Chapter 2
General Description of Study Area

CHAPTER 2 GENERAL DESCRIPTION OF THE STUDY AREA

2.1 Definition of Internal Drainage Basin

"River Basin Management" has been applied for water resources management in Tanzania since the 80s. The national land was sub-divided into nine river basins in the Act No.10 (1981). On the other hand, "Integrated Water Resources Management (IWRM)" was propounded through the discussion that water problems were caused by fragmentary water resources development and management plan in the "International Conference on Water and the Environment in Dublin (1992)". IWRM was applied in the "National Water Policy" (NAWAPO, July 2002) in Tanzania which deals with water resources including river water, groundwater, lake water etc. comprehensively allocating them for the related stakeholders. IWRM is not only to manage water as a resource but also to supply safe water effectively and stably, and to improve river from the view point of disaster prevention and to preserve water environment considering conservation of natural environment.

This Study is expected to play an important role in order to provide fundamental information for IWRM in IDB, which is the second largest basin among the nine basins in Tanzania.

Figure 2-1 Previous Area of IDB

Source: National Water Policy (July 2002)

At the beginning of the Study, the IDB boundary was redefined as the river basin or watershed because the area of IDB as shown in Figure 2-1 provided by the Tanzanian Government was not precise.

IDB boundary and sub-basin boundaries were defined precisely with DEM (Digital Elevation Model) data by SRTM (Shuttle Radar Topographic Mission) as illustrated in the Figure 2-2. According to this analysis, it reveals that several sub-basins should not be included in IDB but in the neighbouring basins, namely "J" sub-basin belongs to the "Pangani Basin", "K" and "L" sub-basins belong to the "Wami Basin". "I" sub-basin is considered to be an internal basin itself. Approximately 11.5% of the whole IDB basin is located in Kenya. As for "E"; Lake Natron sub-basin which is considerably big catchment as large as 26,224km^2, Tanzanian side of it is 33% only. The area of IDB in the Study is 143,099km^2 which consists of Tanzanian side of "A" to "I" sub-basins as shown in Table 2-1.

Table 2-1 Area of IDB and Sub-basins

Sub-basin	Area	Tanzanian Side	Kenyan Side	Internal Drainage Basin	Note
A	64,545	64,545	-	64,545	Lake Eyasi Sub-basin
B	4,115	4,115	-	4,115	Monduli Sub-basin (1)
C	1,385	1,385	-	1,385	Monduli Sub-basin (2)
D	18,491	18,491	-	18,491	Lake Manyara Sub-basin
E	26,224	8,658	17,566	8,658	Lake Natron Sub -basin
F	4,577	4,577	-	4,577	Olduvai Sub-basin
G	26,445	26,445	-	26,445	Bahi (Manyoni) Sub-basin
H	9,313	9,313	-	9,313	Masai Steppe Sub-basin
I	14,080	5,570	2,939	5,570	Namanga Sub-basin (Internal)
J	7,122	7,122	-	-	Belong to Pangani Basin
K	1,018	1,018	-	-	Belong to Wami Basin
L	907	907	-	-	Belong to Wami Basin
Total	178,221	152,146	20,505	143,099	-

(Unit: km^2)

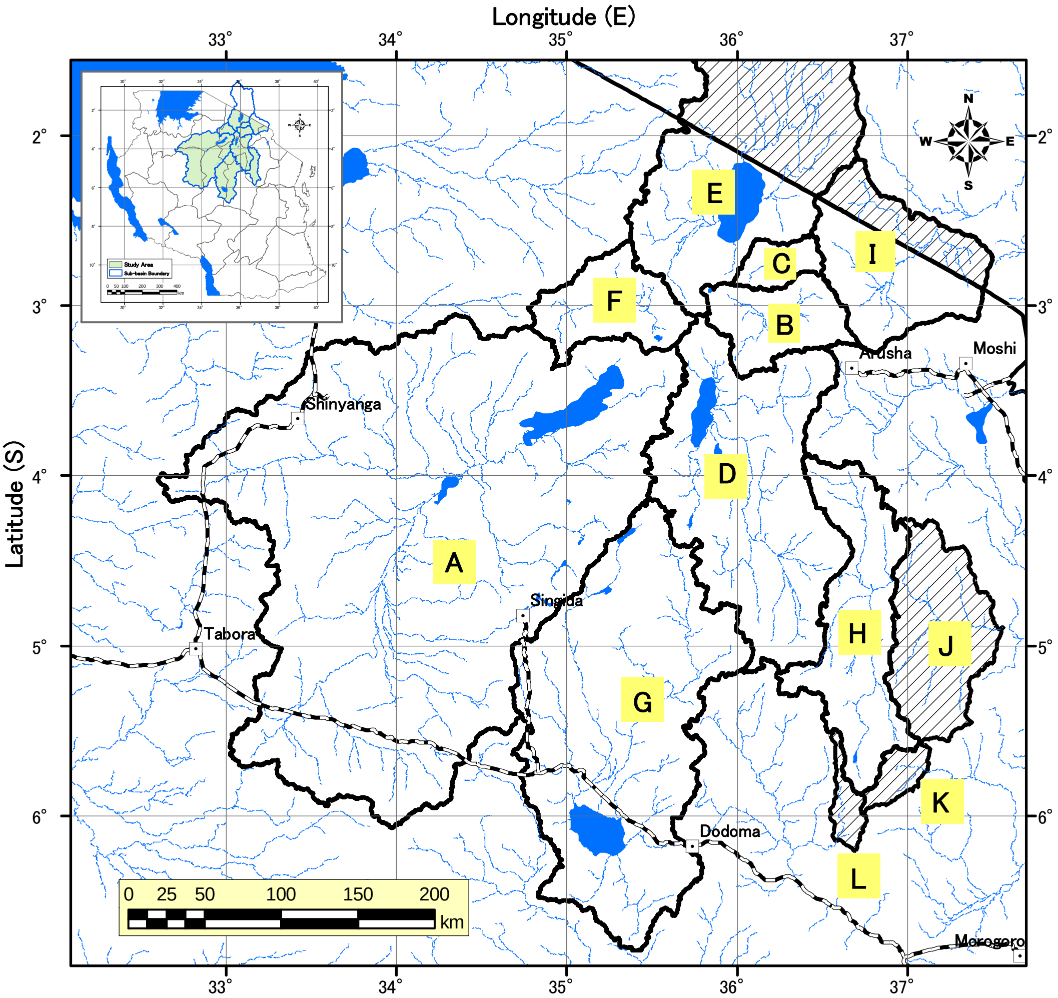


Figure 2-2 Basin and Sub-basin Boundaries of IDB

