUDY

The objectives of the Study are;

(1) Formulation of water supply plan for Tabora Region,

(2) Preliminary design of priority projects and to carry out a feasibility study, and

(3) To develop the capacity of counterpart personnel of MoW and other authorities concerned in the course of the Study.

1.3 STUDY AREA AND STUDY TARGET VILLAGES

1.3.1 STUDY AREA

The Study covers the one (1) Municipality and five (5) Districts as shown below:

Igunga, Nzega, Sikonge, Tabora Rural, Tabora Municipality and Urambo.

1.3.2 TARGET VILLAGES FOR THE STUDY

The administrative structure of the Local Governments in the Study Area is shown in Figure 1.3.1.

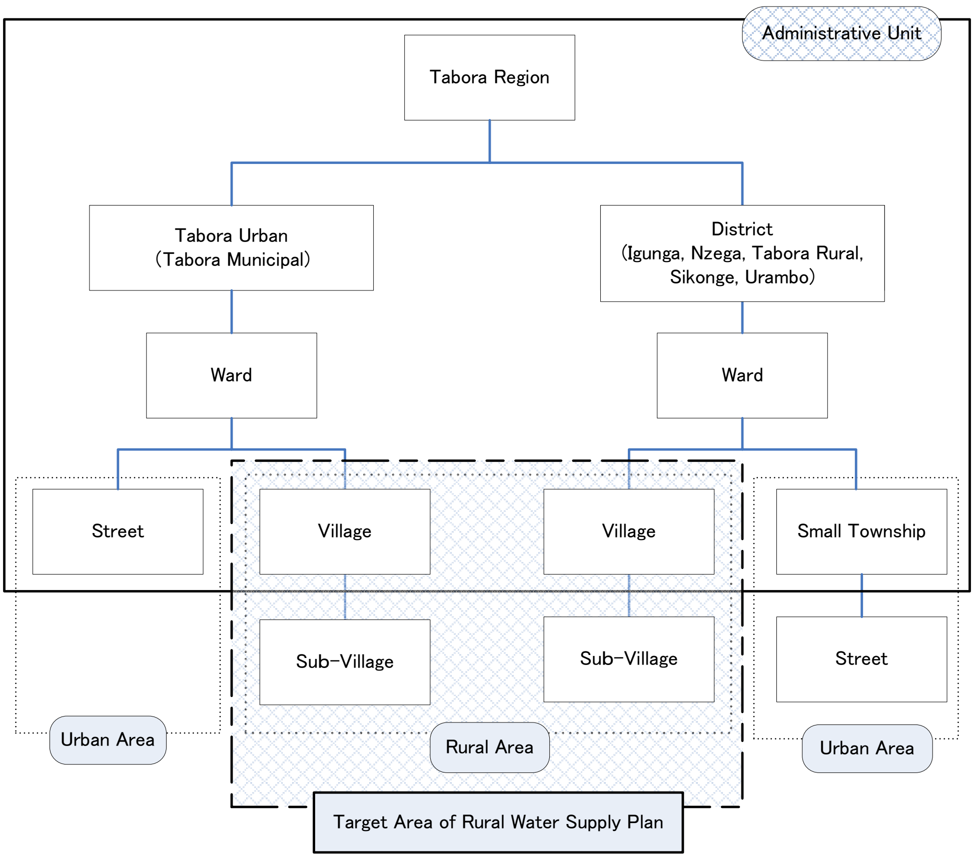

Figure 1.3.1 Administrative Structure of the Local Governments in the Study Area

The total number of Street, Small Township and Village (hereinafter referred to as “Villages”) is 666 as shown in Table 1.3.1. Among them, the number of target villages for the Study is confirmed to be 547 by the Socio-Economic Survey described in Chapter 2.

Street is the lowest administrative unit in the urban area. Small Township is the centre of the

District. A Village is subdivided into Sub-Villages. A Small Township is also subdivided into Streets, while Street in the urban area is not subdivided.

Villages are subject to subdivided or changed to Small Township as the population of villages increases. However, details have not been announced. Therefore, villages confirmed in the Socio-Economic Survey are the target villages of the Study. These are subdivided into 2,918 sub-villages.

Table 1.3.1 Number and Population of Target Villages of the Study

District /Municipality	Street (A)	Small Township (B)	Village (C)	Sub Villages	Population in Target Villages (2009)	Population Ratio (%)
Igunga	0	1	97	630	363,188	19.3
Nzega	0	1	152	978	469,112	24.9
Sikonge	0	0	53	229	164,219	8.7
Tabora Rural	0	0	109	467	393,552	20.9
Tabora Municipality	117	0	24	117	58,842	3.1
Urambo	0	0	112	497	435,277	23.1
Total	117	2	547	2,918	1,884,190	100.0
Total (A+B+C)	666			-	-	-

1.3.3 TARGET POPULATION OF THE STUDY

The Study Area includes the entire rural area and a part of the urban area as mentioned in Table 1.3.1 above. The population of the target area in 2009 is 1,884 x 10^3 persons. It is projected to become 2,801 x 10^3 persons in the target year of the Study 2020.

1.4 IMPLEMENTATION OF THE STUDY

The Community Water Supply Division (CWSD) of the Ministry of Water (MoW) 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 members of Earth System Science Co., Ltd. in association with Japan Techno Co. Ltd and Kokusai Kogyo Co., Ltd. , officially retained by JICA for the Study, and the counterpart staff provided by MoW, Tabora Region and, five (5) Districts and one (1) Municipality.

The total schedule of the Study is shown in the Flow Chart (See, Figure 1.6.1). The Study was commenced in August 2009 and completed in May 2011.

1.5 COMPOSITION OF THE REPORT

This Final Report summarizes the results obtained through the Study conducted from August 2009 to May 2011.

1.6 MEMBERS INVOLVED IN THE STUDY

1) The JICA Study Team

The Team is composed of the following 16 members shown in Table 1.6.1.

Table 1.6.1 List of Members of the Study Team

Name	Assignment
Mr. Yasumasa YAMASAKI	Team Leader/Rural Water Supply Planner
Mr. Takuya YABUTA	Deputy Team Leader/Groundwater Development Planner
Mr. Masakazu SAITO	Hydrogeologist 1, Implementation and Procurement Planner/Cost Estimator 1
Mr. Tadashi YAMAKAWA	Hydrogeologist 2
Mr. Hiroyuki NAKAYAMA	Specialist for Water Quality, Database/GIS 1
Mr. Shigekazu FUJISAWA	Hydrologist/Meteorologist
Ms. Mana ISHIGAKI	Socio-Economist
Mr. Teruki MURAKAMI	Urban Water Supply Planner
Mr. Susumu ENDO	Geophysicist 1
Mr. Kengo OHASHI	Geophysicist 2
Mr. Tatsuya SUMIDA	Drilling Engineer, Supervisor of Hand Pump Repairing, Implementation and Procurement Planner/Cost Estimator 2
Mr. Daisuke NAKAJIMA	Water Supply Facility Designer
Mr. Naoki MORI	Specialist for Operation and Maintenance
Mr. Norikazu YAMAZAKI	Specialist for Environment and Social Consideration
Mr. Naoki TAKE	Specialist for `Public Health and Hygiene
Mr. Tadashi SATO	Coordinator, Specialist for Database/GIS 2

2) Ministry of Water: MoW

Table 1.6.2 List of Members of the Ministry of Water

Name	Position
Mr. Chiristopher N. Sayi	Permanent Secretary
Mr. John A. Mukumwa	Director, Community Water Supply Division
Ms. Frida Rweyemamu	Assistant Director, Community Water Supply Division
Mr. Gibson J. Kisaka	Assistant Director, Community Water Supply Division

3) Regional Water Expert and District/Municipal Water Engineers

A total of 11 members composed of Regional Water Expert, and District/Municipal Water Engineers and their staff are involved in the Study.

Table 1.6.3 List of Regional Water Expert and Water Engineers

Name	Position
Mr. Muhibu Sosthenes Lubasa	Regional Water Expert, Tabora Region
Mr. Benard Chikarabhani	Senior Hydrogeologist, Tabora Water Office, Lake Tanganyika Basin Water Office
Mr. Gaston R. Ntulo	District Water Engineer, Igunga District
Ms. Mariam Majala	District Water Engineer, Nzega District
Mr. Paschal Ngunda John	District Water Engineer, Sikonge District
Mr. Nicodemo N. M	District Water Engineer, Tabora Rural District
Mr. Faustine K. Misango	Acting District Water Engineer, Tabora Rural District
Mr. Mohamed Almas	Municipal Water Engineer, Tabora Municipality
Mr. Rebman Ganshonga	District Water Engineer, Urambo District
Mr. Joseph Kubena	Environmental Coordinator
Mr. Wilson Shadrack Yomba	Acting Regional Environmental Officer

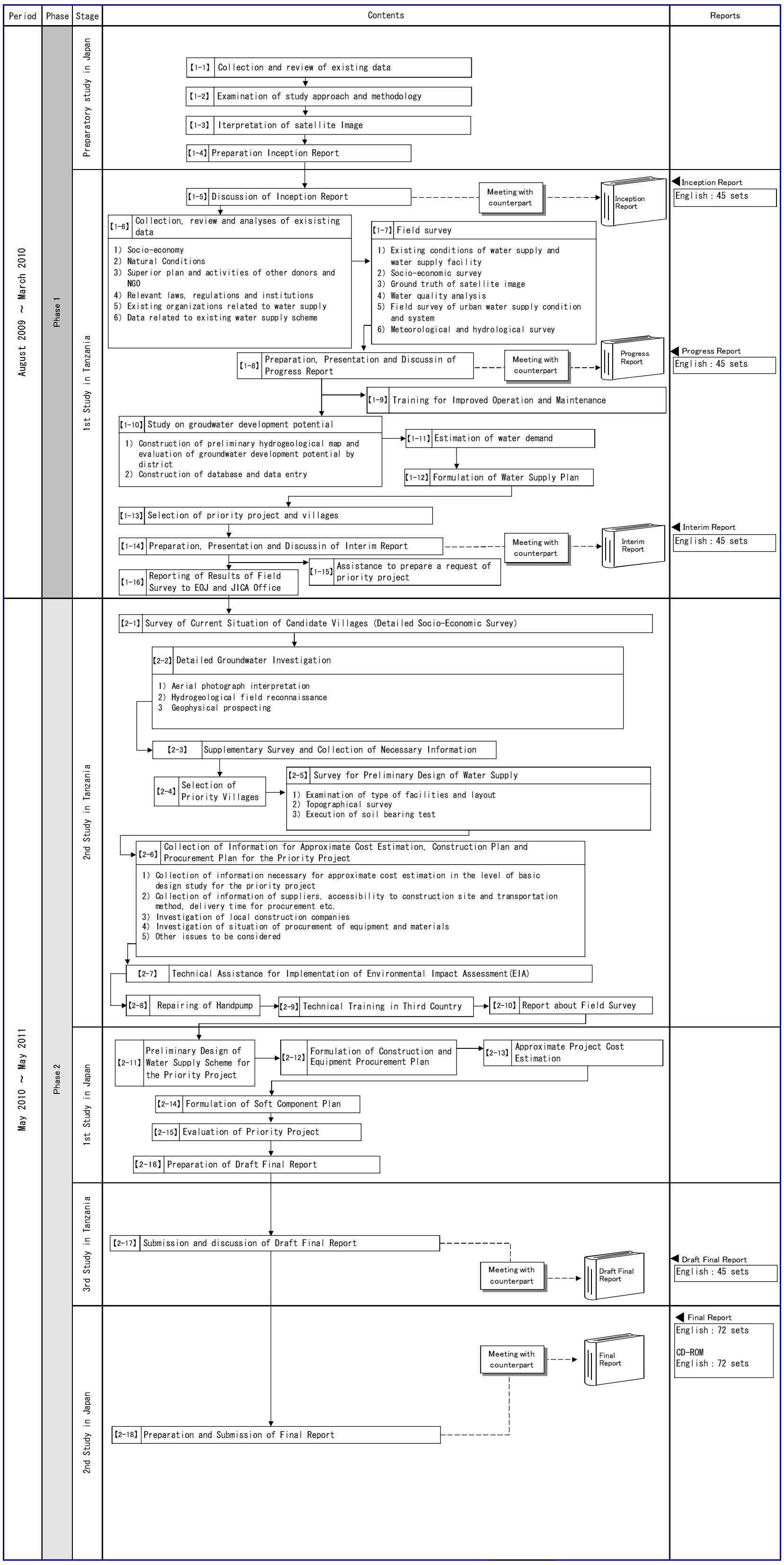

Figure 1.6.1 Flow Chart of the Study Work

CHAPTER 2 SOCIO-ECONOMY

2.1 GENERAL

This Chapter provides socio-economic information from the regional profile as well as the outcomes and findings of the socio-economic survey conducted by the JICA Study Team. The survey collected information for selection of priority projects, formulation of the water supply plan, design of priority projects and formulation of public health and hygiene plans. The collected information pertains to demography, infrastructure, economy, health, other basic social services, and gender issues.

2.1.1 REGIONAL SOCIO-ECONOMIC CONDITIONS

(1) Administrative Structure

As explained in Chapter 1, the Tabora Region has the following administrative divisions: district; ward. Ward is sub-divided into village and sub-village in rural areas, or small townships and streets in urban areas. The region has five districts (Igunga, Nzega, Sikonge, Tabora Rural, and Urambo) and one municipality (Tabora). Although each district has an 'urban area' and a 'rural area', this study focuses on the latter. However, the study includes two small townships from Igunga and Nzega as villages. As Table 2.1.1 shows, target villages of the study are included 6 districts and municipality, 121 wards and 547 villages.

Table 2.1.1 Numbers of Wards and Villages in Target Areas in Tabora Region

District/Municipality	Ward	Village
Igunga District	26	97
Nzega District	36	152
Sikonge District	11	53
Tabora Rural District	17	109
Tabora Municipality	8	24
Urambo District	23	112
Total	121	547

(2) Ethnic Groups

There are two main ethnic groups in the Tabora Region: Nyamwezi and Sukuma. Nyamwezi are primarily engaged in agriculture, and Sukuma are both farmers and livestock keepers. As minorities, there are Ha in Urambo and Wanyiramba and Taturu in Igunga, who are purely livestock keepers. Wakimbu live in Sikonge. Burundi refugees are based in Urambo.

(3) GDP

Tabora's regional Gross Domestic Product (GDP) in 2008 was Tanzania shilling (Tsh) 932,640 million (US Dollar (USD) 738,199,000: USD 1 =Tsh 1,263.4), which accounts for 4.2% of the national GDP, Tsh 22,452,059 million (USD 17,771,141,000). This amount is ranked the 10th among the 21 regions of Tanzania, excluding Zanzibar.

GDP per capita of Tabora region in 2008 was Tsh 429,605 (USD 340.0), the 14th among the 21 regions. Tabora's GDP per capita was 24.5% less than GDP per capita of Tanzania Mainland excluding Zanzibar which is Tsh 568,771 (USD 450.2) (Source: GDP amount: Tabora Regional Economist, Exchange rate: Bank of Tanzania, Annual Report 2008/09).

(4) Economic Infrastructure

1) Road Network

Tabora Municipality, the centre of the region, is located in the central part within the regional boundary and connected to each district by roads. The overall road condition is poor. There are no tarmac roads in the region excess in Tabora Municipality, Nzega and Igunga.

As shown in Table 2.1.2, in the Tabora Region, the total length of tarmac roads is 161km and that of gravel roads is 1,082km. The vast majority of the region's roads, 4,386km, are made of earth. It is necessary to pave earth roads for better access to villages, markets, and social services in rural areas.

Table 2.1.2 Length of Road Network by Type of Road Surface and by District

District/Municipality	Tarmac	Gravel	Earth	Total
Igunga District	88	206	725	1,019
Nzega District	62	220	764	1,046
Sikonge District	-	335	629	964
Tabora Rural District	-	140	1,023	1,163
Tabora Municipality	11	141	240	392
Urambo District	-	40	1,006	1,047
Total	161	1,082	4,386	5,630

Source: District Engineers from respective districts (Unit: km)

Reliability of roads during the rainy season is important for planning the study and implementation of the project. As Table 2.1.3 and Figure 2.1.1 shows, less than 40% of the roads in Igunga, Sikonge and Tabora Rural are passable during the rainy season. In contrast, Tabora Municipality and Urambo have relatively good roads that are passable even in the rainy season at 77% and 90% respectively. Thus the timing of conducting surveys, especially in the rainy season, must be carefully considered.

Table 2.1.3 Length of Road Network Passable Year Round by District

District/Municipality	Passable year round	Not passable during rainy season	total	% Passable
Igunga District	306	713	1,019	30%
Nzega District	790	256	1,046	76%
Sikonge District	134	201	335	40%
Tabora Rural District	359	804	1,163	31%
Tabora Municipality	302	90	392	77%
Urambo District	940	166	1,046	90%
Total	2,831	2,230	5,001	57%

Source: District Engineers from respective districts (Unit: km)

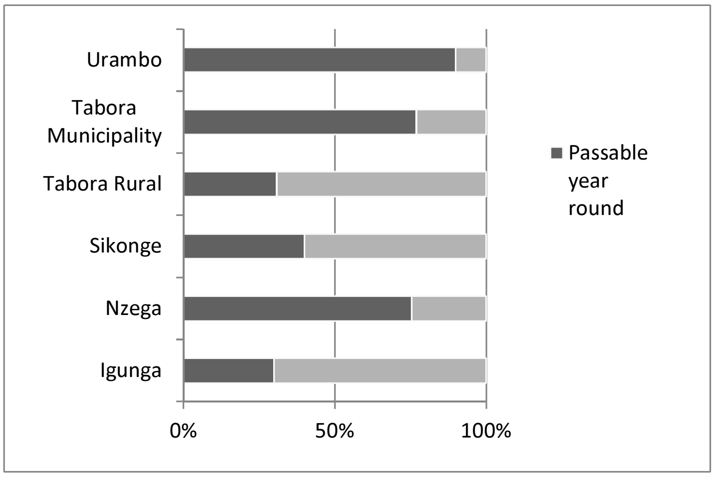

Figure 2.1.1 Percentage of Road Network Passable Year Round by District

2) Railway Network

Tabora is the hub of the railway network in western Tanzania, and has an advantage in transportation of goods. The eastern line is connected to Dar es Salaam, the western one to Kigoma Municipality, and the northern one to Mwanza city, respectively. Among the railway network, 55km is in Nzega, 236km in Tabora Rural, 275km in Urambo, and 38km in Tabora Municipality. The total length of railway lines in the region is 604km.

3) Air Transport Service

Tabora has one airport in Tabora Municipality, and ten airstrips for light aircraft. The airstrips are one in Igunga, four (4) in Nzega, one in Tabora Rural, and four (4) in Urambo.

4) Electricity

Tabora Region depends on the National Grid for its electricity needs. According to the Regional Profile 2008, Tanzania Electric Supply Company Limited (TANESCO) provided 95 million kWh to Tabora in 2006. Rural electrification in Tabora has stagnated. The 2002 Population Census indicates that 12,965 households out of 291,369 in Tabora Region have access to electricity, which accounts for only 4.45% of the total households.

(5) Poverty Indicators

This section examines three selected poverty indicators of respective districts in the region. First, the portion below the basic needs poverty line is provided by headcount. The international standard for the poverty line set in 1993 is one (1) USD per day at the Purchasing Power Parity exchange rate. Meanwhile, as the Poverty and Human Development Report 2005 explains, the poverty line in Tanzania is set as USD 0.26/adult/day at the PPP exchange rate.

As *Table 2.1.4* shows, of all the residents, 48% in Igunga and Tabora Rural, 43% in Sikonge, and 41% in Urambo live under the poverty line. In Nzega, 35% of the people are under the poverty line, which is almost the same as the Tanzania average of 36%. The best district is Tabora Municipality where 23% of the people are under the poverty line.

Secondly, the Gini Coefficient measures the inequality of income distribution. It varies from zero, which indicates perfect equality, with every household earning exactly the same, to one, which indicate perfect inequality between the rich and the poor. The Gini Coefficient of 0.3 or higher indicates substantial inequality in income distribution.

The Gini Coefficient in Tabora is not severe compared to the Tanzania average of 0.35. The district which has the largest inequality is Tabora Municipality (0.33) and the one with the smallest inequality is Tabora Rural (0.30).

Thirdly, the poverty gap is given by the depth of poverty below the poverty line, as a proportion of the line. The non-poor are counted as having a zero poverty gap. The poverty gap is large in Igunga and Tabora Rural (15) respectively, followed by Urambo (12) and Nzega (10). Poverty is not prevalent in Tabora Municipality with the poverty gap at six (6).

Based on these three indicators, it is fair to say that the Tabora Region is relatively poor while inequality is smaller than the Tanzania average. In the region, Igunga is the poorest district in terms of the number of poor people and the depth of poverty. Many of the poor in the district may be facing chronic poverty that keeps them below the poverty line even in the harvest season. On the contrary, Tabora Municipality and Nzega are comparatively better off as they have fewer poor people. Moreover, some of those poor people may be the transitional poor who can rise above the poverty line during the harvest season. Urambo and Sikonge are moderate in terms of poverty indicators.

Table 2.1.4 Selected Poverty Indicators in Tabora Region

District/Municipality	Percentage (%) of the population below the poverty line 2000/01	Gini Coefficient 2000/01	Poverty Gap 2000/01
Igunga District	48	0.31	15
Nzega District	35	0.31	10
Sikonge District	43	0.31	12
Tabora Rural District	48	0.30	15
Tabora Municipality	23	0.33	6
Urambo District	41	0.31	12
Tanzania average	36	0.35	-

Source: Poverty and Human Development Report, 2005

(6) Distribution of Budget by District by Sector

Figure 2.1.*2* depicts the distribution of the accumulated budget 2009/10 of the districts by sector. As a regional total, the education sector receives the highest portion, followed by local government administration and health including HIV/AIDS. These sectors have their own basket fund from the sector ministries of the central government. The water sector comes fourth with the proportion of 5%. Thus budget allocation for the water sector is smaller than that for other major sectors.

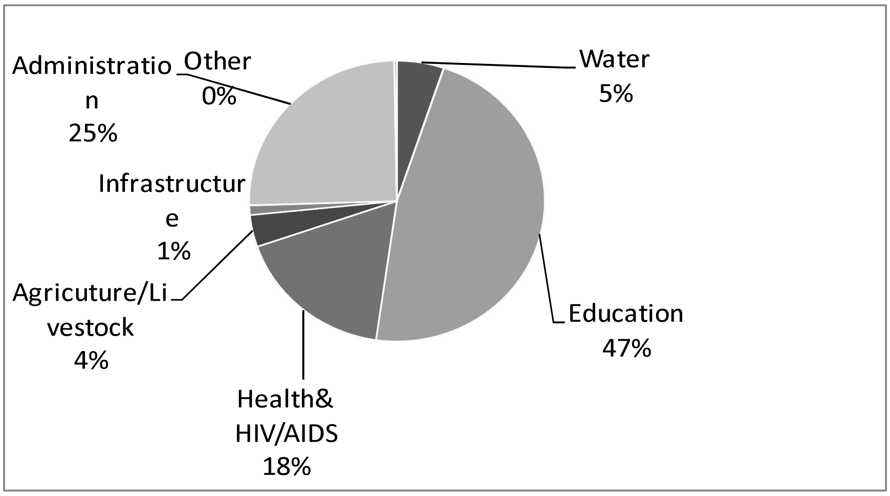

Figure 2.1.2 Distribution of Accumulated Budget by Sector in Tabora Region (2009/10)

2.2 SOCIO-ECONOMIC SURVEY

2.2.1 OBJECTIVES AND METHODS

The purposes of the Socio-Economic Survey are to provide the following: i) target villages for the study to formulate the Rural Water Supply Plan; ii) socio-economic information of the Tabora Region as a general background of the study; iii) basic information of six (6) districts in the study area, which is necessary for the formulation of the rural water supply strategy; and iv) baseline information required for the plan of intervention to strengthen the capacity of the implementing agency, service providers and communities to manage the water supply facilities.

The field study is contracted out to a Dar es Salaam-based local consultant. The JICA Study Team supervised the local consultant throughout the survey process. The field survey started in October and ended in November, along with the inventory survey. The field survey, carried out by three field survey teams, covered all the villages in Tabora Region by means of key informant interviews with questionnaires. Data analysis was done by the consultant.

2.2.2 SURVEY ITEMS

Table 2.2.1 shows the survey items.

Table 2.2.1 Survey Items

General Information	Global Positioning System (GPS) Coordinates Key Informant
Population and Household	Population Number of Sub-villages Dwelling Type Distance to District Town Village and Sub-Village within the Forest Reserve
Economy	Main Source of Income Local Industry Household Income and Expenditure Month of Cash Income
Health and Sanitation	Access to Health Sanitation Primary Health Care Provider Common Illness Type of Toilet Facility
Basic Social Service	Water Supply Facility Access to Educational Facility Adult Literacy Rate Material for Wall and Roof Energy Source for Lighting Type of Community Organisation Any Other Issues
Gender Issue	Responsibility for Fetching Water Time for Fetching Water Decision Maker

2.2.3 OUTCOME OF THE SURVEY ON SOCIO-ECONOMIC CONDITIONS

(1) Village and Population

Here are the two necessary conditions for formulating a water supply plan of Level-2 (piped water supply scheme with public water point): 1) a sufficient water source for the village's water demand is available; and 2) the population is large enough for the collection of sufficient water tariffs which allow the proper operation and maintenance. Based on the experiences of grant aid from the Government of Japan, a population of more than 2,500 is necessary for the proper operation and maintenance of Level-2. In addition, the dwelling type of the village, i.e., distribution of the sub-villages and homesteads, is an important parameter to determine the level of water supply scheme to the villages. Namely, the concentrated type is favourable for cost effectiveness. Based on these points, this section defines the target village, population and analyses the dwelling type. Besides, it provides information on villages within the forest reserve areas which were not considered in the planning stage of the study.

1) Target Village

As stated in Chapter 1 and shown in Table 2.2.2, the number of target villages for the Socio-Economic Survey is 547. As this study focuses on the Rural Water Supply, urban areas, ie, towns within Tabora Municipality, Igunga Small Township and Nzega Small Township were excluded from the target areas. Village location is shown in Figure 2.2.1.

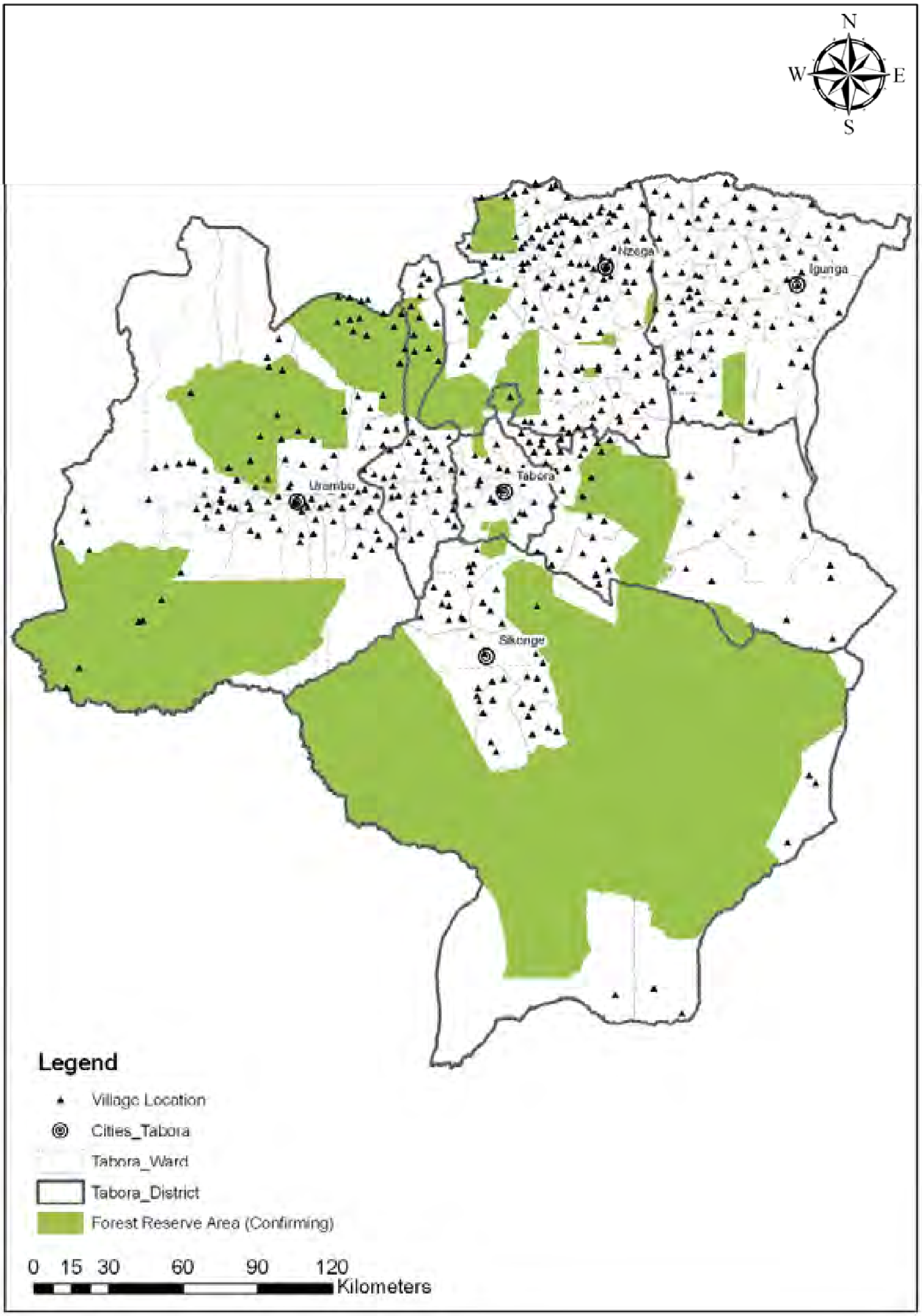

FIGURE 2.2.1 VILLAGE LOCATION IN TABORA REGION

THE STUDY ON RURAL WATER SUPPLY IN TABORA REGION | JICA

Table 2.2.2 Number of Villages Where Field Survey was Conducted

District/Municipality	Number of Wards	Number of Villages	Number of Sub-Villages
Igunga District	26	97	630
Nzega District	36	152	978
Sikonge District	11	53	229
Tabora Rural District	17	109	467
Tabora Municipality	8	24	117
Urambo District	23	112	497
Total	121	547	2,918

2) Findings on Demography

Through the field survey, the JICA Study Team encountered difficulties in obtaining population statistics and the number of households through interviews in villages. The team's target contact person as a key informant was either the Village Executive Officer (VEO) or chairperson of the Village Council who were supposed to keep all official records on village administrative issues. However, it was found that about 20% of the villages have no office to keep official documents. Even if they have offices, record keeping was in poor condition. The districts and the region also depend on information of the census 2002. Until the next census in 2012, no official data are available on the 31 newly registered villages.

3) Population and Household Size

The total population of 547 villages is 1,884,190 and the average household size is 6.3 persons.

Table 2.2.3 Population and Household Size of Target Villages

District/Municipality	Number of villages	Population 2009	Average household size
Igunga District	97	363,188	7.7
Nzega District	152	469,112	5.8
Sikonge District	53	164,219	6.3
Tabora Rural District	109	393,552	5.8
Tabora Municipality	24	58,842	4.8
Urambo District	112	435,277	6.8
Total	547	1,884,190	6.3

4) Population Forecast

Based on the population growth rate which is shown in Census 2002, future population is estimated. Here a linear, not exponential, curve is applied. Table 2.2.4 and Figure 2.2.2 give population projections for 2010, 2015, 2020 and 2025. The target population for the study is the one of 2020 which is estimated as 2,800,926.

Water demand is estimated at 0.025 m^3/day (25 liter/day) as Ministry of Water and Irrigation defines. Detailed demand in each village is shown from Table 2.1 to Table 2.6 in the end of this chapter.

Table 2.2.4 Population Forecast from 2009 to 2025

District/Municipality	2009	2010	2015	2020	2025	Growth Rate census 2002 (1988-2002)
Igunga District	363,188	375,586	443,920	524,687	620,146	3.4%
Nzega District	469,112	480,913	544,101	615,589	696,471	2.5%
Sikonge District	164,219	169,995	201,893	239,779	284,780	3.5%
Tabora Rural District	393,552	407,381	483,833	574,633	682,471	3.5%
Tabora Municipality	58,842	61,854	79,318	101,710	130,426	5.1%
Urambo District	435,277	457,092	583,369	744,528	950,213	5.0%
Total	1,884,190	1,952,821	2,336,434	2,800,926	3,364,507	3.6%

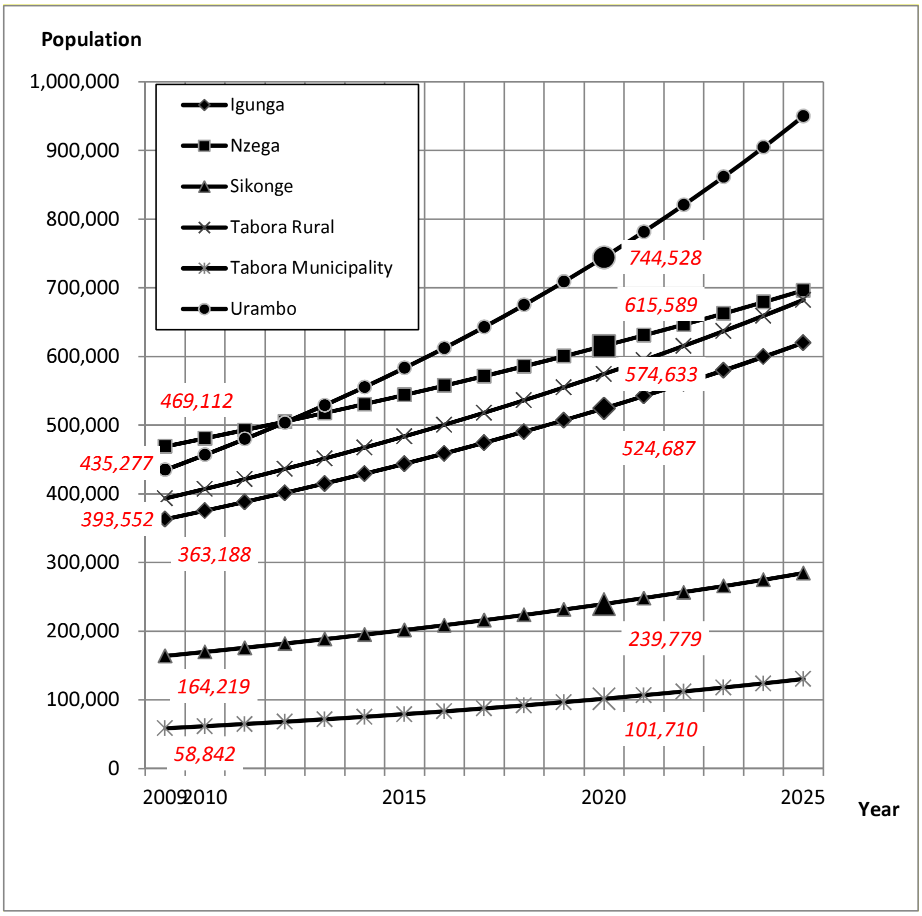

Figure 2.2.2 Population Forecast from 2009 to 2025

5) Dwelling Type

The dwelling type of the village, i.e., distribution of sub-villages and homesteads, is an important parameter to determine the level of water supply scheme to the village. In the field survey, the following four dwelling types were observed: 1) Concentrated type: most households are close to one another as well as to sub-villages; 2) Linear type: households and sub-villages are developed along roads; 3) Clustered type: distance to sub-villages is long, but households are in a compact area; and 4) Scattered type.

For the planning of Level-2, the preferable dwelling types are 1) Concentrated type or 2) Linear type. If the water distribution boundary is selected within the village, 3) Clustered type is also acceptable.

However, if any sub-village is in a higher elevation than the rest of the village, the sub-village will be excluded from the target area for Level-2 due to difficulty in water distribution by gravity.

The Scattered type of villages will be excluded for the planning of Level-2 considering cost effectiveness. To meet the target distance of less than 400m between a water point and a dwelling as advocated in the National Water Policy, the number of public water points must be increased. Hence the cost for construction as well as operation and maintenance will be too high. On the other hand, for Level-1, it is not necessary to consider the dwelling type and any type of village is acceptable.

The most common dwelling type in Tabora is the Scattered type, with 34% as shown in Figure 2.2.3. The Concentrated and Linear types, the preferable types for Level-2, remain 18% within the region.

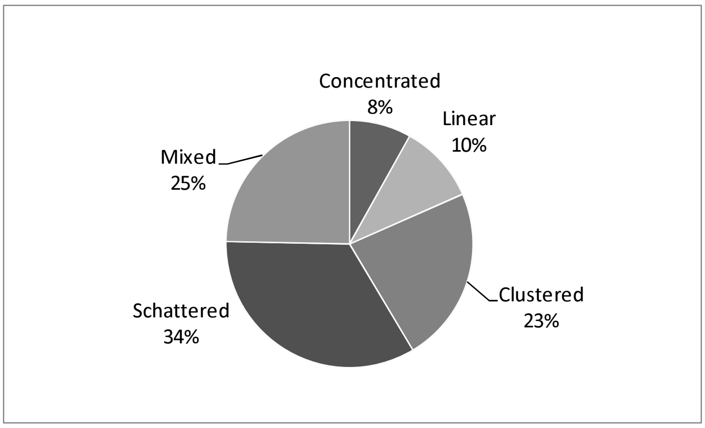

Figure 2.2.3 Dwelling Type in Village in Tabora Region

Table 2.2.5 and Figure 2.2.4 illustrate information on distance between the village centre and sub-villages. Each village has an average four (4) to six (6) sub-villages. 40% of sub-villages are located within 1km, but the average distance to sub-villages is 2.7km and 12% of villages are located more than 5km from the village centre. The interviews revealed that four (4) sub-villages of Igigwa village in Sikonge district are more than 80 to 100km away from the next village centre. Thus some sub-villages are not reachable during the rainy season because flooding makes roads impassable.

Table 2.2.5 Number of Sub-Villages and Average Distance to Them

District/Municipality	Number of sub-villages per district	Average no. of sub-villages per village	Average distance to sub-village (km)
Igunga District	630	6.5	2.9
Nzega District	978	6.4	2.2
Sikonge District	229	4.3	3.6
Tabora Rural District	467	4.3	3.6
Tabora Municipality	117	4.9	3
Urambo District	497	4.4	4.5
Total	2,918	5.3	2.7

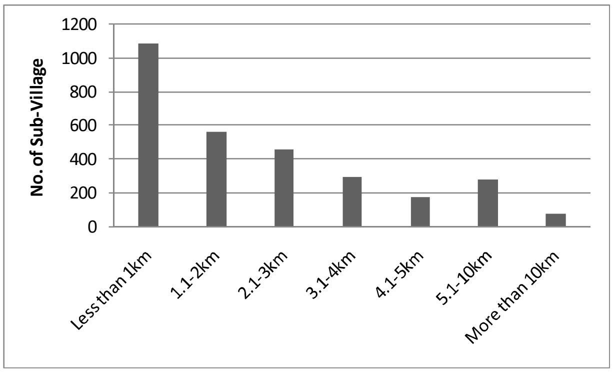

Figure 2.2.4 Number of Sub-Villages and Average Distance to Them

6) Access to District Town

Access to the town is one of the serious concerns of community people. Without a road in good condition, it is difficult to reach a market to buy spare parts for water facilities and sell their products, schools or health facilities. Table 2.2.6 shows average distances to district towns and transportation means from the community. The average distance to the district town is 38 km. 50.9% of the villages use a bicycle as the main means of transportation, followed by minibus (32.3%). Walking is applied to villages near the district town. If a village is in a remote area, transportation to the district town is limited to either motorbike or car. Urambo has some remote villages where roads are all impassable during the rainy season. In such villages, the only means for access to the district town is train.

Table 2.2.6 Distance to District Town and Means to Reach There, by District

District/ Municipality	Average Distance	Bicycle	Minibus	Car	Walk	Motor Bike	Others
Igunga District	46.7km	51.3%	28.0%	14.0%	2.7%	3.3%	0.7%
Nzega District	41.4km	49.1%	41.1%	6.7%	2.5%	0%	0.6%
Sikonge District	63.9km	65.5%	19.0%	0%	6.9%	8.6%	0%
Tabora Rural District	65.5km	47.5%	43.2%	4.2%	2.5%	1.7%	0.8%
Tabora Municipality	14.9km	68.8%	0%	3.1%	18.8%	6.3%	3.1%
Urambo District	52.7km	46.5%	30.8%	4.7%	6.4%	7.0%	4.7%
Total	38.0km	50.9%	32.3%	6.6%	4.6%	3.8%	1.7%

7) Villages and Sub-Villages within the Forest Reserve

The field survey found that there are inhabitants within the forest reserve areas. There are three types of inhabitants according to the definition used by the district forest officer. One is encroachments who cut trees, cultivate land, and settle down within the forest reserve areas against the Forest Act 2002 (Act No 14). The second type is people who live in the registered villages whose authorized village boundaries are all included within the forest reserve. The third one is the villages whose centre is located outside, but some sub-villages are expanded inside, the forest reserve area.

Table 2.2.7 shows the number of villages within forest reserve area. Other than Igunga and Tabora urban, there are villages within the forest reserve areas. As a total of the region, 38 villages are included. Some villages were officially registered more than 20 years ago and public services such as primary school or dispensary have been provided for many years.

According to the manager of the regional catchment forest office in Tabora, a number of villages have been removed for securing a forest reserve. However, in such districts as Urambo and Sikonge that are mostly covered by the forest reserve, decision making of either secure life of local people or conserve the forest reserve is not easy.

The JICA study targets only villages that are partially included within the forest reserve. If an entire village is included in the forest reserve, the village will not be selected for the priority projects.

Table 2.2.7 Numbers of Village and Sub-Village in Forest Reserve Area, by District

District	Forest Reserve name	No. of Village			No. of Sub-Village		
		Village Totally in Forest Reserve	Village partly in Forest Reserve	Total	inside of Forest Reserve	Outside of Forest Reserve	Total
Nzega District	Puge South	5	0	5	34	0	34
	Puge North	2	0	2	17	0	17
	Mwakalundi	5	0	5	21	0	21
	Igombe River	3	3	6	37	3	40
	Total	**15**	**3**	**18**	**109**	**3**	**112**
Sikonge District	Sikonge	3	2	5	14	9	23
	Total	**3**	**2**	**5**	**14**	**9**	**23**
Tabora Rural District	Igombe River	3	0	3	12	0	12
	Goweko	1	0	1	5	0	5
	Total	**4**	**0**	**4**	**17**	**0**	**17**
Urambo District	Uliyanyakulu	5	0	5	20	0	20
	Igombe River	2	4	6	26	6	32
	Total	**7**	**4**	**11**	**46**	**6**	**52**
Total	**-**	**29**	**9**	**38**	**186**	**19**	**205**

(2) Economy

It is clear that the responsibility for operation and maintenance (O&M) is handed over to the community after the construction of water supply schemes. Thus water tariffs should be borne by the community. As Level-2 requires a higher O&M cost compared with Level-1, the village's ability to pay water tariffs must be evaluated properly. If the villages do not meet certain conditions for collecting the water user fee, the water supply scheme must be changed to those with a lower O&M cost such as Level-1.

In the regions of Dar es Salaam (DSM), Coast, Lindi, Mtwara and four regions in Central Plateau where grant aid water supply projects by the Government of Japan were implemented, one (1) Tsh/liter is the general water use fee for a piped water supply scheme. According to a previous project, the operation and maintenance cost including the rehabilitation cost for a Level-2 water supply facility whose target population is more than 2,500, can be covered by 1 Tsh/liter, with collection of fees from 80% of the population. Another condition is that the cost to be paid by the user community shall not exceed 5% of the household income. Based on these assumptions, information on the rural economy was collected in the field survey.

1) Income Source

Like in other areas of Tanzania, agriculture is the main source of income in Tabora, amounting to 69.8% of income in villages as shown in Figure 2.2.5. Livestock keeping is also an important economic activity which provides 22.2% of the income in rural areas. Other minor income sources include beekeeping (3.2%), small-scale business, commerce (3.1%), fishing, charcoal making and mining.

The instability of the annual rainfall pattern over the region differentiates crops in districts. In Igunga, the major crops are cotton, maize and sorghum due to low and short rainfall. In Urambo, rainfall is longer and more stable so that tobacco is cultivated as a cash crop. Over the region that has low land and wet land, rain-fed rice is produced. Maize, sorghum, paddy, cassava, sweet potato and bean are common food crops. Tobacco, groundnuts, cotton, sunflower are also produced as cash crops in the Tabora Region.

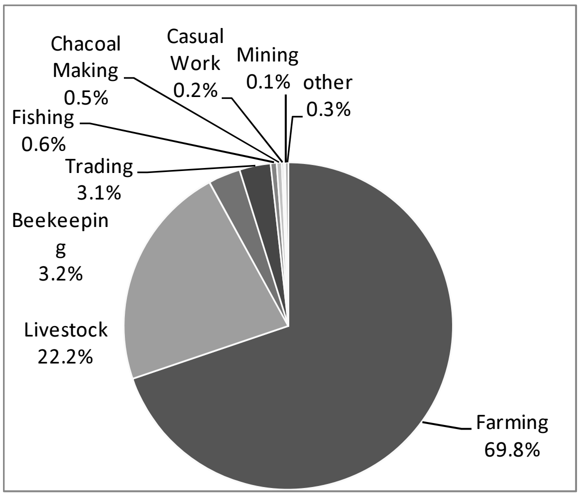

Figure 2.2.5 Source of Income in Tabora Region

2) Local Industry

No local industry is developed in the majority of the villages in Tabora. Most local industries are labour-intensive ones such as carpentry, brick making, pottery and oil processing by individuals utilising basic tools or manual machines. Marketing and sales are also limited within neighbouring communities. As an exception, in Matinje village in Igunga, gold mining has been developed and a relatively large-scale industry is observed.

3) Household Income and Expenditure

As stated in the previous section, major economic activities in the Tabora Region are agriculture and livestock keeping. Therefore, information on household income was collected by questioning inhabitants about the volume of harvested agricultural products and their selling prices, together with cash income from livestock selling.

Expenditure is collected by inquiring inhabitants about weekly cash expenditure per household for their consumption goods, food items, as well as school fees and other cash payments.

Table 2.2.8 shows the median income and expenditure of households. In the region as a whole, the median income is Tsh 400,000 (equivalent to USD 333) per year, and the median expenditure is Tsh 600,000 (equivalent to USD 500). Igunga and Tabora Rural have the lowest income at Tsh 300,000, followed by Sikonge at Tsh 400,000. Nzega, Tabora Municipality and Urambo have a relatively high income of Tsh 500,000.

In terms of expenditure, Urambo showed the highest amount at Tsh 800,000, followed by Sikonge with Tsh 700,000, then Sikonge and Tabora Municipality with Tsh 600,000. Igunga and Tabora Rural have the lowest expenditure at Tsh 550,000.

In all districts, expenditure is higher than income, and amounts were not equal. It is assumed that income is reflected only by the amount of farm cash income and non-farming income is not considered. In fact, household income includes non-farming income such as self employment, transfers, employment in cash, employment paid in kind, and loans. As far as the survey is concerned, people in rural areas rarely save income for any purpose. Therefore, it is reasonable to think that expenditure shows the real amount of income.

In short, Urambo is the wealthiest district in Tabora Region, and Igunga and Tabora Rural are the least wealthy in terms of cash income and expenditures.

Table 2.2.8 Median of Household Income and Expenditure per Year

District/Municipality	Income	Expenditure
Igunga District	300,000	550,000
Nzega District	500,000	600,000
Sikonge District	400,000	700,000
Tabora Rural District	300,000	550,000
Tabora Municipality	500,000	600,000
Urambo District	500,000	800,000
Tabora Region	400,000	600,000

(Unit: Tsh)

4) Months of Income

In most villages, months of cash income are limited from May to August, correspondent with the harvest season as shown in Figure 2.2.6. Careful examination shows that Urambo, Tabora Rural and Nzega also have a harvest season which starts in May and lasts until August. In Tabora Municipality and Igunga, the major harvest season lasts only three months. In the dry season, income sources are very limited, and most villages have no regular cash income. In some areas that have rainfall or irrigation schemes, the harvest continues until November.

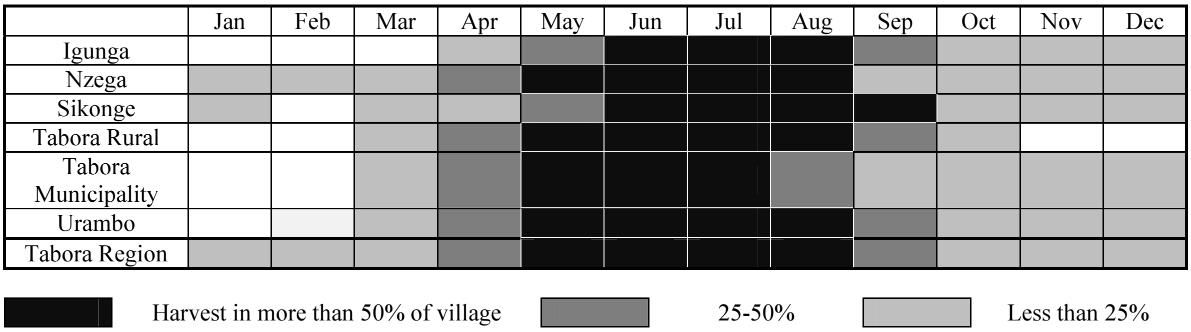

Figure 2.2.6 Income Months by District

(3) Health Service and Sanitation

Water-borne diseases are common in the Tabora Region due to low water supply coverage and lack of hygiene consciousness of community people. However, decrease in water borne diseases is secured only if the people continue to use the water from the improved water supply facilities even if they have to pay a water tariff. If the community people continue to use the existing water, the positive effects of safe and clean water will significantly decrease. A positive cycle will not automatically appear upon the implementation of the improved water supply facilities. Education and awareness raising activities based on the public health and hygiene plan will be indispensable. Thus basic information on the health situation of the community and awareness of health and hygiene of the community people has been collected and analyzed.

1) Availability of Health Facilities within village

Availability of health facilities within a village is a concern for inhabitants. Table 2.2.9 indicates numbers of health facilities in the villages. Despite government support of the health sector, the survey results indicate that 363 (66%) of the villages have no health facilities. 153 (27.8%) have dispensaries, and 4.1% have health centres. Only seven (7) (1%) villages have hospitals within their village boundaries.

Table 2.2.9 Numbers of Health Facilities in Villages by District

District/ Municipality	Dispensary	Health Centre	Hospital	No Facility	Other
Igunga District	30	4	2	62	0
Nzega District	34	9	2	111	0
Sikonge District	20	2	1	30	0
Tabora Rural District	29	7	2	69	2
Tabora Municipality	10	0	0	13	1
Urambo District	31	2	1	78	0
Total	153	23	7	363	3

2) Health Care Provider

Table 2.2.10 shows the distribution of primary health care providers for villagers. This question does not limit to be answered health facilities within village boundaries. Therefore some local people prefer to travel long distance in order to access better health facilities. According to Table 2.2.10, 63.8% of the villages receive primary health care from dispensaries. Pharmacies are the second largest health care provider, amounting to 18.8%. Health centres and hospitals also provide health care to those who have access to them. The survey found that people use herbal treatments for mild symptoms. Sometimes people see traditional healers for treatment. In Tabora Municipality, although there is a Kitete Hospital, it is a top referral hospital in Tabora region which does not provide primary health care service to people. Therefore people access health centre or dispensary first.

Table 2.2.10 Distribution of Primary Health Care Providers for Villagers by District

District/ Municipality	Dispensary	Pharmacy	Health Centre	Hospital	Others	Total
Igunga District	72.4%	13.3%	4.1%	2.0%	8.2%	100%
Nzega District	51.6%	28.8%	5.2%	3.9%	10.5%	100%
Sikonge District	73.6%	0.0%	17.0%	9.4%	0.0%	100%
Tabora Rural District	61.5%	10.1%	16.5%	3.7%	8.3%	100%
Tabora Municipality	83.3%	8.3%	8.3%	0.0%	0.0%	100%
Urambo District	66.1%	29.5%	0.9%	1.8%	1.8%	100%
Total	63.8%	18.8%	7.7%	3.5%	6.4%	100%

3) Common Illnesses

In the Tabora Region, differences between the rainy and dry seasons lead to variation in health problems and illnesses. The field survey queried about common illnesses in the villages. Thus the results shown here are not correspondent with the records at the health facilities. It is found that village inhabitants without a serious symptom tend not to go to health facilities.

As indicated in *T*ables 2.2.11 and 2.2.12*,* malaria is the most prominent cause of morbidity in all the districts in Tabora throughout the year. In the rainy season, it is followed by diarrhoea, dysentery, typhoid and respiratory diseases. In the dry season as well, malaria is the most common disease. The second most common cause of morbidity is respiratory diseases, followed by eye diseases, scabies, dysentery, and typhoid. Cholera outbreak, an indicator in various health reports, is not common in Tabora.

The survey results show that waterborne diseases are more common in the rainy season than in the dry season as ample water is available in the former.

Table 2.2.11 Common Cases of Morbidity in Villages in Rainy Season by District

District/ Municipality	Malaria	Diarrhoea	Dysentery	Typhoid	Respiratory	Other
Igunga District	98	85	37	5	3	3
Nzega District	131	150	28	16	0	3
Sikonge District	53	50	5	20	3	4
Tabora Rural District	104	91	28	43	3	1
Tabora Municipality	21	19	2	11	0	1
Urambo District	108	91	17	8	10	0
Total	515	486	117	103	19	12

*Multiple answers are allowed

Table 2.2.12 Common Cases of Morbidity in Villages in Dry Season by District

District/ Municipality	Malaria	Respiratory	Diarrhoea	Eye Diseases	Scabies	Dysentery	Typhoid	Other
Igunga District	89	75	25	10	2	5	2	3
Nzega District	139	56	21	10	1	6	1	2
Sikonge District	53	50	5	20	3	6	12	3
Tabora Rural District	104	91	28	43	3	0	2	0
Tabora Municipality	21	19	2	11	0	1	3	0
Urambo District	108	91	17	8	10	5	3	2
Total	518	331	141	65	25	23	23	10

*Multiple answers are allowed

4) Types of Toilet Facilities

With regards to availability of toilets in villages, as shown in Table 2.2.13, 66.1% of the villages use the traditional pit latrine. This latrine is dug one meter deep and is placed between two rocks, surrounded by grass. 18.9% use either the traditional pit latrine or no toilet. 13.1% of the villages answered that the majority of households have no sanitation facility and use a bush as a substitute. Ventilation Improved Pit latrine (V.I.P) is the improved type of facility which the vent acts to draw odour and insects into the pit and up the vent. In remote areas, flush toilets are not seen at all.

Table 2.2.13 Distribution of Toilet Facilities in Villages, by District

District/Municipality	Traditional pit latrine	Mix of traditional pit latrine and no toilet	No toilet	Ventilation improved latrine
Igunga District	39.8%	45.9%	12.2%	2.1%
Nzega District	66.0%	1.3%	30.1%	2.6%
Sikonge District	94.3%	0%	5.7%	0%
Tabora Rural District	98.2%	0.9%	0.9%	0%
Tabora Municipality	95.8%	0%	4.2%	0%
Urambo District	38.4%	50.0%	8.0%	3.6%
Total	66.1%	18.9%	13.1%	1.9%

5) Sanitation Awareness

With regard to sanitation awareness, the survey team asked village inhabitants about causes of diarrhoea. It was found that 100% of the interviewees recognise that unclean and unsafe water is a direct cause of diarrhoea. The interviewees also raised other causes for diarrhoea including eating rotten food, touching food without washing hands, sharing plates with others without cleaning, lack of pit latrine, lack of knowledge on sanitation, and poverty. However, there seems to be a gap between awareness and behaviour change. For instance, it was noted through free discussions that most villagers drink water from contaminated shallow wells or rivers without boiling it at all. It was also noted people do not like the smell of water when it is boiled using charcoal. Furthermore, people dig shallow wells within their homestead, but only 2 to 3 m from pit latrines. In Sukuma culture, livestock are assets and treated carefully. As a result, people and livestock share the same water sources such as rivers or ponds which are contaminated by livestock manure.

In order to lead to behaviour change for public health and hygiene, it is important to consider various factors such as poverty alleviation, income generation, public education, gender, tradition and culture or individual tastes.

(4) Other Basic Social Conditions

After the construction of the water schemes, the prime responsibility for O&M will be handed over to the community. Proposed roles for the community include technical operation and maintenance, organizational management of the water users' group, water tariff collection, accounting, and financial management. To help the community meet its obligations, the study supports preparation of various types of training. The questions in this section will be useful to grasp the overall environment of the communities prior to preparing such training and plan.

1) Availability of Educational Facilities

Recent strong initiatives of the central government on the education sector, such as the Primary Education Development Programme (PEDP) and the Secondary Education Development Programme (SEDP), have had a positive impact on availability of educational services in rural areas. Among the 547 villages surveyed, only 19, or 3.5%, answered that they have no educational facilities, as indicated in Table 2.2.14. 74.9% have primary schools, and 21.5% have both primary and secondary schools. 2.6% have only secondary schools.

However, several villages are too far from sub-villages to have children go to school on foot. Elsewhere, hundreds of children study in the open air without proper educational facilities because classrooms are not large enough. Therefore services to education sector continuously need to be improved.

Table 2.2.14 Numbers of Educational Facilities in Villages by District

District/Municipality	Primary school	Both primary and secondary	Secondary school	No school
Igunga District	71	26	0	1
Nzega District	118	29	13	6
Sikonge District	36	16	0	1
Tabora Rural District	88	15	0	6
Tabora Municipality	16	7	0	1
Urambo District	82	25	1	4
Total	411	118	14	19

2) Adult Literacy Rate

The literacy rate of young people is improving as the primary school enrolment rate has risen. However, the aggregate literacy rate of adults aged above 18 is relatively low. Table 2.2.15 demonstrates the median of the literacy rate of adults over 18. No district has a higher literacy rate for women than men. In some villages, the literate gap by sex is large. The median literacy rate for men in the Tabora Region is 60% while that of women is 40%. Thus women in rural areas are at a disadvantage in literacy.

During the field survey, an election of the local government was held, and the voter registration lists were shown at the village council office. It was observed that more than one third of the voters confirmed their name by finger printing rather than signature. It was also noted that villagers are unable to utilize the short mail function of their mobile phones although communication through SMS (short message service) is often less costly than face-to-face conversation that involves travel.

Thus a special arrangement for illiterate villagers is needed when conducting detailed surveys, training or awareness campaigns in villages.

Table 2.2.15 Literacy Rate of Adults Aged 18 or Above (Median)

District/Municipality	Male	Female
Igunga District	50%	30%
Nzega District	60%	45%
Sikonge District	60%	35%
Tabora Rural District	50%	40%
Tabora Municipality	73%	60%
Urambo District	70%	50%
Tabora Region	60%	40%

3) Roofing and Wall Materials

Figure 2.2.7 illustrates that the most common material for roofing is grass which is used in 76.8% of the villages. 12.1% of the villages use iron sheet as roof material, followed by 9.2% that use grass and mud. Only 1.6% use concrete. Houses with iron-sheet roofs can install a rainwater harvest tank, which benefits communities facing serious water problems.

Figure 2.2.8 indicates that mud bricks are the most common wall material in the villages with a proportion of 75.9%. 12.1% of the villages use mud and pole, 7.9% use burnt bricks, and 4.0% use concrete block.

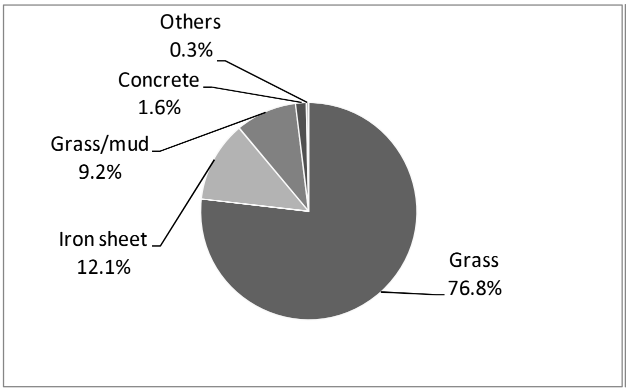

Figure 2.2.7 Percentage of Villages by Type of Roof Material in Tabora Region

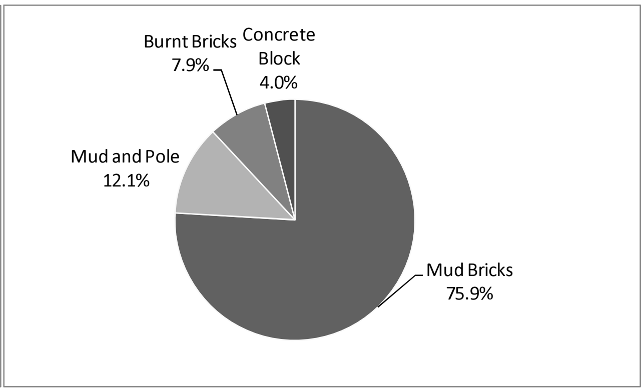

Figure 2.2.8 Percentage of Villages by Type of Wall Material in Tabora Region

4) Source of Lighting Energy

Electrification in rural areas has stagnated. As shown in Figure 2.2.9, the kerosene lamp, locally called wick lamp, is the main source of lighting in the Tabora Region. 93.6% of the villages use this source of energy, followed by 4.3% that use electricity, and 1.6% that use firewood.

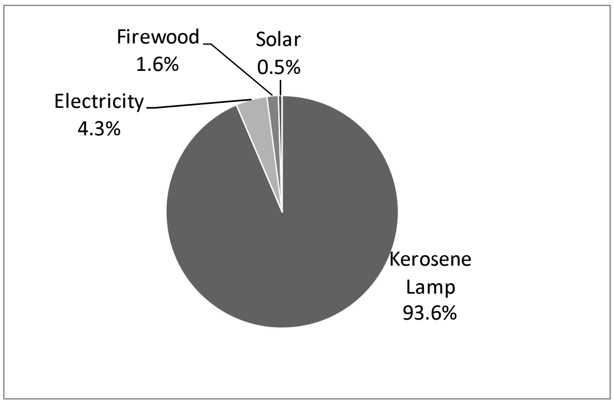

Figure 2.2.9 Percentage of Villages by Main Source of Energy for Lighting

5) Ownership of the Mobile Phone

Ownership of the mobile phone is another status of wealth in rural villages in Tanzania. There is no district where an equal percentage of women and men own a mobile phone. Table 2.2.16 shows the proportion of possession of a mobile phone. On average, 39.3% of male villagers own a mobile phone, while 17.1% of females do. Most women who have a mobile phone are either teachers or those who earn a salary. Although villagers have mobile phones, there is no electricity in the villages. To charge mobile phones, villagers use car batteries by paying car owners. Network coverage is also very limited in rural areas. Thus people keep their mobile phone switched off until they reach a certain spot where there is a network.

Given the relatively poor economic status of the villages, the mobile phone possession rate is moderately high. This will provide an opportunity for villagers when the community starts operation and maintenance of the water facilities. Technical advice and order of spare parts can be done without travelling to a given town.

Table 2.2.16 Average Proportion of Possession of a Mobile Phone in Villages

District/ Municipality	Male	Female
Igunga District	31.6%	10.9%
Nzega District	39.3%	8.9%
Sikonge District	45.8%	19.4%
Tabora Rural District	43.7%	17.1%
Tabora Municipality	38.3%	21.1%
Urambo District	39.2%	17.5%
Tabora Region	39.3%	17.1%

6) Community Organisation

More than 86.7% of the villages have at least one community organisation officially registered or known to the public. Table 2.2.17 indicates types of community organisations among the villages that have them. 338 villages have a village water committee. 278 villages have a farmers' group or farmers' class to share knowledge on agriculture, or keep chickens as a group for income generation. 207 villages form a women's group, followed by 82 villages with a cultural group, 46 villages with a youth group, 31 villages with a carpenter's group, and 16 villages with a water users' association. Meanwhile, although 338 villages indicate that they each have a village water committee, it does not mean the committees are actively working. After the Water Sector Development Programme started, the district instructed the villages to form a village water committee, open a bank account, and contribute money to it as a condition of a new project. Most of the villages followed this instruction, but there are no regular activities for the existing water supply schemes. In order to improve this situation, water uses' group or water users' associations which are formed under every water scheme have been changing to the mainstream for a body of O&M. However, as far as the survey discovered, water users' groups and water users' associations are not common in rural areas.

Table 2.2.17 Types of Community Organisations by District

District/ Municipality	**Village water committee	Farmer s' group	Women' s group	Cultural group	Youth group	Carpenter' s group	**Water users' group	**Water users' association	Others
Igunga District	57	19	20	19	12	5	6	3	14
Nzega District	73	82	61	43	10	8	23	10	14
Sikonge District	42	40	27	8	3	3	0	2	0
Tabora Rural Distrivt	64	69	24	4	3	5	2	0	15
Tabora Municipality	18	17	13	2	3	2	0	0	7
Urambo District	84	51	62	6	15	8	7	1	4
Total	338	278	207	82	46	31	38	16	54

*Multiple answers were allowed

** Interviewers asked the number of active committees and groups, not registered numbers. It was found that some committees and groups conducted no activities for many years after registration. In other cases, village representatives did not recognize its existences. In these cases, it is not counted.

7) Village Concerns

In the interview survey, two priority concerns each were raised from the villages as shown in Table 2.2.18. 94.9% of the villages cited water as the most serious concern. Health, especially demand for dispensary, is a serious concern for 60.3% of the villages. 27.5% raised strong voices mainly from men to improve road conditions and access to town. 9.3% request a primary school, and 2.6% desire electrification in their villages. Other concerns include a police station, mobile network and agricultural tools.

Table 2.2.18 Two Priority Concerns in Villages, by District

District/Municipality	Water	Health	Road	Education	Electricity	Others
Igunga District	100.0%	39.8%	48.0%	5.1%	2.0%	3.1%
Nzega District	91.5%	62.7%	25.5%	11.8%	4.6%	3.9%
Sikonge District	98.1%	60.4%	18.9%	13.2%	3.8%	5.7%
Tabora Rural District	93.6%	72.5%	21.1%	7.3%	0.0%	5.5%
Tabora Municipality	87.5%	50.0%	20.8%	16.7%	0.0%	29.2%
Urambo District	96.4%	65.2%	24.1%	8.0%	2.7%	3.6%
Total	94.9%	60.3%	27.5%	9.3%	2.6%	5.3%

*Two most serious concerns were raised by villages

(5) Gender Issues

The low coverage rate of the safe water supply in Tabora means that people mainly use water from ponds or streams, causing the burden of fetching water for women and children. It also decreases women's access to primary education and health care facilities, and leads to more water-borne diseases and a higher infant mortality rate. Based on this background, gender issues related to water were researched and analyzed.

1) Time Taken for Fetching Water

As stated in the previous section, needs for improving the water situation are strong. The reasons for the needs and difficulties of the community can be found by analyzing the time taken for fetching water. The National Strategy for Growth and Reduction of Poverty (NSGPR) set the target time of fetching water from water facilities in 65 % of rural areas as less than 30 minutes by 2010. As shown in Figures 2.2.10 to 2.2.15, in the rainy season, more than 80% of the villages in all districts said that time for fetching water including queuing are less than 30 minutes.

In the dry season, the picture is very different. Igunga District faces the most difficult situation. More than 70% of the villages there stated that it took more than 90 minutes to fetch water, while other districts such as Nzega District, Sikonge District, Tabora Municipality and Urambo District need less than an hour. The best district was Tabora Rural where only 16.5% of the villages spent more than 90 minutes, and most of the rest spend 30 to 60 minutes. It must be noted that the question was on the time from the village centre to the water source point. Thus, if the homestead is far from the village centre or in a different sub-village, time spent might be different.

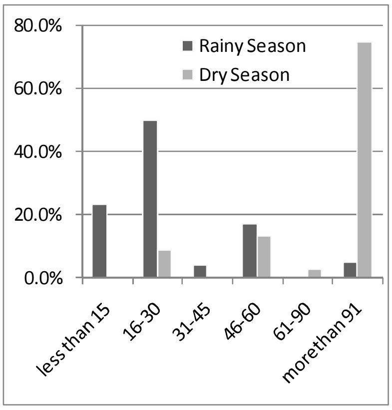

Figure 2.2.10 Time Taken for Fetching Water in Igunga District

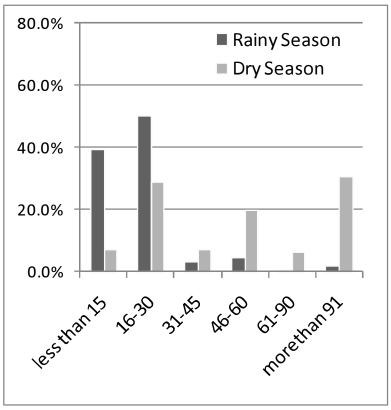

Figure 2.2.11 Time Taken for Fetching Water in Nzega District

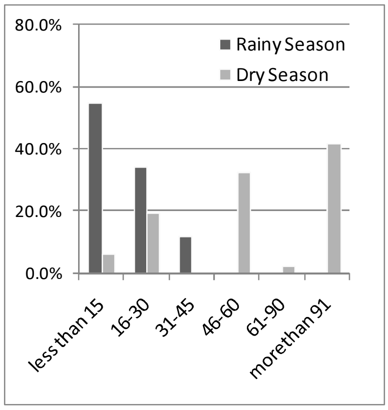

Figure 2.2.12 Time Taken for Fetching Water in Sikonge District

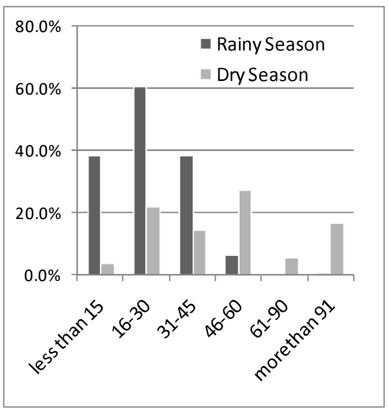

Figure 2.2.13 Time Taken for Fetching Water in Tabora Rural District

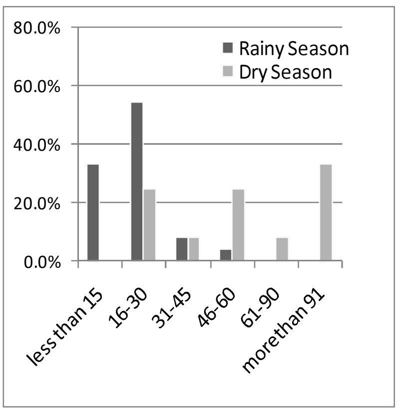

Figure 2.2.14 Time Taken for Fetching Water in Tabora Municipality

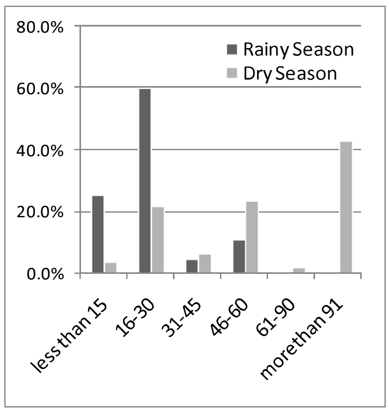

Figure 2.2.15 Time Taken for Fetching Water in Urambo District

2) Responsible Persons for Fetching Water

Figures 2.2.16 and 2.2.17 show the results of primary and secondary responsible people within households for fetching water. It is obvious that the prime responsibility for fetching water is on adult women. The secondary responsible person differs among districts. In Igunga, access to water is difficult during the dry season. Most of the communities take more than 90 minutes and it is impossible to reach the water point on foot. Therefore, in the dry season, 60% of the men are in charge of fetching water by using bicycle, hand cart or ox cart. In Urambo, water is rather ample and children, both girls and boys, help fetch water. In Tabora Rural, 60% of the villages stated girls, not boys, are responsible for assisting their mother.

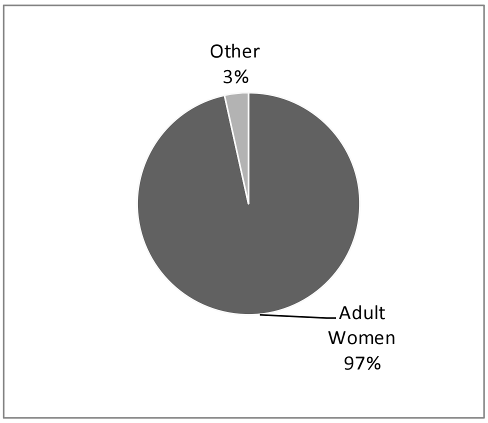

Figure 2.2.16 Primary Responsible Person for Fetching Water

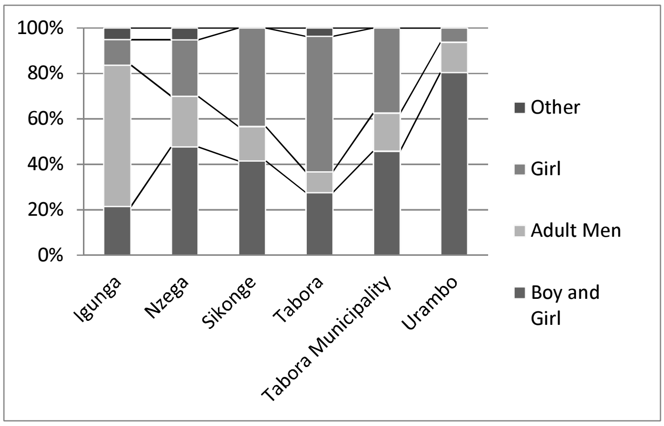

Figure 2.2.17 Secondary Responsible Person for Fetching Water

3) Decision Maker

The final decision maker in a household is male. As shown in Figure 2.2.18 only 3.5% of the villages indicate decisions are made on discussion between the man and woman. This result means that traditions of rural areas are still disadvantageous for women as a whole. It is noted that decisions are made not only within households but outside them. For example, in the Sukuma tradition, women are neither allowed to sit in front of men in public, nor speak before they are directed to do so by men. Men also control household budgets, women's behaviour, and other activities. It was also found that women are busy as they are responsible for cooking, cleaning, taking care of children, collecting firewood and water fetching. Therefore, to encourage women's participation in any training, meetings or workshops for awareness raising of public health and hygiene or other meetings for a water user's group, involvement of the men is critical.

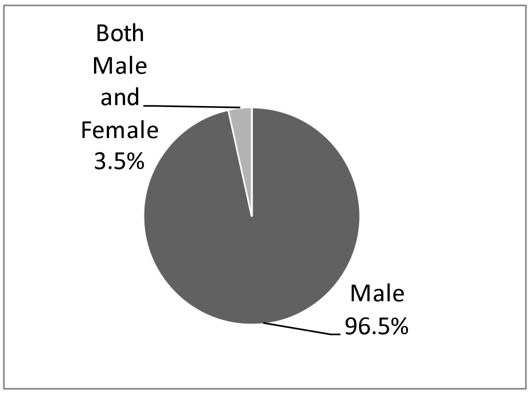

Figure 2.2.18 Percentage of Decision Maker in Households

2.2.4 OTHER OBSERVATIONS

Other than the analyses above, the following four observations are made for selecting priority projects, formulation of a water supply plan, design of water supply facilities, and formulation of 'soft' or social and institutional components.

1) Lack of road infrastructure

In Tabora, road infrastructure is underdeveloped, and access among regions, districts, villages, and sub-villages is not easy. During the rainy season, two thirds of roads are impassable and means of transportation are limited. Thus the JICA Study Team shall carefully plan its activities such as field surveys, workshops and training. Meanwhile, the community side has no network of public transportation to the district town. The Study Team shall take this point into consideration when formulating a plan for establishment, operation and maintenance of a supply chain. The most common means for transportation in the community is bicycle. Arrangement of bicycle spare parts, technicians, and a repair office needs to be considered within a reasonable distance for the community people.

2) Needs for Information Delivery System

Limited means of travel also affect access to information. Although a relatively large number of people have a mobile phone, communication opportunities are not fully utilised due to limited network coverage in rural areas. Thus the community is mostly passive in receiving information. The low adult literacy rate in rural areas also hinders the dissemination of information to the community. In formulating a plan for operation and maintenance, it is necessary to consider providing information to illiterate people without depending too much on written guidelines or manuals. In some villages in Igunga, the Sukuma language is the most commonly used language among the inhabitants and minority groups mostly uses their languages. It should be noted that Swahili language is not the only common communication tool in rural areas of Tabora Region. Asymmetry can be seen among men and women because men have strong control over women's behaviour. To sum up, when providing information, it is necessary to identify the recipients of the information, and examine if it can be fully disseminated among the recipients.

3) Needs for income generation during the dry season

The field survey found that approximately 40% of livelihoods are at the subsistent level in rural areas. Months of income last only three to four months. For the rest of the year, the community has no alternative income source. To secure positive outcomes, it is necessary for the community to continue to use safe and clean water that is obtained by paying water tariffs. However, the existence of an improved water scheme itself does not necessarily generate income or employment opportunities. To secure sustainable operation and maintenance, awareness raising on sanitation and hygiene together with income generation is necessary, especially in Tabora. The long custom of accessing water without paying water tariffs might cause difficulties in changing behaviour of the community people. In fact, some men stated that they do not want to pay for water if they can pay a higher price for the local beer. Income generation activities such as small scale irrigation or basket making by existing community organizations will help the community members pay water tariffs. In Tabora Municipality, a missionary Non-Governmental Organization (NGO) produces and sells water filters made of clay pot that filtrate bacteria without boiling water. This might be a good example in improving both income generation and public health.

4) Expectations from the communities

Fetching water is a major burden for women and children. It also deprives them of access to education or health facilities in rural areas. Demand for reliable water sources within the village is high in most communities in the region. On the other hand, Communities are concerned that there are insufficient opportunities to consult with District Water Engineer (DWE)s. In response to higher demands for water schemes, many villages contributed money, and opened a new bank account after the launching of WSDP in 2006. The communities have been waiting for next step to do since then. Community people also request advices and consultation to repair water facilities in their villages. However, in reality, due to large coverage of DWE's service area and number of facilities, as well as insufficient personnel and transportation, service is not reached to communities sufficiently.

2.3 CONCLUSION

Development of water supply schemes in the Tabora Region is urgently needed to improve the quantity of water facilities and the quality of water there. However, implementation of such schemes faces several difficulties. First, the dwellings of villages and distribution of sub-villages are the scattered type which does not suit the planning of Level-2 type water facilities. Access to villages is not secure because of the poor road conditions. Community people have been using deteriorated water sources due to low awareness on public health and hygiene, lack of water sources, and poverty which keeps them from paying for clean and safe water. Moreover, traditions in rural areas control women's activities and behaviours and limit their access to education and health care service to improve the quality of life.

Hence, together with formulation of a water supply plan, improvement of public health and hygiene and income generation activities for poverty alleviation are necessary. Given gender issues and the community's limited ability to travel, distance is another important consideration for formulating plans for sustainable operation and maintenance of water supply schemes.

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CHAPTER 3 METEOROLOGY AND HYDROLOGY

3.1 GENERAL

The meteorological and hydrological data were collected and analyzed for formulation of the rural water supply plan. Then, water balance in Tabora Region was analysed in order to evaluate groundwater recharge which is the most important factor for analyse the groundwater potential.

3.2 CLIMATE

3.2.1 CLIMATIC CONDITIONS IN TABORA REGION

Tabora Region is the largest of Tanzania's 26 administrative regions at approximately 76,700 km^2. It is located from 31°00’ to 34°15' east longitude, and from 3°45’ to 7°00’ south latitude. It is an inland region surrounded by Shinyanga Region to the north, Kigoma Region to the west, Singida Region to the east, and Rukwa Region and Mbeya Region to the south.

According to the Köppen-Geiger classification (Figure 3.2.1) the climate is equatorial savannah with dry winter (Aw). Generally, its climate is characterized by a limited daily temperature range, clearly defined rainy and dry seasons, and grasslands (savannah) sparsely dotted with trees tolerant of dry conditions.

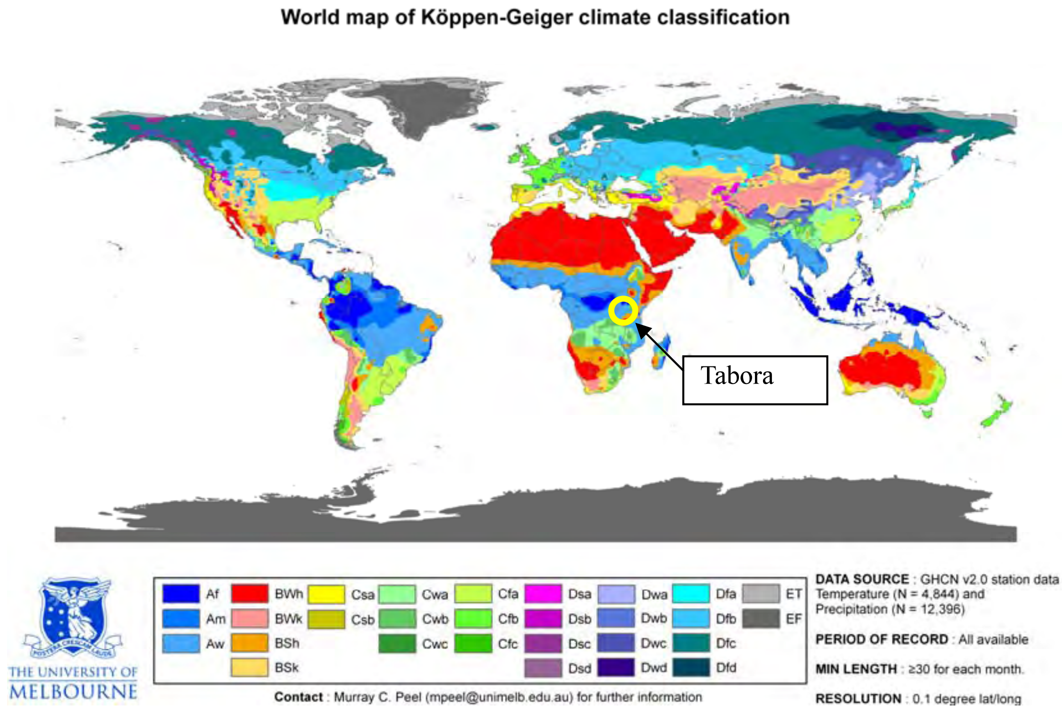


Figure3.2.1 Köppen-Geiger Climate Classification Map

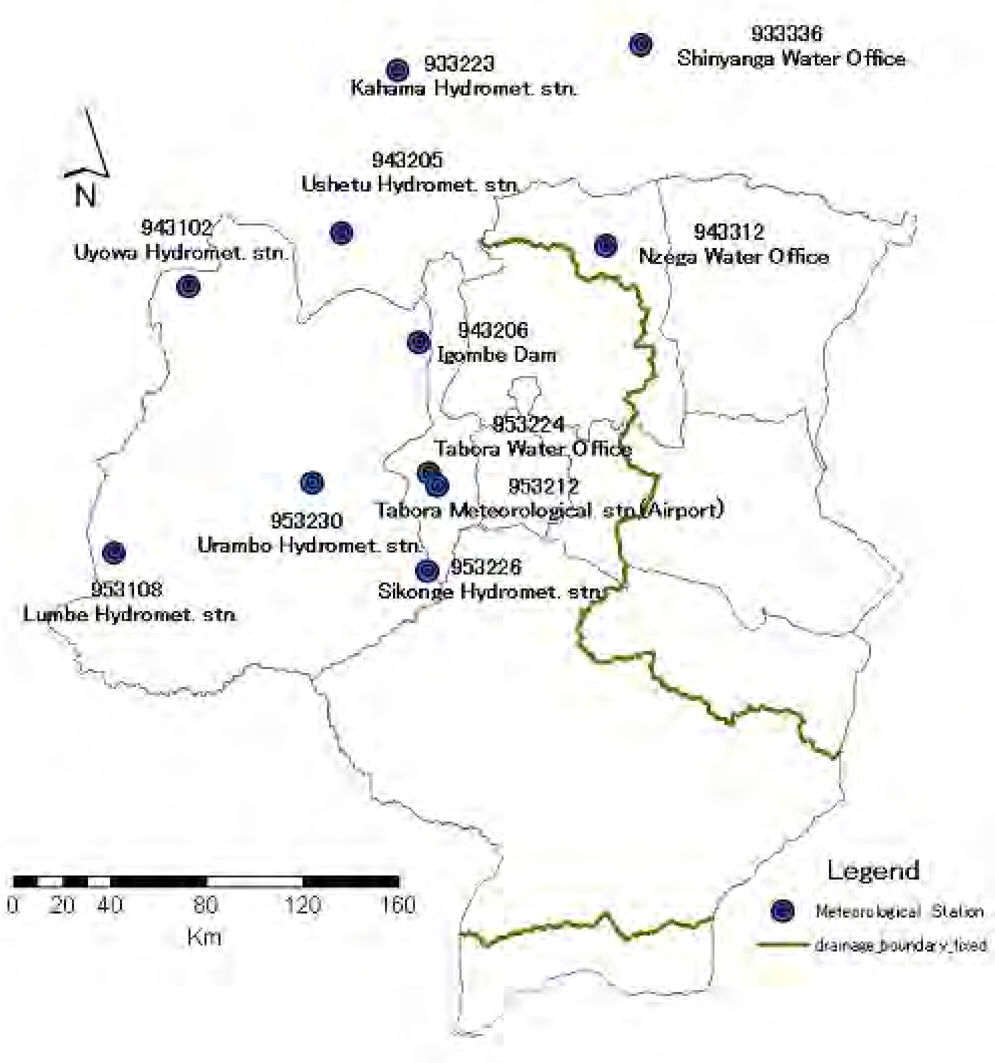
Tanzania has a long history of meteorological observation, with weather stations first established in the environs of Tabora in the 1920s. Since then, a great number of weather stations have been established and are making observations. According to the Hydrological Studies Final Report Vol.4 of the Tabora Region Water Master Plan (Brokonsult 1980), there were 465 precipitation stations in Tabora Region and their surroundings at the time, and of these 125 were reporting within Tabora Region. However, as Tabora's regional boundary has since changed and the conditions under which this precious data is managed is unclear, this study used data assembled mainly from the meteorological agency and the Lake Tanganyika Authority (see section 3.2 Hydrology) which manages a catchment area encompassing most of Tabora Region. Unfortunately most of the data has been lost, weather stations have been closed, and the general state of document management is extremely poor. This study accumulated and put in order climatic and hydrological data such as precipitation, temperature, sunlight hours, evaporation, humidity, wind direction and speed, and river flow rate for use in water balance analysis.

3.2.2 DATA ACCUMULATION

(1) Position of weather stations

The map, Figure 3.2.2, acquired in this study, shows the position of weather stations. Most of the data accumulated are paper based and extremely poorly managed and many have been lost. Moreover, the reliability of this data is very low because the staff is not considered to have much meteorological or climatic knowledge and the state of their observation instruments is poor.

However, hourly meteorological observation data is recorded correctly at the Tabora Meteorological Station (hereinafter "Met. Stn"), and the equipment is properly maintained by experts.



stn.No	Observatory Station	Coordinates		Altitude (m)	Established
		latitude	longitude		
953108	Lumbe Hydromet. stn.	-5°30'	31°29'	No data	04/10/1976
953230	Urambo Hydromet. stn.	-5°04'	32°03'	1,110	24/09/1976
943102	Uyowa Hydromet. stn.	-4°30'	31°57'	1,190	09/10/1976
953226	Sikonge Hydromet. stn.	-5°37'	32°46'	1,160	05/10/1976
933223	Kahama Hydromet. stn.	-3°49'	32°35'	1,260	31/01/1921
943312	Nzega Water Office	-4°15'	33°13'	990	01/07/1978
943206	Igombe Dam	-4°51'	32°43'	No data	03/01/1961
953224	Tabora Water Office	-5°00'	32°47'	No data	03/01/1961
953212	Tabora Meteorological. stn.	-5°05'	32°50'	1,182	08/01/1951
943205	Ushetu Hydromet. stn.	-4°10'	32°14'	No data	15/03/1972
933336	Shinyanga Water Office	-3°40'	33°26'	950	01/02/1971

FIGURE 3.2.2 LOCATION OF WEATHER STATIONS

THE STUDY ON RURAL WATER SUPPLY IN TABORA REGION | **JICA**

3.2.3 PRECIPITATION

(1) Location and observation period

The location of the observatory stations is shown in Figure 3.2.2. The period and content of the observation data are shown in Table 3.2.1. Most of these records are paper based therefore, it is very difficult to decipher many of the old documents.

Table 3.2.1 List of Accumulated Precipitation Data

Station No.	Place of Measurement	Year 1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
953108	Lumbe Hydromet. stn.			○M	○M	○M	○M	○M	○M	○M	○M	○M	○M	○M				
953230	Urambo Hydromet. stn.				○M	○M	○M	○M	○M	○M								
943102	Uyowa Hydromet. stn.				○M	○M	○M	○M	△M									
953226	Sikonge Hydromet. stn.			△M	○M	○M	○M	○M	○M	○M	○M	○M	○M	○M	○M	△M	△M	
933223	Kahama Hydromet. stn.																	
943312	Nzega Water Office		△M	○M	△M	△M				○M	○M	○M	○M	○M	○M	○M	○M	○M
943206	Igombe dam		△M	△M				△M	○M	○M	○M	○M	○M	○M	○M	○M	○M	○M
953224	Tabora Water Office		○M	○M	○M	○M	△M	○M	○M	○M	○M	○M	○M	○M	○M	○M	○M	○M
953212	Tabora Met. stn.																	
943205	Ushetu Hydromet. stn.		△D															
933336	Shinyanga Water Office	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	

Station No.	Place of Measurement	Year 1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
953108	Lumbe Hydromet. stn.								○D	○D	○D	○D	○D	○D	○D	○M	○M	○M
953230	Urambo Hydromet. stn.								○D	○D	△D	○D	△D	△D	△D	△D		△D
943102	Uyowa Hydromet. stn.								○M	○M	○M	○M	○M	○M	○M	○M	○M	○M
953226	Sikonge Hydromet. stn.						○M	○M	△M	△M			○M	△M	○M	△M		△M
933223	Kahama Hydromet. stn.				○D	△D	○D	△D	△D	△D	○D	○D	○D	△D	△D			△D
943312	Nzega Water Office	○M	○M	○M	○D	△D	○D	○D	○D	○D	○D	○D	○D	△D	△D			
943206	Igombe dam	○M	○M	○M	○D	△D	○D	○D	○D	○D	○M	○M	○M	△M	○M			
953224	Tabora Water Office	○M	○M		○D	△D	○D	○D	○D	○D	○D	○D	○D	△D	△D			
953212	Tabora Met. stn.				○D	△D	○D	△D	○M	○M	○M	○M	○M	○M	○M	○M	○M	○M
943205	Ushetu Hydromet. stn.	△D	△D	△D	○D												△D	△D
933336	Shinyanga Water Office	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D	○D

Note: M:Monthly, D:Daily, ○: missing is 10% or less, △: 30%～90% missing, ×: 90% or more is missing, Blank:No Data

(2) Precipitation Pattern

The precipitation patterns shown in Figure 3.2.3 and Figure3.2.4 were summarized using data collected from the Tabora Met. stn.. Precipitation is distinctly separated into the rainy season (October to May) and the dry season (June to September). There is hardly any precipitation in the dry season. Relatively large variations are observed in yearly precipitation. Whereas annual precipitation was approximately 700mm in 2005, it was 1,200mm in 2006, almost double of that in 2005. The average precipitation is just less than 1,000mm, which is about the same as the national average of 1,100mm. The 38 years of daily precipitation data (from 1970 to 2008, excluding 1991) were acquired from the Shinyanga Branch Office of the Internal Drainage Basin Office (on the north side of Tabora Region). They are shown in Figure 3.2.5 and Figure 3.2.6. The precipitation patterns at Shinyanga are very similar to those at the Tabora Met. stn., although the annual mean precipitation is just over 800mm, approximately 150mm less than that at the Tabora Met. stn.. Moreover, rainfall probabilities computed by the Gun Belle method are shown in Table 3.2.2.

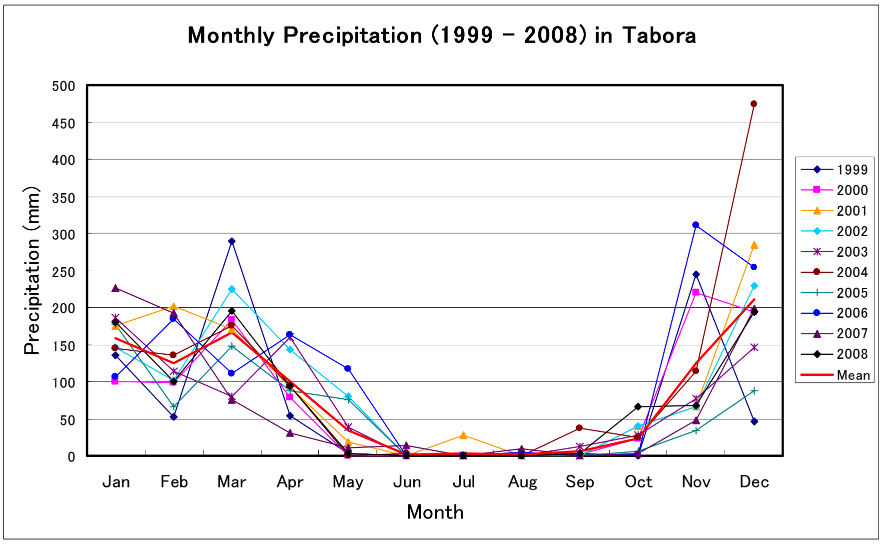


Figure 3.2.3 Monthly Precipitation (Tabora Met. stn.)

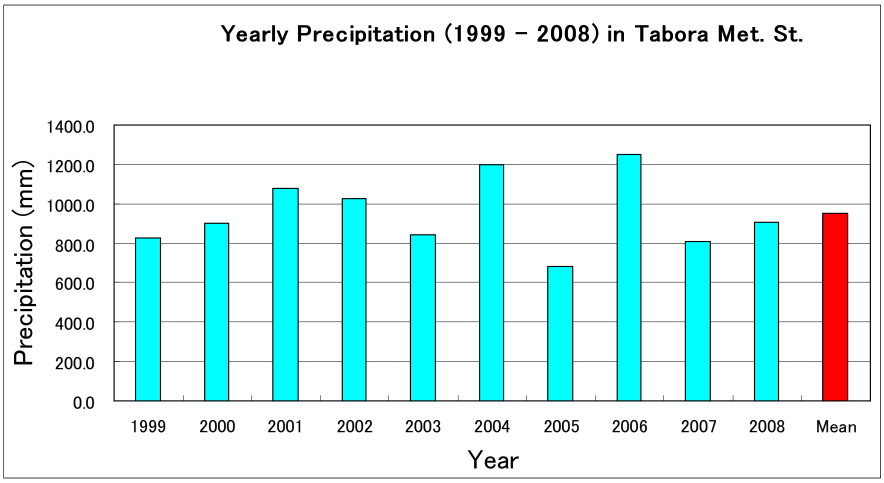


Figure 3.2.4 Yearly Precipitation (Tabora Met. stn.)

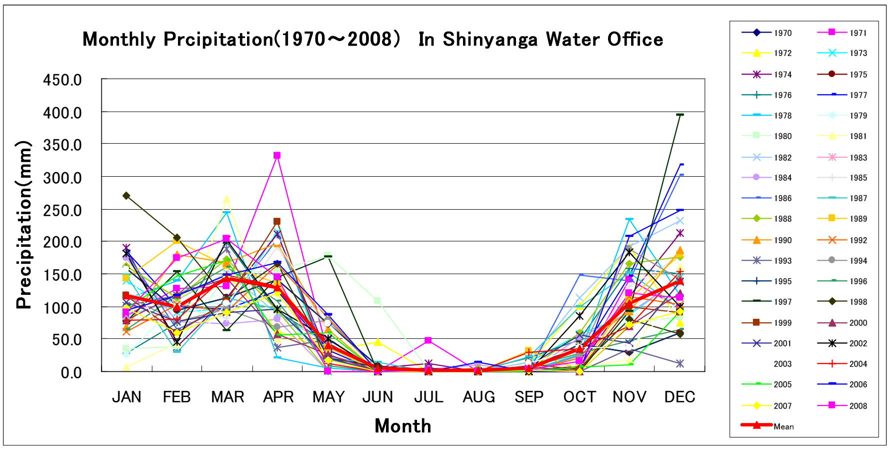


Figure 3.2.5 Monthly Precipitation (Shinyanga Water Office)

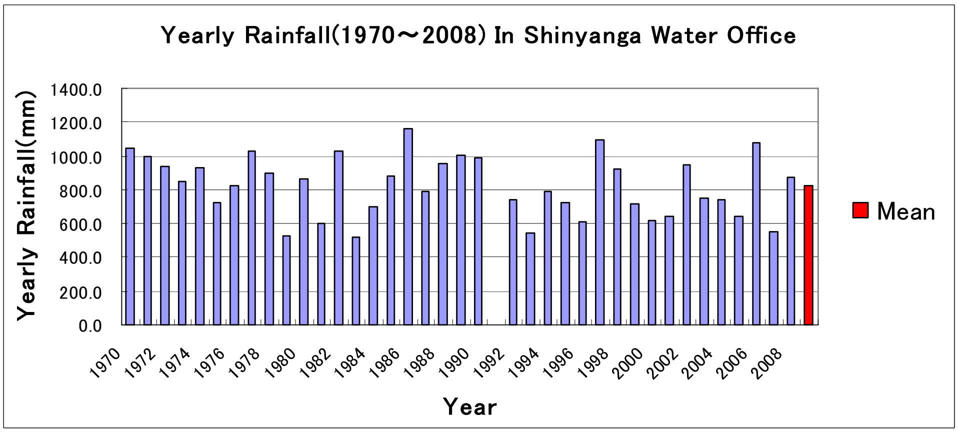


Figure 3.2.6 Annual Precipitation (Shinyanga Water Office)

Table 3.2.2 Probability of Precipitation

Return Period	Lumbe Hydromet. stn.	Uyowa Hydromet. stn.	Urambo Hydromet. stn.	Sikonge Hydromet. stn.	Kahama Hydromet. stn.	Nzega Water Office	Igombe Dam	Tabora Water Office	Tabora Met. stn.	Ushetu Hydromet. stn.	Shinyanga Water Office	Mean
2	981.9	830.2	1029.5	992.5	921.3	809.7	808.0	873.7	815.8	incomputable	795.8	886
5	1181.8	1009.1	1208.0	1236.0	1116.7	1002.2	1003.2	1104.8	1019.3		965.0	1085
10	1314.1	1127.6	1326.1	1397.2	1246.1	1129.5	1132.3	1257.8	1154.0		1077.1	1216
20	1441.0	1241.3	1439.4	1551.8	1370.2	1251.7	1256.3	1404.6	1283.2		1184.5	1342
30	1514.0	1306.6	1504.6	1640.8	1441.6	1322.0	1327.5	1489.0	1357.6		1246.3	1415
50	1605.3	1388.4	1586.1	1752.0	1530.9	1409.9	1416.6	1594.5	1450.5		1323.6	1506
70	1665.1	1441.9	1639.6	1824.9	1589.4	1467.5	1475.1	1663.7	1511.4		1374.3	1565
100	1728.4	1498.6	1696.1	1902.0	1651.3	1528.4	1536.8	1736.9	1575.8		1427.8	1628
150	1800.2	1562.9	1760.2	1989.4	1721.5	1597.5	1606.9	1819.9	1648.9		1488.6	1700
200	1851.1	1608.4	1805.6	2051.4	1771.2	1646.5	1656.6	1878.7	1700.7		1531.7	1750
500	2012.9	1753.3	1950.1	2248.5	1929.5	1802.3	1814.6	2065.9	1865.5		1668.7	1911
1000	2135.2	1862.8	2059.3	2397.5	2049.1	1920.1	1934.0	2207.3	1990.0		1772.2	2033

3.2.4 TEMPERATURE

The maximum and minimum (air) temperatures are recorded at the Tabora Met. stn.. Figure 3.2.7 shows the mean monthly temperatures for the past 10 years from 1999 to 2008. Minimal changes in temperature are observed throughout the year. The maximum temperature (32.2°C) was observed in September and October, and the minimum temperatures (14.7 to 14.8°C) were observed in the dry season, June and July. Also, the difference between the maximum and minimum temperatures is approximately 10 to 15 degrees throughout the year.

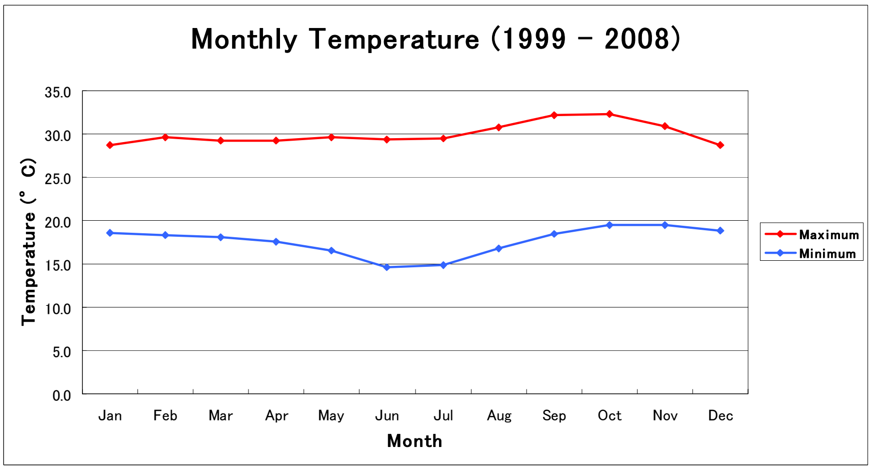


Figure 3.2.7 Monthly Temperature (Tabora Met. stn.)

3.2.5 RELATIVE HUMIDITY

Figure 3.2.8 shows the changes in humidity at Urambo where some data is missing. Humidity exceeds 70% in November, the start of the rainy season. High humidity (72.6 to 86.2 %) continues up to April. It starts decreasing at the end of the rainy season in April. The lowest humidity (45.7 %) appears in September.

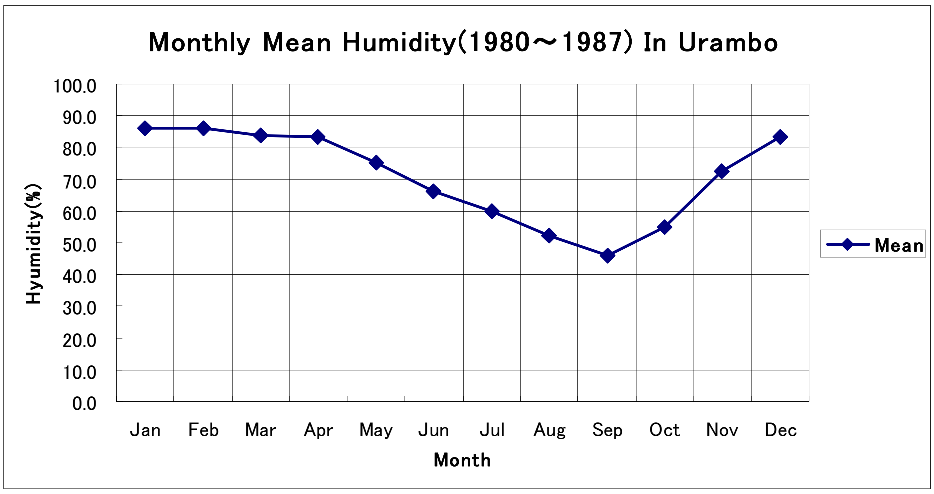


Figure 3.2.8 Monthly Mean Relative Humidity (Urambo)

3.2.6 Solar Radiation and Sunshine Hours

Few of the weather stations in Tabora Region are observing solar radiation or sunshine hours. Even when observations are made, data is often missing or includes seemingly abnormal values. However, we acquired the only reliable data, observed at the Tabora Met. stn. over the past ten years. According to this data, solar radiation is at its highest around October, and the mean value over the ten years was 5.75 kWh/m^2/day. The lowest value is 4.65 kWh/m^2/day, in December. The mean annual value is about 5 kWh/m^2/day.

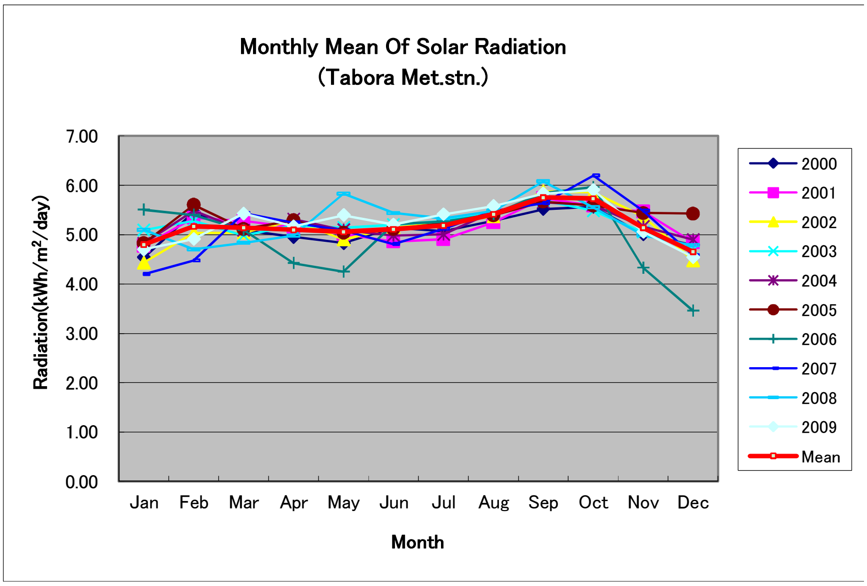


Figure 3.2.9 Monthly Mean Solar Radiation (Tabora Met. stn.)

The highest mean value for sunshine hours over ten years is 10.2 hours in July, and the lowest is 7.6 hours in January. The mean annual value is 8.9 hours.

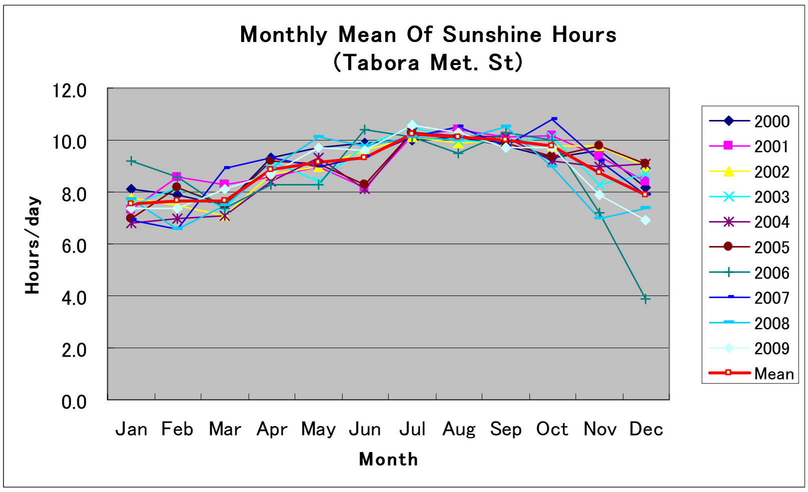


Figure 3.2.10 Monthly Mean Sunshine Hours (Tabora Met. stn.)

3.2.7 EVAPORATION

Evaporation is observed at Tabora Met. stn.. Monthly mean evaporation in the years from 2003 to 2008 is shown in Figure 3.2.11. Evaporation increases during the dry season and reaches 250mm from July to October. It is approximately 150mm during the rainy season. Accordingly, the daily evaporation calculates to be 5 to 8 mm/day.

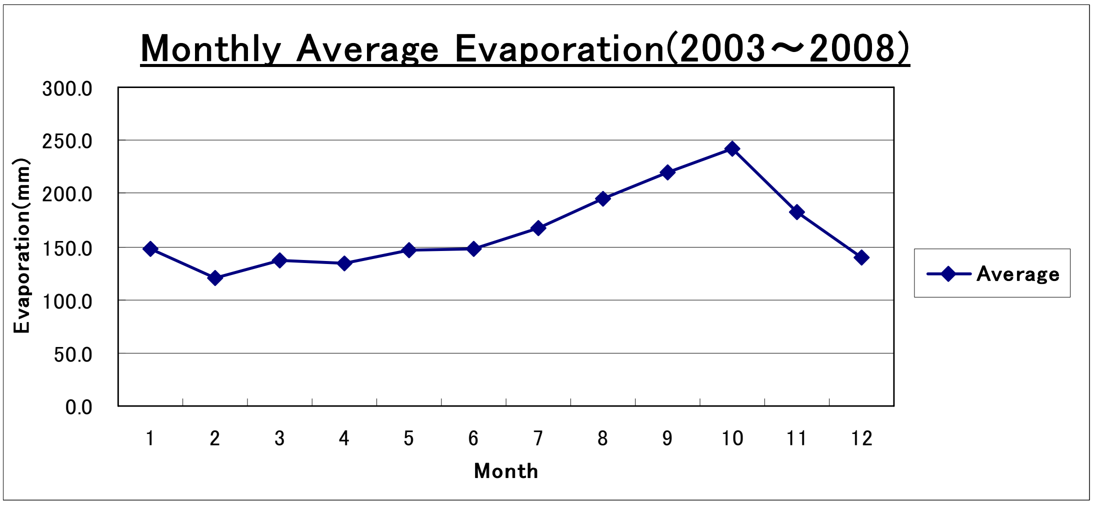


Figure 3.2.11 Monthly Mean Evaporation (Tabora Met. stn.)

3.2.8 WIND DIRECTION AND SPEED

There are very few records of wind direction or wind speed in and around the Study Area except the Tabora Met. stn.. The data at the Tabora Met. stn. is shown in Table 3.2.3, Figure 3.2.12 and 3.2.13.

Wind run was observed twice daily at 6 a.m. and at noon. It shows that easterly to south easterly winds prevail throughout a year.

According to the observations made at 6:00 a.m., a wind velocity of 7 to 16 knots/hour (0.52 m/sec to 8.2 m/sec) accounted for 74%. According to the observations made at noon, a wind velocity of 4 to 10 knots/hour (2.1 m/sec to 5.2 m/sec) exceeded 80%, marking lower values than in the morning.

Table 3.2.3 Annual Wind Direction and Speed (Tabora Met. stn.)

(observed at 6:00 AM)

Speed knot/hour	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm	Total
1 to 3	0.1	0.2	0.1	0.1	0.3	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
4 to 6	0.4	0.7	0.6	1.3	2.7	1.7	0.4	0.8	1.6	0.2	0.1	0.1	0.4	0.2	0.0	0.2	0.0	11.4
7 to 10	0.3	1.9	1.8	3.1	9.3	6.8	1.5	1.3	1.0	0.1	0.1	0.2	0.2	0.2	0.1	0.3	0.0	28.3
11 to 16	0.3	1.7	2.7	3.1	9.8	8.3	2.5	1.3	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	30.0
17 to 21	0.0	0.5	0.9	1.1	2.1	1.3	0.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8
over 22	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	1.1	5.0	6.1	8.6	24.2	18.3	5.2	3.6	3.0	0.4	0.3	0.4	0.6	0.5	0.1	0.5	22.2	100.0

(observed at noon)

Speed knot/hour	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm	Total
1 to 3	0.1	0.3	0.2	0.4	0.5	0.3	0.1	0.3	0.4	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	2.8
4 to 6	0.9	1.1	0.8	2.0	4.3	3.4	1.1	1.5	2.9	1.0	0.3	0.5	1.0	0.3	0.2	0.9	0.0	21.9
7 to 10	1.5	1.9	2.3	5.1	10.1	8.0	3.5	3.8	4.3	1.0	0.6	0.8	0.6	0.5	0.3	0.8	0.0	45.0
11 to 16	0.4	0.4	0.5	1.5	2.6	2.4	1.4	1.2	1.0	0.1	0.1	0.1	0.4	0.1	0.1	0.1	0.0	12.3
17 to 21	0.1	0.0	0.0	0.0	0.2	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.7
over 22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	3.0	3.7	3.8	8.9	17.7	14.2	6.2	6.7	8.6	2.3	1.0	1.4	2.1	1.0	0.5	1.8	17.2	100.0

Note: observed at 6 a.m. (top half) and at noon (bottom half

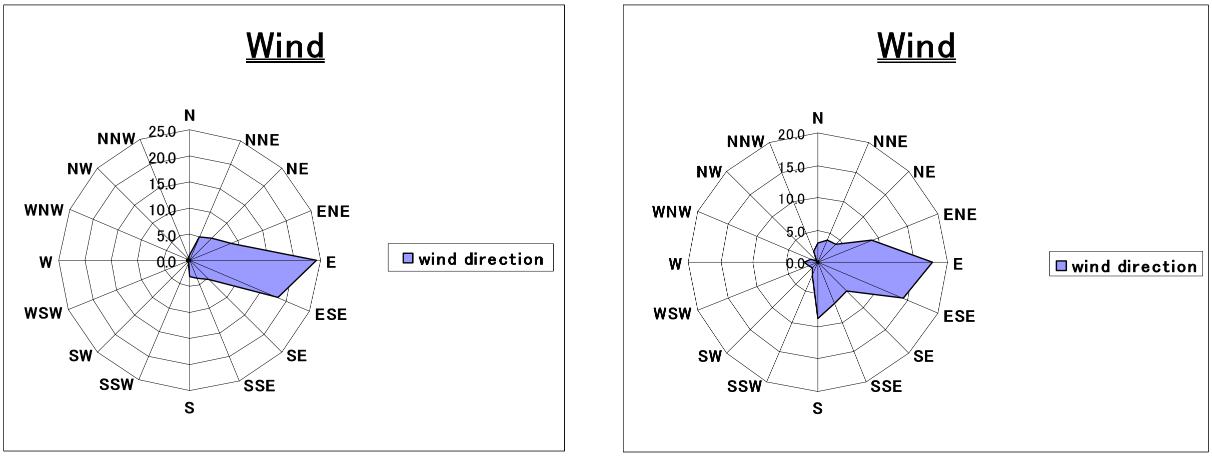
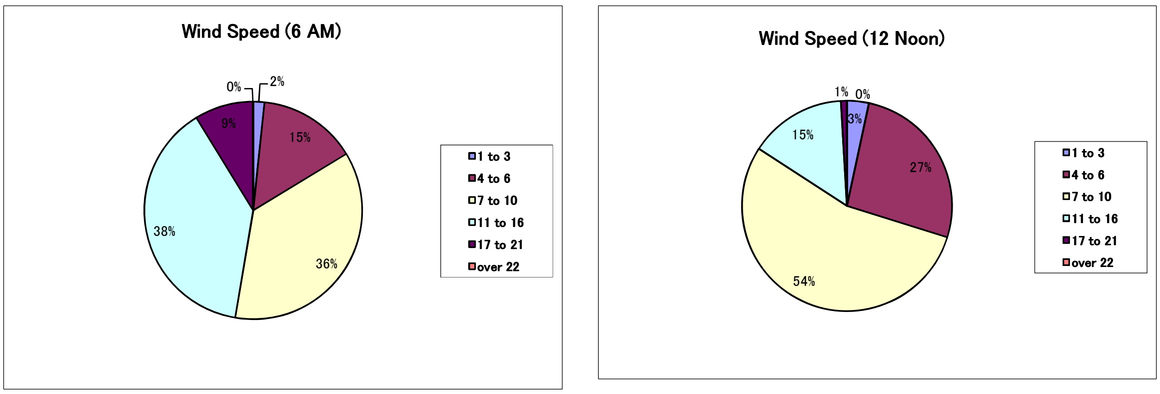


Figure 3.2.12 Monthly Precipitation with Wind Direction Frequency Distribution (Tabora Met. stn.)



Note: Observed at 6:00 a.m. (left) and at noon (right) Unit: knot/hour

Figure 3.2.13 Frequency of Wind Direction (Tabora Met. stn.)

3.3 HYDROLOGY

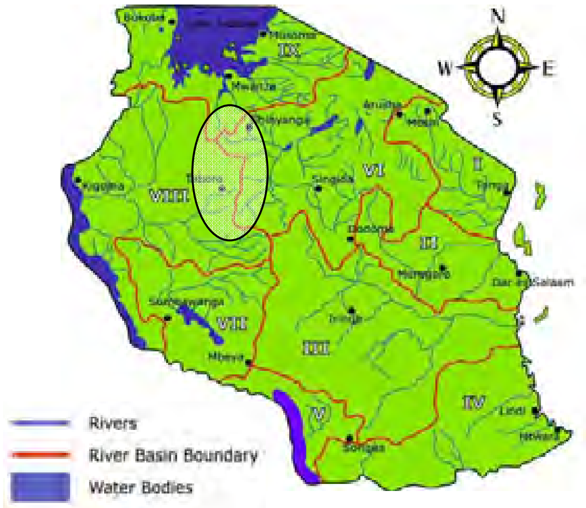
3.3.1 CATCHMENT CLASSIFICATION IN TANZANIA

There are nine (9) catchments in Tanzania and there is a Basin Water Office in each basin. These catchments are shown in Figure 3.3.1.

Tabora Region is a part of three (3) catchments: Internal Drainage Basin (VI), Lake Rukwa Basin (VII) and Lake Tanganyika Basin (VIII). The ratio of these areas is: VI : VII : VIII=0.70 : 0.25 : 0.05

N0.	Basin	Area (km^2)
I	Pangani	56,300
II	Wami and Ruvu	72,930
III	Rufiji	177,420
IV	Ruvuma & the Southern Coast	103,720
V	Lake Nyasa	75,230
VI	**Internal Drainage**	**153,800**
VII	**Lake Rukwa**	**81180**
VIII	**Lake Tanganyika**	**137,900**
IX	Lake Victoria	79,570

Note: The basins in red are those which include the Tabora Region



Source: Main Water Resource Catchments in Tanzania (MoWLD)

Figure 3.3.1 Catchments in Tanzania

3.3.2 Drainage System in Tabora Region

The drainage system in Tabora Region is shown in Figure 3.3.2.

The target of the Study is mainly two (2) major catchments, the Malagarasi and the Manonga Rivers in Tabora Region. The Malagarasi River flows into Lake Tanganyika and then flows out to the Atlantic Ocean. The Manonga River flows into Lake Eyasi in the Internal Drainage Basin.

The northern and northwestern parts of Tabora Region (whole areas of Urambo District and Tabora Municipality, and a part of Nzega and Tabora Rural Districts) are located in the catchment of the Malagarasi River which includes three (3) major tributaries, the Igombe, Ugalla and the Wara Rivers.

On the other hand, the eastern part of Tabora Region (the whole of Igunga District and a part of Nzega and Tabora Rural Districts) is included in the Wembere catchment. The Wembere River flows into Lake Eyasi located in the southern Serengeti Plains.

The eastern part of Tabora Region is in the Rungwa catchment. The Rungwa River flows along the southern border between Tabora and Mbeya Regions, and flows into Lake Rukuwa.

3.3.3 Flow Rate

(1) Location of observatory stations

A total of 10 observatory stations were constructed in Tabora Region. The location and summary of the stations are shown in Figure 3.3.2. Most of them were constructed in 1974 and 1975. None of these stations are currently operating.

(2) Observation data collected

Duration of the collected observation data is 12 to 13 years in longer case while the most of them are three (3) to four (4) years. No stations have continuous records through the year. Some data are only water level records without the flow rate.

Table 3.3.1 List of Accumulated Discharge Data

St.No	Place of Measurement	Year													Note
		1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	
4AG2	Ipala		△	△	△	△	△	△	△	△	△	△	△	△	
4AG4A	Igombe Road bridge		△	△	△	△									
4AH7	Pangale			△	△	△				△	△	△	△	△	
4AH13	Ngoywa	△				△									
4AH3	Ugalla Sawmill					△									
4AH14	Road Bridge			△	△	△									
4AH20	Magawe			△	△	△									
4AH21	Magawe			△	△	△									
2K14	Masenge		×	×	×	×	×	×	×	×	×	×	×	×	*H-Q Missing
2K15	Loya	△	△	△	△	△		△							*H-Q Missing(1970～1974)

Note: Blank: No Data, ×:No H-Q, △:20%～90%of data missing

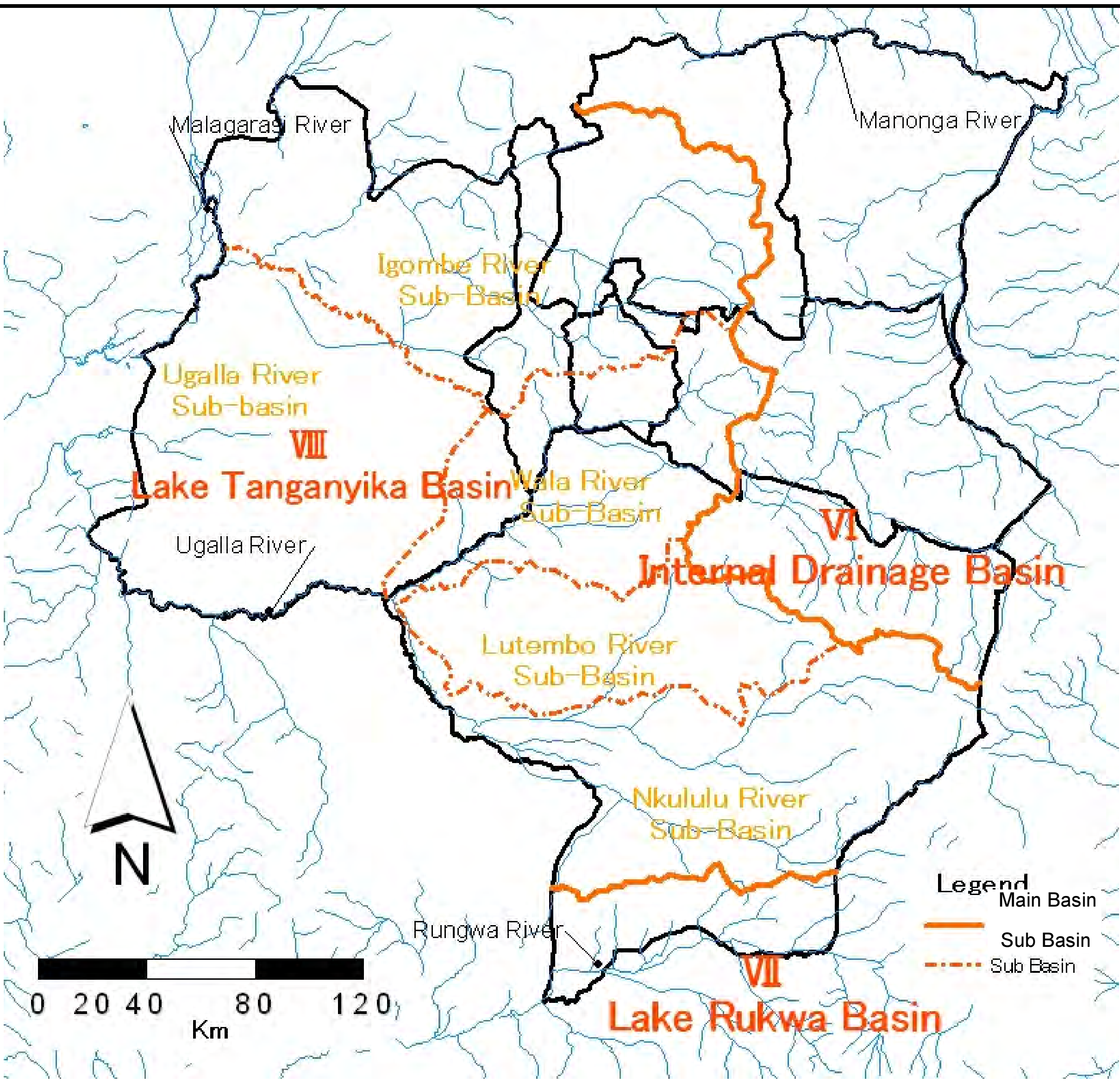


FIGURE 3.3.2 DRAINAGE SYSTEM IN TABORA REGION

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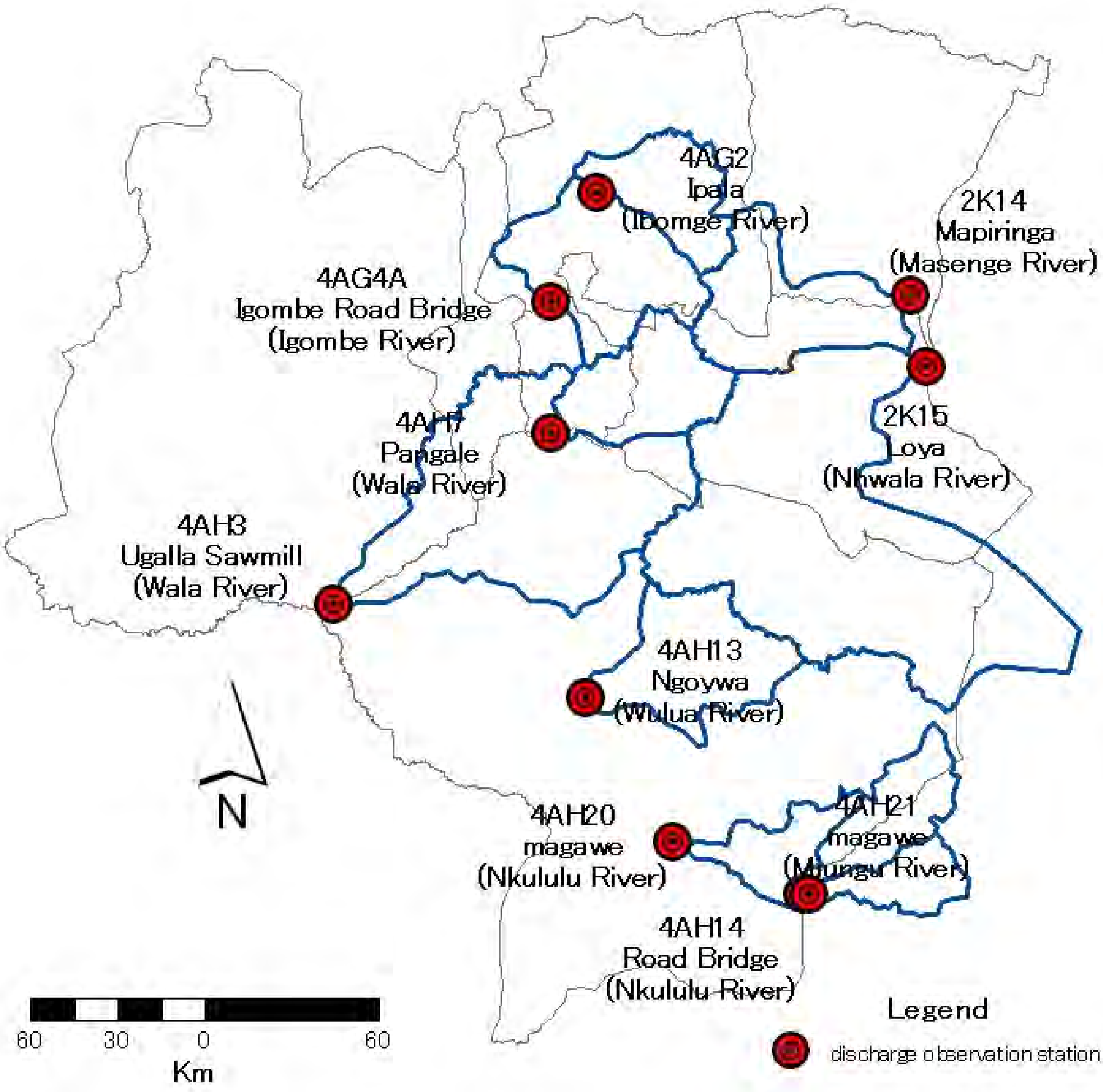

FIGURE 3.3.3 LOCATION OF FLOW RATE OBSERVATORY STATIONS

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(3) Flow rate

Figure 3.3.4 shows the flow rate in the three (3) years from 1977 to 1979 of the Nukululu River, a tributary of the Ugalla River flowing in southern Tabora Region, which has relatively continuous records. Flow rate is clearly observed from February and no flow rate by the end of May. Maximum daily flow rate was approximately 26.6 m^3/sec (drainage area A=3,051km^2) recorded in 1978.

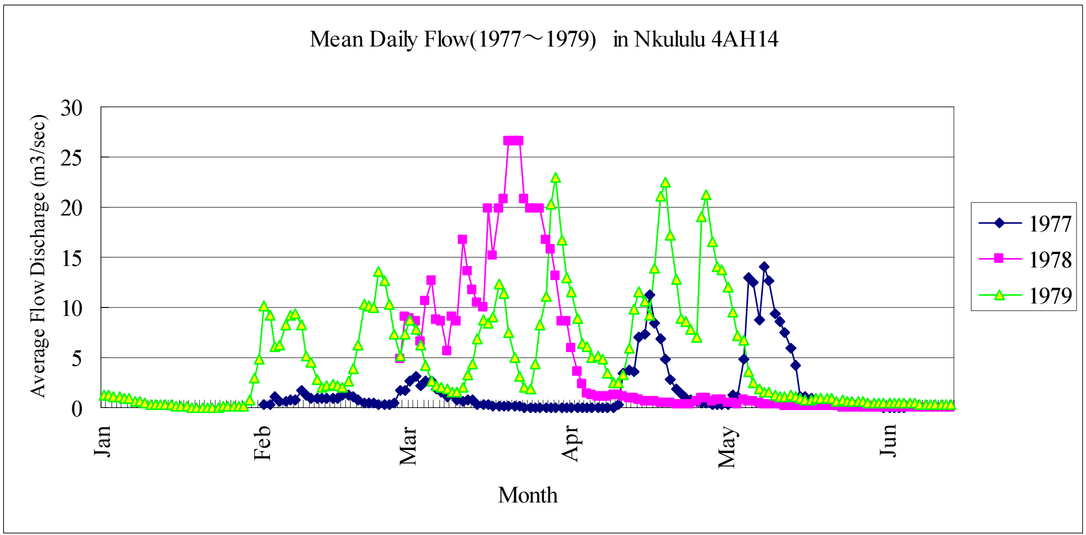


Figure 3.3.4 Mean Daily Flow (Nukululu Weather Station)

3.3.4 Water Level Fluctuation of Igombe Dam

The Igombe Dam was constructed in 1958 by the Water Development and Irrigation Department, and supplies water to the Tabora urban area. The embankment was raised by 1.1m and rehabilitation work was carried out in 1977. Figure 3.3.5 shows the last six (6) years of water level fluctuation data. The fluctuation patterns in six (6) years are almost similar: The water level starts to decline in April to June and to recover in late November with the arrival of the rainy season. In particular, the same negative gradient from June to November every year indicates that daily water withdrawal and evaporation is constant. In the Igombe Dam, water intake and water supply quantities have not been recorded because the meters are out of order. However, it is thought to be roughly 10,000 m^3/day - 12,000 m^3/day, and water is supplied to about 150,000 persons. Judging from this data, the following can be said.

Dam storage-of-water area: Approximately 12 km^2

Water level change: 76cm (six (6) annual average)

Period: July 1st to October 30th (for 121 days)

Decrease depth: 76 cm/121day = 0.6 cm/day = 6 mm/day

Decrease depth of water by water supply (Intake): 12,000 m^3/day / (12 km^2 x 1,000 x 1,000) = 0.001 m/day = one (1) mm/day, i.e., evaporation will be about five (5) mm/day, and quantity of water intake is become in about one (1) mm/day. The value appropriate as an amount of water loss is shown.

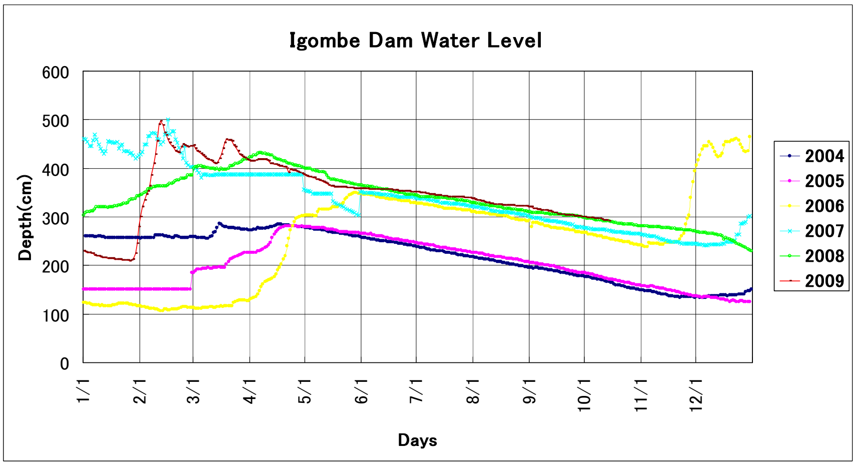


Figure 3.3.5 Water Level Fluctuation of Igombe Dam

3.3.5 PROSPECTS

All the precipitation data accumulated to date show the same precipitation patterns and amounts for most areas within Tabora Region. The main characteristics being a clearly defined rainy season (October to May) and dry season (June to September). It does not rain during the dry season and annual precipitation is approximately 700 to 1,000 mm.

Judging from the annual water level fluctuation at the Igombe Dam, the manner of storing as much water in the dam as possible during the rainy season and to withdraw it for consumption in the dry season is considered extremely effective.

3.4 WATER BALANCE

3.4.1 WATER BALANCE ANALYSIS

One of the important objectives of this project is the development of water resources (calculation of groundwater recharge). For this purpose, it is important to analyse the water balance in Tabora Region and estimate the groundwater recharge. Generally, the water balance in a catchment area can be represented by the following formula:

$$P = D + E + R$$

P is precipitation, D is discharge, E is evapotranspiration, and R is groundwater recharge. The groundwater recharge in Tabora Region is estimated on the basis of the data and references, etc. collected so far.

3.4.2 AVAILABLE REFERENCES

There have been a number of water resource development projects and studies of water balance in Tanzania implemented in the past. This section, focussing on groundwater recharge, summarizes reference materials related to this project and compares them to the data used in this project. The reference numbers are the same as those listed at the end of this chapter.

Reference (i) summarizes the results of a study of groundwater recharge in the bedrock section of the East African highlands, located more or less in the central part of Tanzania. The study area is a basin 30km to the north of Dodoma with a tropical semidry climate similar to that of Tabora. The annual precipitation in this area is approximately 600mm, which is lower than in Tabora. The residual surplus (recharge) in the rainy season in this area is 3% to 20% of the annual precipitation according to this reference.

Reference (ii) estimates the quantity of water resources in Tabora Region and analyzes the water balance of the existing water reservoirs. In the process of calculation, the potential evapotranspiration (mm/day) is estimated to be as follows:

Table 3.4.1 Monthly Evapotranspiration

Month	Evapotranspiration (mm)	Month	Evapotranspiration (mm)	Month	Evapotranspiration (mm)
Jan	5.4	May	5.3	Sep	6.7
Feb	5.4	Jun	5.0	Oct	6.9
Mar	5.3	Jul	5.1	Nov	6.0
Apr	5.2	Aug	6.0	Dec	5.4

Reference (iii) provides the master plan for irrigation throughout Tanzania. The groundwater recharge values have been estimated based on the flow rate observation data from the nine (9) catchment areas in Tanzania. The annual groundwater recharge for the catchment areas relevant to this project has been estimated as follows:

Table 3.4.2 Groundwater Recharge in each Catchment Area in Tabora

No.	Catchment Area	Groundwater recharge (mm/year)
VI	Internal Drainage Basin	5.0
VII	Lake Rukwa Basin	6.0
VIII	Lake Tanganyika Basin	4.0

3.4.3 SUMMARY OF DATA TO BE USED

(1) Precipitation

According to the data acquired in Tabora Region, most of the weather stations are located to the north of the central part of Tabora, and are quite unevenly distributed. The Thiessen Method was applied to the collected positions of the weather stations (see Figure 3.4.1). Little of the acquired data is continuous throughout the year, and the accuracy of observation seems quite low for all but a few of the weather stations. This section summarizes year-round observation data only for those years in which they are reliable.

Figure 3.4.2 shows an isohyetal map for annual precipitation in Tabora Region.

Table 3.4.3 Thiessen Precipitation at each Flow Rate Observatory Station

St.Name	Area (km^2)	ThiessenRainfall (mm)							
		Rainfall	Sub-Catchment						Catchment
		Area(km^2)	1,401.4	0.5					
4AG2	1,402	Rainfall(mm	835.8	835.4					835.8
		Area(km^2)	929.7	162.3	799.2	0.4	1,401.4	581.7	
4AG4A	3,886	Rainfall(mm	835.4	908.1	835.8	835.4	835.8	858.6	842.2
		Area(km^2)	1,783.7						
4AH7	1,784	Rainfall(mm	858.6						858.6
		Area(km^2)	2,187.6						
4AH13	2,188	Rainfall(mm	1,020.2						1,020.2
		Area(km^2)	3,051.0						
4AH14	3,051	Rainfall(mm	1,020.2						1,020.2
		Area(km^2)	2,069.3						
4AH20	2,069	Rainfall(mm	1,020.2						1,020.2
		Area(km^2)	795.4						
4AH21	795	Rainfall(mm	1,020.2						1,020.2
		Area(km^2)	967.0	1,405.7	6,935.2				
2K15	9,306	Rainfall(mm	835.8	858.6	1,020.2				976.6

(2) Flow Rate

There is little data available on flow rates because there are few observation records and the data acquired contains many defects, such as a lack of flow rate observation results. Furthermore, it is unclear whether a blank column in the records represents a zero flow rate or missing data. Each of the catchment areas for flow rate observation points have been classified and measured based on the river network map created in this project.

Figure 3.4.1 shows the catchment area map and the sizes of the catchment areas. From this it is obvious that the size of some of the catchment areas differs greatly from the data provided by the Drainage Basin Office. In the future, a detailed topographical map must be created, and the catchment areas verified in accordance with the map.

(3) Potential Evapotranspiration

Although evapotranspiration is important in estimating the groundwater recharge, direct measurement of evapotranspiration is difficult. Therefore, it is common practice to estimate the evapotranspiration rate on the basis of pan evaporation loss and meteorological data. In this project, the potential evapotranspiration was estimated by applying the Thornthwaite method to the 10-year temperature data acquired from the Tabora Meteorological Observatory (Tabora Met. stn.). Using the Thornthwaite method, which requires only data on temperatures and possible sunshine duration, calculation is easier than using the Penman or Morton method. Moreover, the possible sunshine duration, which normally shows seasonal fluctuation, is more or less constant throughout the year in Tanzania (12 hours per day). It can be argued that the Thornthwaite method, being an empirical formula devised on the basis of experimental data in the U.S., can produce large errors if it is applied to a region where the meteorological conditions are significantly different. However, the Thornthwaite method is applied in this project taking into consideration the accuracy of other items of data such as flow rate and precipitation. The Thornthwaite formula is as follows:

$$PEPT = 0.533 \times \mathrm{D} \times \left(\frac{10T}{I}\right)^{a}$$

$$I = \sum_{i=1}^{12} \left(\frac{T_i}{5}\right)^{1.514}$$

$$\mathrm{a} = (492390 + 17920I - 77.1I^2 + 0.675\,I^3) \times 10^{-6}$$

where, *PEPT*: Potential evapotranspiration (cm/month)
D: Possible sunshine duration (12 hours per day is assumed to be 1. D≒30 in Tanzania)
T: Mean monthly temperature (℃)

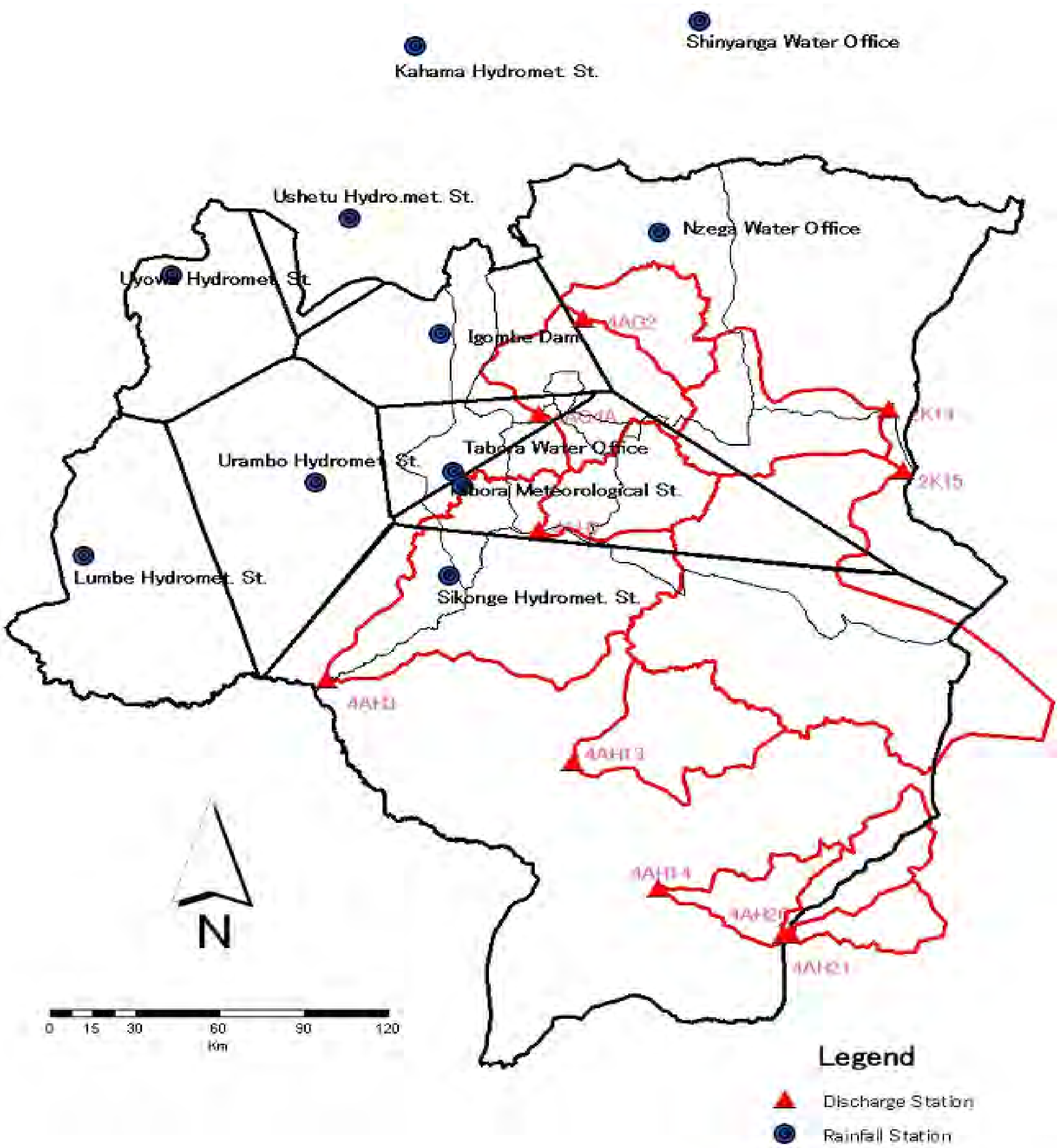
Table 3.4.4 Mean Monthly Temperatures (Tabora Met. stn.)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max (°C)	28.7	29.6	29.2	29.2	29.6	29.3	26.6	30.7	32.2	32.3	30.9	28.8
Min (°C)	18.5	18.3	18.1	17.6	16.5	14.7	14.8	16.8	18.5	19.5	19.5	18.8
Mean (°C)	23.6	23.9	23.7	23.4	23.1	22.0	20.7	23.8	25.3	25.9	25.2	23.8

Table 3.4.5 Calculation Results for Evapotranspiration

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
PEPT(mm)	97.4	101.2	97.9	94.6	90.7	79.1	66.5	98.9	119.1	127.3	117.5	99.3	99.1

Note that the evapotranspiration calculated using the Thornthwaite method is the maximum potential evapotranspiration, not the actual evapotranspiration. In an arid region in particular, no evaporation occurs even at a high evapotranspiration level because there is no water to evaporate. It should be kept in mind that calculated values can sometimes be excessively high.



Station Number		4AG2	4AG4A	4AH7	4AH13	4AH3	4AH14	4AH20	4AH21	2K14	2K15
Drainage Area	New	1,402	3,886	1,784	2,188	5,837	5,837	2,069	795	2,317	9,306
(km^2)	Old	1,800	4,180	1,520	1,740	8,848	8,848	1,525	700	No Data	8,710

FIGURE 3.4.1 THIESSEN METHOD AND CATCHMENT MAP WITH FLOW RATE OBSERVATORY STATIONS

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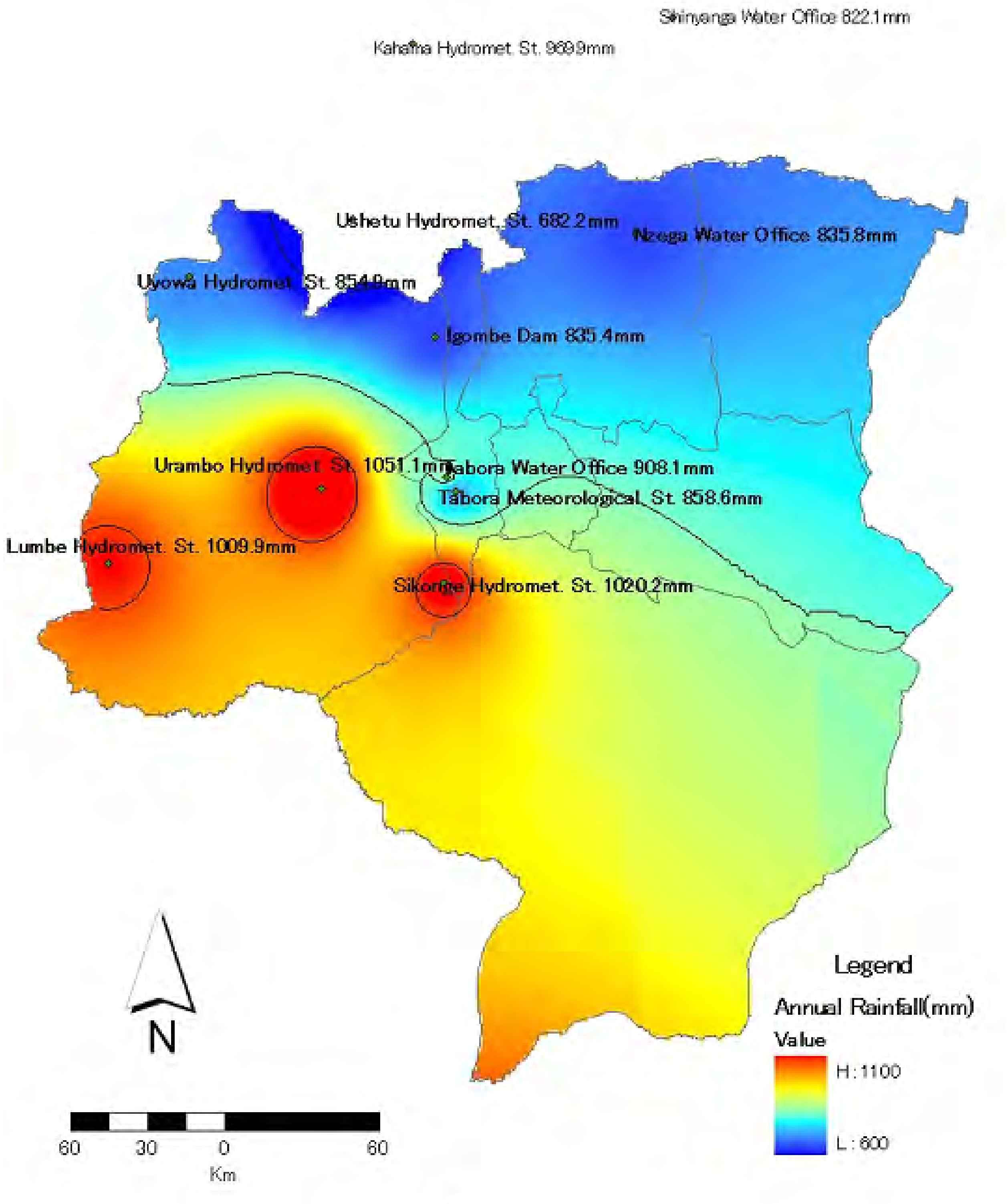

FIGURE 3.4.2 ISOHYETAL MAP (MEAN MONTHLY PRECIPITATION)

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3.4.4 CALCULATION OF GROUNDWATER RECHARGE

(1) Arithmetical Computation Method

As described in 3.3.1, the groundwater recharge can be calculated by subtracting the flow rate and evapotranspiration (output) from the precipitation (input). The groundwater recharge is calculated for each of the catchment areas for which flow rate data has been acquired and then these results are used to make estimates for each of the areas in Tabora.

1) Target Catchments for Calculation

The target catchment areas for calculation are eight of the ten catchment areas shown in Figure 3.2.2: the 4AH3 and 2K14 catchment areas are excluded as there is little available data.

2) Precipitation (P)

The precipitation values are those shown in Table 3.4.6, calculated by applying the Thiessen method to the mean annual precipitation data from the observatory stations in and around Tabora Region.

Table 3.4.6 Flow Rate Observatory Station Wise Catchment Areas and Thiessen Annual Precipitations

St. No	4AG2	4AG4A	4AH7	4AH13	4AH14	4AH20	4AH21	2K15
Area (km2)	1,402	3,886	1,784	2,188	3,051	2,069	795	9,306
Rainfall Thiessen Method	835.8	842.2	858.6	1020.2	1020.2	1020.2	1020.2	976.6

3) Flow Rate (D)

The flow rate is derived by selecting from the records of the observatory stations the annual precipitation of a year for which the data are considered valid, calculating the annual flow rate, and converting it to a runoff depth (discharge divided by area). The calculation results are shown below.

Table 3.4.7 Mean Annual Discharge by Flow Rate Observatory Station

St. No	Runoff of Each Year											Mean (m3/s)	Depth of Runoff (mm)
4AG2	Year	1978	1979	1980	1981	1982	1983	1984	1986	1987		246.94	15.22
	Total Runoff (m3/s)	796.40	217.69	45.05	138.66	322.42	58.65	83.62	235.54	324.39			
4AG4A	Year	1977	1978	1979								1007.19	22.39
	Total Runoff (m3/s)	666.32	1105.13	1250.13									
4AH7	Year	1977	1978	1979	1985	1986						560.05	27.12
	Total Runoff (m3/s)	202.37	1151.82	603.30	595.23	247.51							
4AH13	Year	1975	1979									434.59	17.16
	Total Runoff (m3/s)	350.10	519.08										
4AH14	Year	1977	1978	1979								489.66	13.87
	Total Runoff (m3/s)	219.65	437.55	811.78									
4AH20	Year	1977	1978	1979								274.77	11.47
	Total Runoff (m3/s)	166.02	234.26	424.04									
4AH21	Year	1978	1979									150.74	16.38
	Total Runoff (m3/s)	138.79	162.69										
2K15	Year	1969	1970	1971	1972	1973	1974	1977	1978	1979	1981	888.45	8.25
	Total Runoff (m3/s)	387.91	1299.35	928.52	324.90	486.56	627.26	1195.08	1520.43	633.82	1480.68		

4) Evapotranspiration (E)

The evapotranspiration in Tabora Region, for which almost no data is available, was calculated on the basis of the values obtained using the Thornthwaite method as shown in Table 3.4.5, assuming that evapotranspiration during the dry season is 0 (zero). The dry season was estimated by calculating the number of months with a monthly precipitation of 30mm or less according to the precipitation data, and taking the total mean value of about 5.0months, i.e., 150 days, to be days without evapotranspiration. For this calculation, the potential evapotranspiration was assumed to be 108.5mm per month, the mean value for the months excluding the dry season (May through September) shown in Table 3.4.5, i.e., January through April and October to February. Therefore, the total annual evapotranspiration is as follows:

$$Et = (365 \text{ days} - 150 \text{ days}) \times (105.0 \text{ mm} \div 30 \text{ days}) \fallingdotseq 752.5 \text{ mm}$$

5) Calculation Results Using Arithmetical Computation

The above precipitation (P), flow rate (D), and evapotranspiration (E) can be used in a simple arithmetical computation to derive the groundwater recharge as follows:

Table 3.4.8 Calculation Results for Groundwater Recharge

Station No	Rain(thiessen) (mm)	Evapo-transpiration (mm)	Depth of Runoff (mm)	Groundwater Recharge (mm)
	P	E	D	R
4AG2	835.8	752.5	15.2	68.1
4AG4A	842.2	752.5	22.4	67.3
4AH7	858.6	752.5	27.1	79.0
4AH13	1020.2	752.5	17.2	250.5
4AH14	1020.2	752.5	13.9	253.8
4AH20	1020.2	752.5	11.5	256.2
4AH21	1020.2	752.5	16.4	251.3
2K15	976.6	752.5	8.2	215.9

(2) Tank Model Method

1) Overview of Tank Model Method

The tank model method proposed by Masami Sugawara in 1972 is used to create a water balance model, and normally consists of tanks on three (3) or four (4) levels. Each of the tanks conceptually represents the natural phenomenon of water accumulation in the surface soil or aquifer level, or the water balance.

A runoff hole in the side of the tank represents runoff to rivers, and a hole in the lower part of the tank represents infiltration into the underground. Therefore, a tank model can reproduce changes in the river flow rate and enable the groundwater recharge to be estimated. For example, rainwater that enters the ground tank in the first level enters the soil tank through Hole F11 in the second level while that part of the rainwater that exceeds the infiltration capacity flows through Hole F12 to become the river flow rate. The rainwater that has entered the soil tank in the second level further flows through Hole F21 to become shallow groundwater in the third level, part of which flows through Hole F12 to become spring water and, if there is more supply, flows out through Hole F13 to rivers.

Although this model is characterized by the ease of data input and manipulation, the shape of the tank model needs to be determined on the assumption of the water balance structure of the area to be analyzed.

2) Construction of Tank Model

Figure 3.4.3 shows the shape of the tank model used for the water balance analysis of the study area. This model has approximately the same structure as the one used in The Study on Rural Water Supply in Mwanza and Mara Regions in United Republic of Tanzania (JICA 2007.)

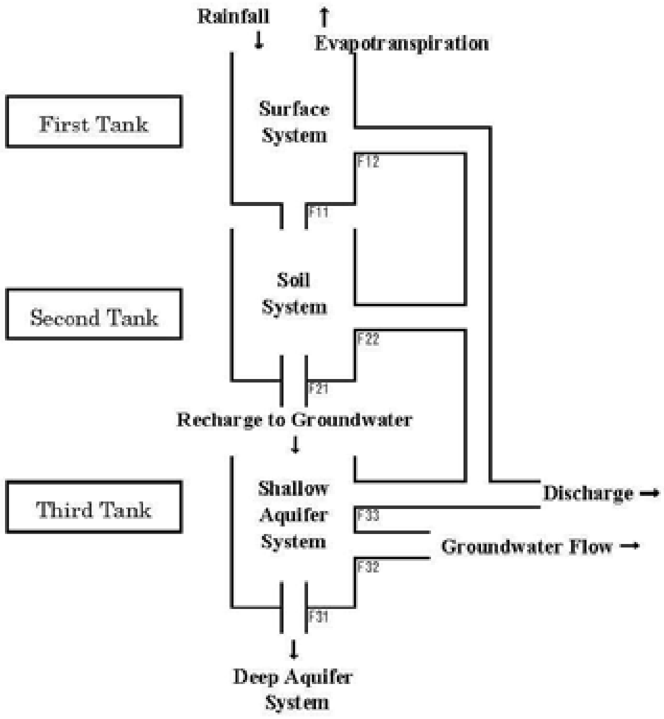

Figure 3.4.3 Structure of Tank Model

3) Input Data

The input data required for calculation consists of catchment area precipitation, evapotranspiration and observed flow rate. Calculation was performed month by month, and all the results were converted into millimetres for the sake of unification of the unit of measurement. The data used was from the 4AH7 flow rate observatory station, which had a complete set of data for monthly precipitation and flow rates over the same period, for the two years 1985 and 1986 (24 consecutive months). (No other catchment area apart from 4AH7 had a complete set of observation data for monthly precipitation and flow rates over the same period.) In addition, the evapotranspiration data shown in Table 3.4.5 was also used.

4) Results of Calculation Using Tank Model

The above conditions and data were input into the tank model, and then the parameters of the tank model were varied on a trial basis until the calculated flow rates were approximately equal to the observed flow rates. Below are shown the results of calculation using the tank model.

Table 3.4.9 Parameters of Tank Model

TANK1

P 11=	0.000 mm
A 11=	0.500
P 12=	3.000 mm
A 12=	1.000
INIH=	10.000 mm

TANK2

P 21=	0.500 mm
A 21=	0.500
P 22=	5.000 mm
A 22=	0.500
INIH=	10.000 mm

TANK3

P 31=	0.000 mm
A 31=	0.500
P 32=	1.500 mm
A 32=	0.500
P 33=	2.000 mm
A 33=	0.500
INIH=	10.000 mm

P: Position of hole in the tank (height from the tank bottom)

A: Size of hole in the tank

INIH in the lowest part represents the initial value of the tank.

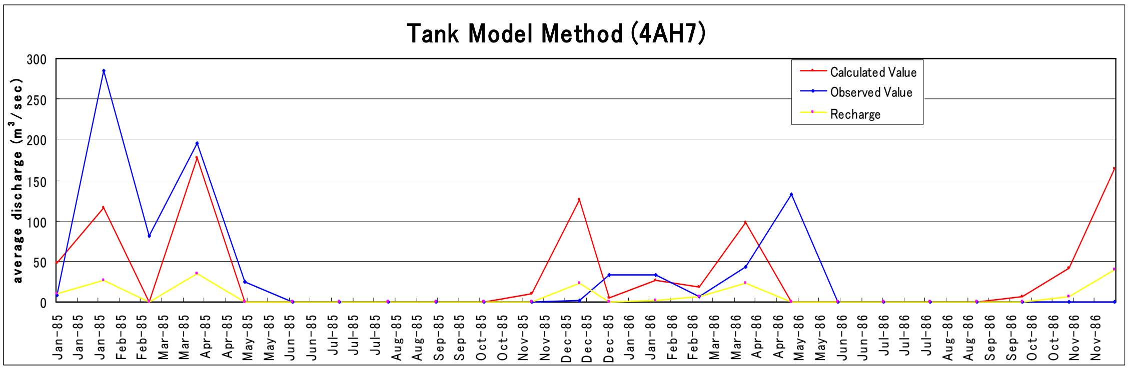

Figure 3.4.4　Hydrograph

Using the tank model constants that have been created, the precipitation data in the same 4AH7 catchment area (1981 through 1993) was input to estimate the groundwater recharge. Table 3.4.10 shows the results.

Table 3.4.10　Calculation of Groundwater Recharge Using Tank Model (1981-1983)

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Mean
Recharge (mm/month)	45.0	30.6	44.0	44.4	85.1	78.0	25.4	124.7	66.5	106.0	7.1	60.4	37.7	58.1

3.4.5 CALCULATION RESULTS

According to the calculation results thus obtained, the groundwater recharge in the study area is estimated to be as follows: (Figure 3.4.5)

(i) The 4AG2 and 4AG4A areas in the upper reaches of the Igombe River (part of Nzega District, Tabora Municipality, and Tabora Rural District) have a groundwater recharge of 60 to 70mm per year, a relatively small amount in Tabora Region. However, this corresponds to about ten times the 4 to 6mm shown in References (iii).

(ii) Similarly, the 4AH7 area in the upper reaches of the Wara River (part of Tabora Municipality and Tabora Rural District) have a groundwater recharge of a little over 60 mm per year, a relatively small amount in Tabora Region.

(iii) The 4AH20, 4AH14 and 4AH21 areas in the Nkululu River Basin (Sikonge District) have a groundwater recharge of over 250mm per year, a considerably abundant water resource situation.

(iv) The 2K15 catchment area in the Internal Drainage Basin (Sikonge District and Tabora Rural District) shows 200mm per year, a substantial groundwater recharge.

(v) The groundwater recharge for Urambo District in the western part of Tabora Region cannot be calculated because no flow rate observation data is available. However, it is reported that the district has a relatively high annual precipitation (900 to 1,000mm per year) and, as shown in Section 4.5.1, "Surface Condition Map," relatively good surface conditions. With all these circumstances taken into consideration, this area is thought to have a groundwater recharge of about 100～200mm.

(vi) The groundwater recharge of 4AH7 was estimated using the tank model method to be 170mm over two (2) years. The mean value is about 85mm per year, approximately the same value obtained using the arithmetical computation method; but with the year-to-year variation taken into account the groundwater recharge is thought to be about 50 to 100mm per year.

(vii) As shown in Table 3.4.10, there are great variations in groundwater recharge. Therefore, the groundwater potential should be estimated low to be on the safe side.

3.4.6 GROUNDWATER RECHARGE IN TABORA REGION AND FUTURE ISSUES

Calculations indicate that within Tanzania, Tabora Region has a relatively advantageous water environment. As Reference (i) shows, the analysis of data in the Dodoma area where the annual precipitation is said to be about 600mm estimated the groundwater recharge to be 3% to 20% of the annual precipitation. When all the data including these are taken into consideration, the annual recharge for the entire Tabora Region is estimated to be 50 to 200mm per year. As shown in Table 3.4.10, however, the groundwater recharge in a dry year can drop to below one-tenth of what it is in an abundant year. In any case, data on precipitation and flow rates are maintained in poor condition, leaving the authenticity and accuracy of much of the available data open to question. In the future, reliable data must be gathered in order to enhance the accuracy of water resource development planning. It is to be hoped that an appropriate observation system will be constructed and adequate data management carried out.

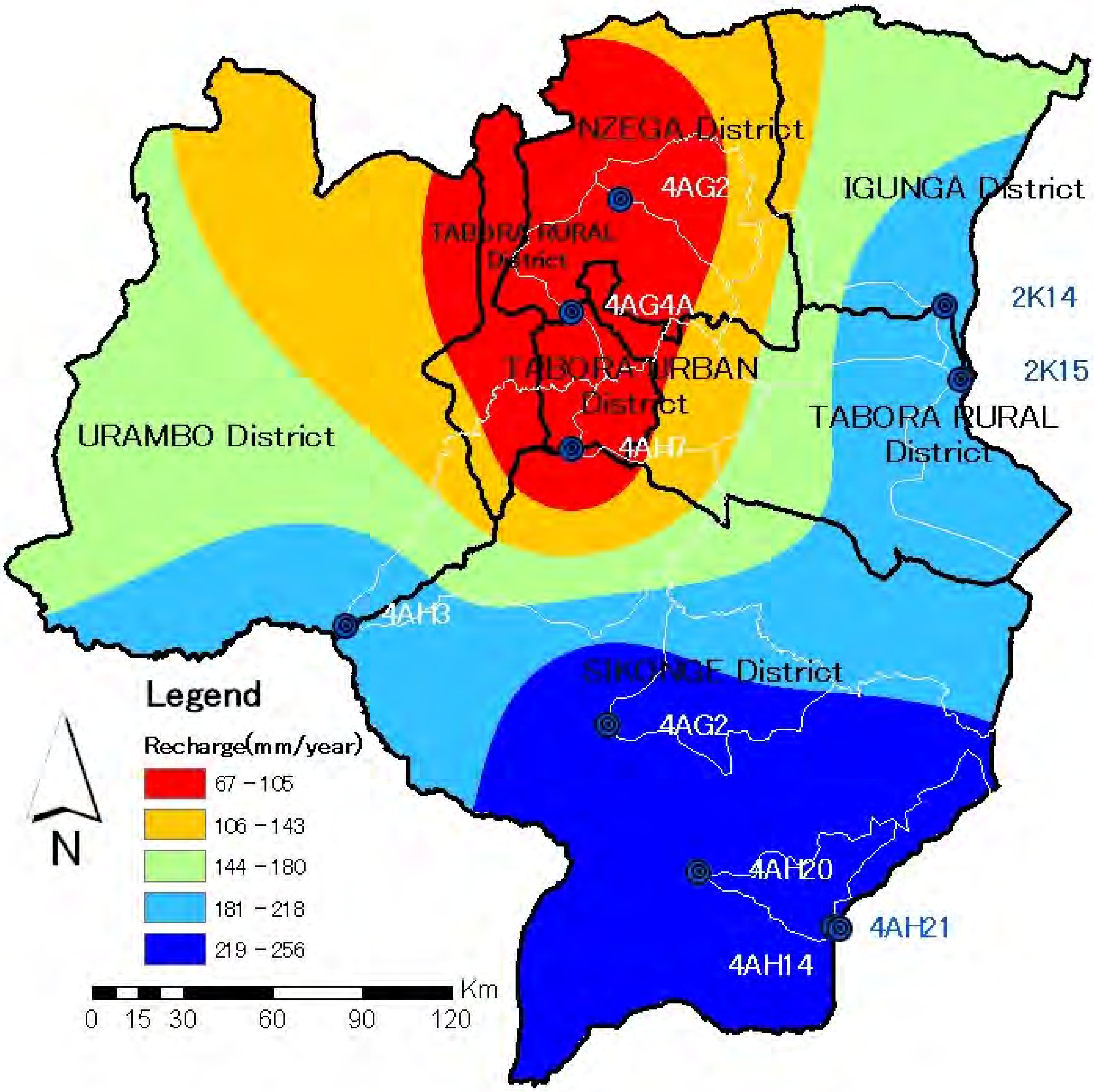

FIGURE 3.4.5 GROUNDWATER RECHARGE ESTIMATION MAP

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REFERENCE

Shinichi Onodera, Akihiko Kondoh, Yoshinori Sato, Masaki Hayashi, Shizuo Shindo, Eiji Matsumoto, Hiroshi Ikeda (1996): Subsurface Water Cycle in Semiarid Tanzania, East Africa, Journal of the Japanese Association of Hydrological Sciences Vol.26 No.2 75－86

(BROKONSULT AB Sweden : Tabora Region Water Master Plan Final Report Volume 4: Hydrological Studies

Japan International Cooperation Agency (2002) Application for Technical Cooperation for Master Plan Study on National Irrigation Development Promotion. Summary Report, JICA, Tokyo

CHAPTER 4 TOPOGRAPHY, GEOLOGY AND HYDROGEOLOGY

4.1 GENERAL

In evaluating the groundwater potential in the Tabora region, a satellite image analysis and field investigations were executed with the analysis of the existing data concerning topography, geology and hydrogeology. The hydrogeological map of the Tabora region was made based on the results of these surveys and analyses.

4.2 TOPOGRAPHY

The Tabora region is situated on a high plateau of the central part in the United Republic of Tanzania between latitude 4-7° south and longitude 31-34° east. The region shares a border with the Shinyanga region in the north, Singida region in the east, Mbeya and Rukwa region in the south and then the western border is shared with the Kigoma region. Most of the altitude in the region ranges between 1,000 and 1,300m with an approximately flat plateau. The inselbergs which the basement rock exposed and the lowlands which become marshes in the rainy season also exist in places so gently undulations are found. The hilly terrain that exceeds 1,600m altitude is located in the southeastern area.

A topographical map of the Tabora region which was created by using Shuttle Rader Terrain Model (SRTM) data is shown as Figure 4.2.1. The Tabora region is divided into three basins (Lake Tanganyika Basin, Internal Drainage Basin and Lake Rukwa Basin). The watershed which divides Lake Tanganyika Basin and the Internal Drainage Basin runs from the northern part of the Nzega district to the east in Sikonge town via south of Nzega town, and then it stretches to the region outside in a southeasterly direction. In the Lake Tanganyika Basin, the altitude declines gently from the east to the west. Beyond the watershed with about 1,200 to 1,500m altitude, the altitude falls from the west to east in the Internal Drainage Basin. The Lake Tanganyika Basin has 68% of the land area of the region, the Internal Drainage Basin has 28% and the Lake Rukwa Basin has 4%.

4.3 GEOLOGY

4.3.1 GENERAL

In the central part of Tanzania where the Tabora region is situated, Precambrian Archean plutonic rocks and metamorphic rocks are widely distributed. Overlying these rocks, sedimentary rocks in the Paleozoic era, Continental deposits of Miocene, lacustrine deposits and old alluvium in the Pleistocene, and recent alluvium of Holocene are distributed in places.

4.3.2 GEOLOGY OF THE STUDY AREA

The geological stratums in the study area are described according to the period.

(1) Archean and Paleozoic

The stratum of the Archean in this area is divided into the Dodoman system, the Nyanzian system, the Kavirondian system and the Ubendian system in chronological order. The Dodoman system is composed of metamorphic rocks such as gneiss, amphibolite, migmatite, schist and so on. It is distributed in a belt shape of 100km width from the south to the west of the region. The Dodoman system is the oldest stratum in Tanzania. The Nyanzian system and the Kavirondian system are composed of metamorphic rocks such as banded ironstone, schist, quartzite, phyllite and sedimentary rocks. It is situated in the Igunga and Nzega districts in the northeast of the region. The Ubendian system is composed of metamorphic rocks such as gneiss and amphibolite, and located at the west end of the region. Additionally, the Archean intrusive rocks which are composed of mainly granite and granodiorite are distributed in the vast area of the eastern part of the region. The intrusive rocks have developed joints and are weathered strongly. The Paleozoic Bukoban system which consists mainly of sandstone is distributed in the limited area of the west end of the region. The Mesozoic stratum is not admitted in the Tabora region.

(2) Cenozoic

The stratum in the Cenozoic period in this region is composed of the continental deposits of the Miocene, lacustrine sediments and the old alluvium of the Pleistocene, and the recent alluvium of Quaternary in chronological order. The continental deposits of the Miocene consist of various materials such as silcrete which is a kind of conglomerate, duricrust and so on. It is distributed in the east of the region mainly in the eastern part of the Tabora Rural district. The lacustrine sediments of Pleistocene are mainly composed of limestone and calcareous mudstone and is found in the northern part of Igunga district which is located in the northeast of the region. The alluvial sediment in the region is divided into old alluvium of the Pleistocene and recent alluvium of the Quaternary. They are distributed mainly in the riverbeds, the marshes, the swamps and the low altitude areas of the region.

The geological feature of the Tabora region is shown in Table 4.3.1.

Table 4.3.1 Geology of Tabora Region

Era	System		Rock Type	Lithology
Cenozoic	Quaternary		Alluvium	Clay
	Neogene	Pleistocene	Unconsolidated sediment	Sand , clay
			Lacustrine	Limestone, Calcareous mudstone
	Neogene	Miocene	Continental deposits	Silcrete, Duricrust and others
Paleozoic	Bukoban		Sedimentary rocks	Sandstone
Archean	Ubendian		Metamorphic rocks	Gneiss, Amphibolite
	Kavirondian		Sedimentary rocks	Quartzite, Sandstone, Mudstone, Siltstone
	Nyanzian		Metamorphic rocks, Metavolcanic rock	Banded ironstone, Schist, Lava, Tuff, Phyllite,Sandstone
	-		Intrusive/ Plutonic rocks	Granite, Granodiorite
	Dodoman		Metamorphic rocks	Gneiss, Amphibolite, Migmatite, Schisit

Source: "Tanzania Tabora Region Integrated Development Project, Land Use Component, Land Unit Atlas"

Land Resources Development Centre, 1982

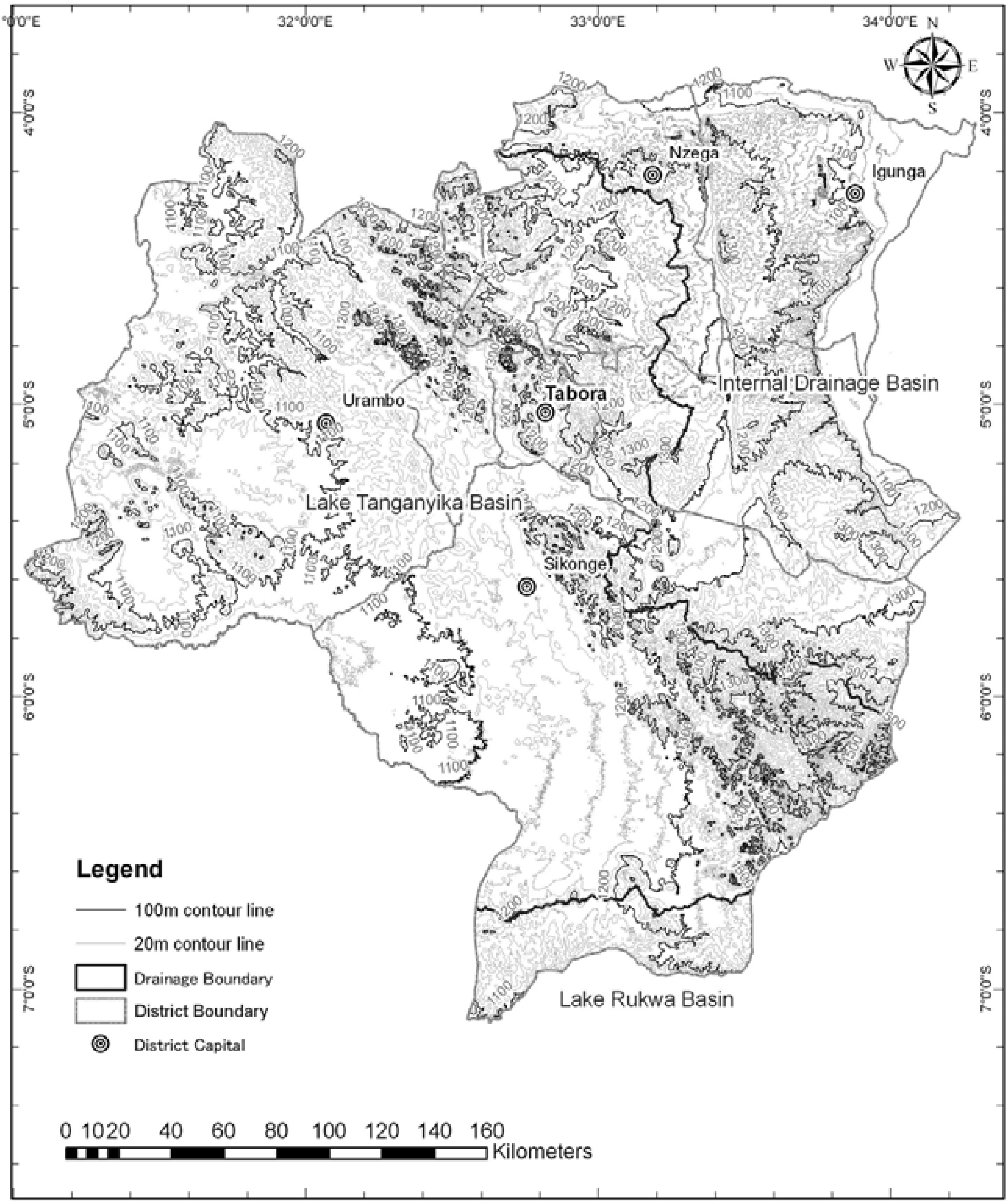

FIGURE 4.2.1 TOPOGRAPHIC MAP OF THE STUDY AREA

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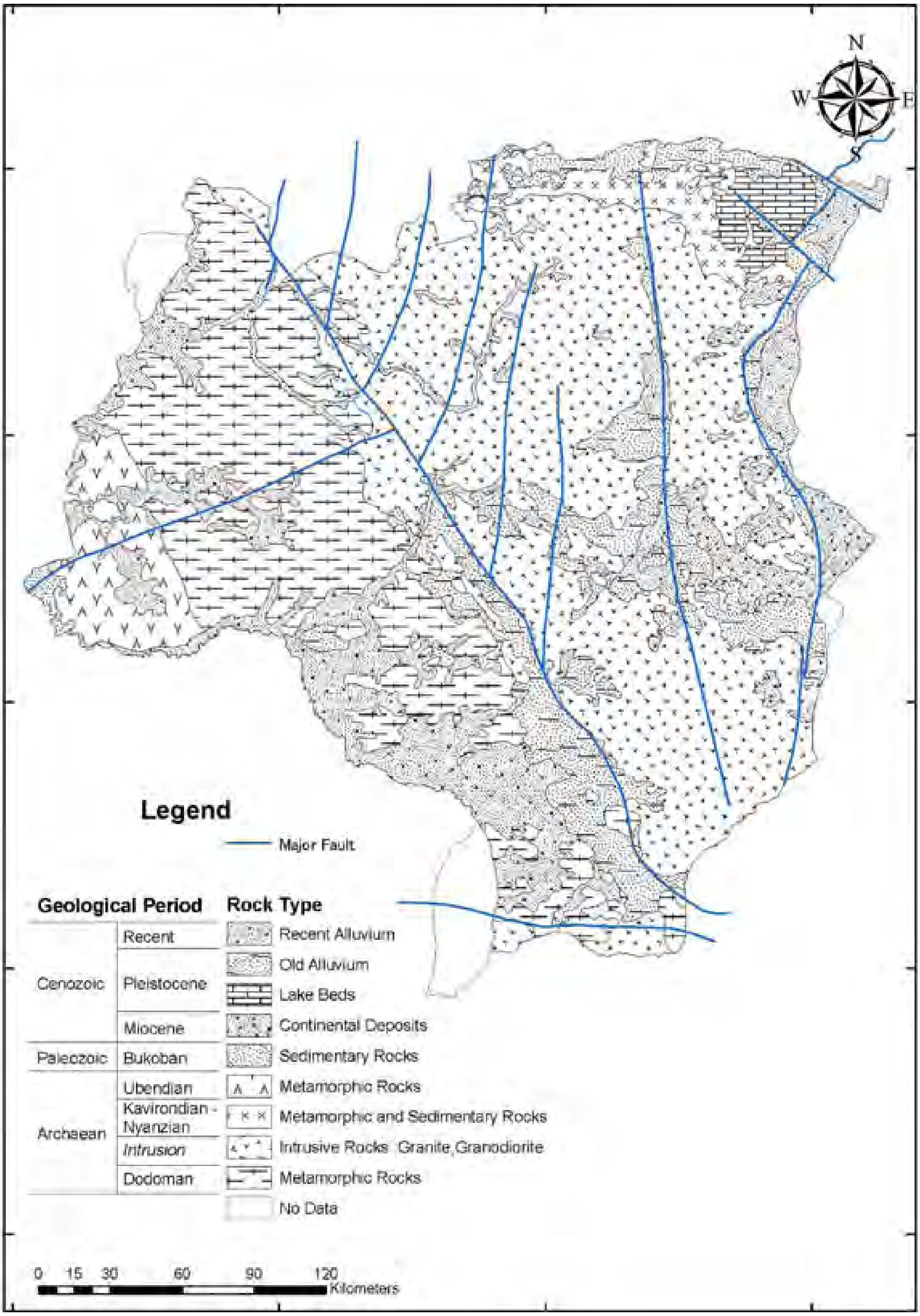

FIGURE 4.3.1 GEOLOGICAL MAP OF THE STUDY AREA

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4.3.3 GENERATED THEMATIC MAPS

Thematic maps and their incorporated information in this survey are shown in Table 4.3.2. An "Integrated hydrogeological map" will be prepared for the item 'Integrated interpretation' afterwards.

Table 4.3.2 Generated Thematic Maps

Map	Scale	Incorporate information
Surface condition	1:200,000	- Drainage system and drainage basin - Vegetation distribution by NDVI in both dry and rainy seasons - Surface water distribution in rainy season - DEM shaded map
Lithofacies	1:200,000	- Lithofacies by image interpretation - Compiling existing geologic map - DEM shaded map
Geologic structure	1:200,000	- Fractures by image interpretation; major faults, certain and uncertain lineaments and dykes - Faults and dykes by existing airborne magnetic data interpretation DEM shaded map
Integrated hydrogeological interpretation	1:200,000	- Drainage and drainage basin - Fracture scoring data - Groundwater Potential estimated in Water Master Plan(1980)

(1) Surface Condition Map

The surface condition map is shown in Figure 4.3.2. This thematic map clarifies the following contents.

- The Tabora region should be divided into four main drainage basins judging from drainage analysis using SRTM data. They are eastern, northwestern, southwestern and most southern drainage basins. Tabora Municipality is located in a ridge between the north-western and the south-western main drainage basins.

- Vegetation is mainly distributed in forest and game reserves of the Sikonge and Urambo districts, while their distribution is different in the rainy and dry seasons. Artificial vegetation boundaries regarding these reserves were extracted from the imagery as well.

- The surface water is distributed in the lowlands of the Igunga and Urambo districts in addition to the Manonga River, Rungwa River, Igombe River and Wala River on the imagery of the rainy season data.

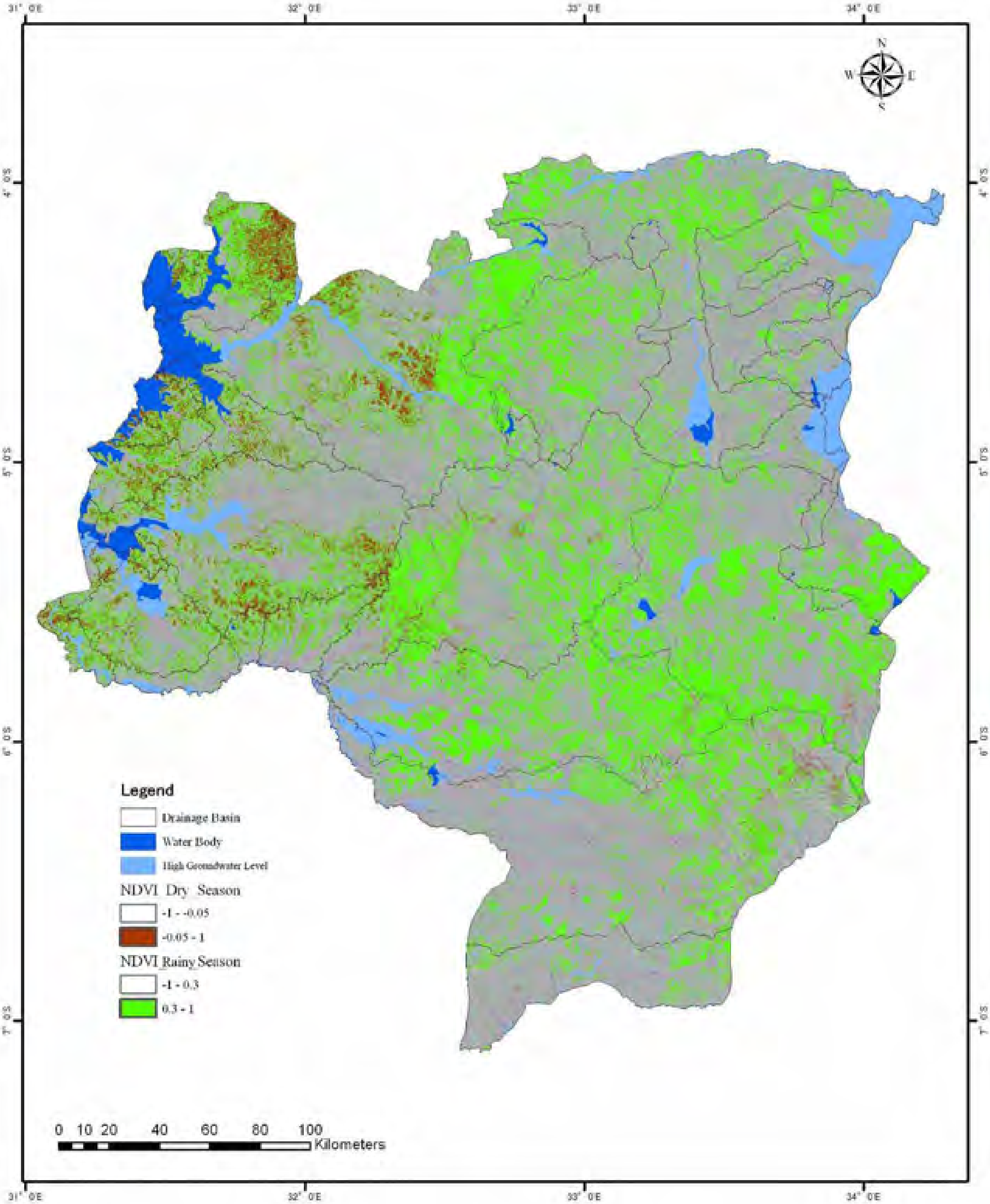

FIGURE 4.3.2 SURFACE CONDITION MAP

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(2) Lithofacies Map

The lithofacies map is shown in Figure 4.3.3.

Lithofacies here in Tabora Region was discriminated into seven geologic units as follows in ascending order,

- Unconsolidated materials in Quaternary (unit name Q): loose materials like sand and mud distributed along drainages and in swamps

- Sedimentary rock (unit name Sr): horizontally structured deposits distributed in the most south-western part of the region

- New granite (unit name Ng): showing intermediate resistance against surface erosion and being distributed in the south-western part of the region

- Greenstone (unit name Gs): showing rough topography and dense vegetation and emplacing in the north-eastern part of the region

- Schist (unit name Sc): showing low resistance against surface erosion and being distributed in the western and the southern part of the region

- Gneiss derived from granite (unit name Gn): showing rough topography and many lineaments developed and being distributed in NW-SE direction belt at the center of the region

- Granite as a basement (unit name Gb): showing high resistance against surface erosion in the northern part and low resistance in the southern part of the region

(3) Geologic Structure Map

The geologic structure map was shown in Figure 4.3.4. This thematic map clarifies the following contents.

- Major faults trending N-S and NW-SE in addition to trending NE-SW and E-W were newly extracted from the Digital Elevation Model (DEM) shaded map. There is a difficulty to extract these major faults from the satellite imagery because its high sun elevation does not show an efficient shadow effect. These faults sitting extension and/or parallel to the 'Eastern African Rift' seem to be younger than any other lineaments in the region.

- Other faults and dykes derived from the airborne magnetic survey are added on as well in order to make the accuracy higher than the ones from satellite interpretation, as the subsurface structure is difficult to detect from satellite imagery in the 1:200,000 scale. In fact, these dykes are very concordant with N-S trending major faults and extend further to the south.

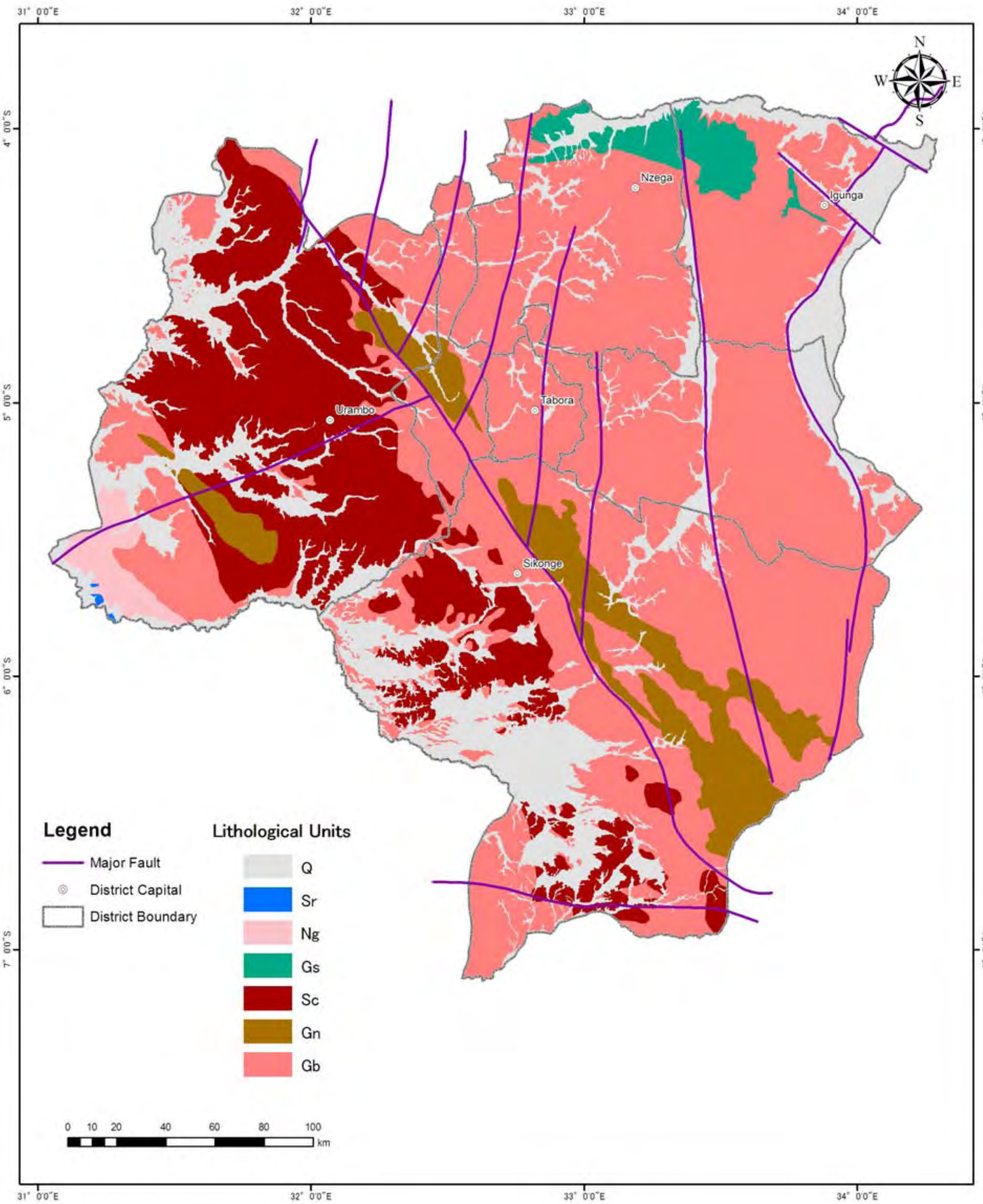

FIGURE 4.3.3 LITHOFACIES MAP

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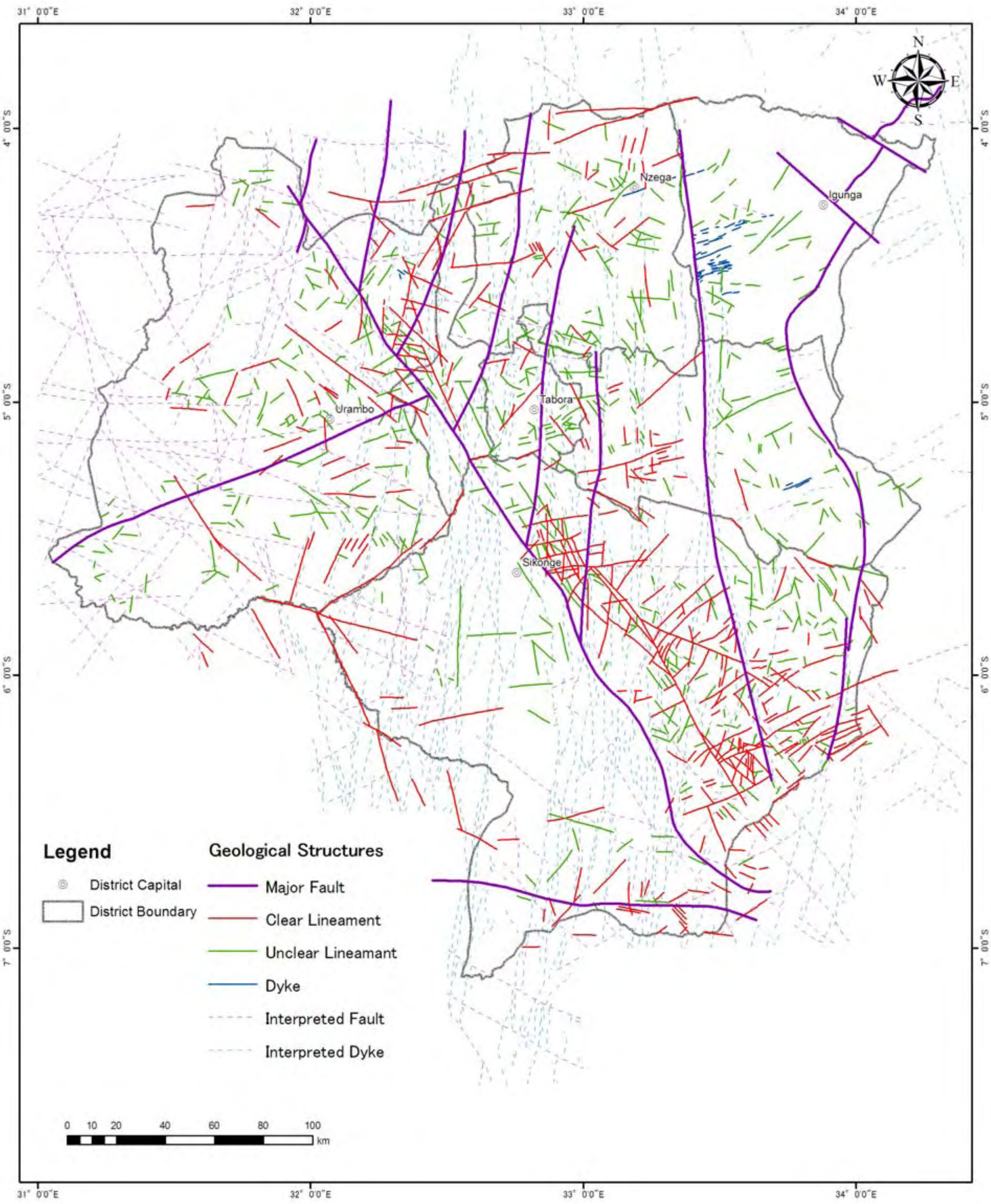

FIGURE 4.3.4 GEOLOGIC STRUCTURE MAP

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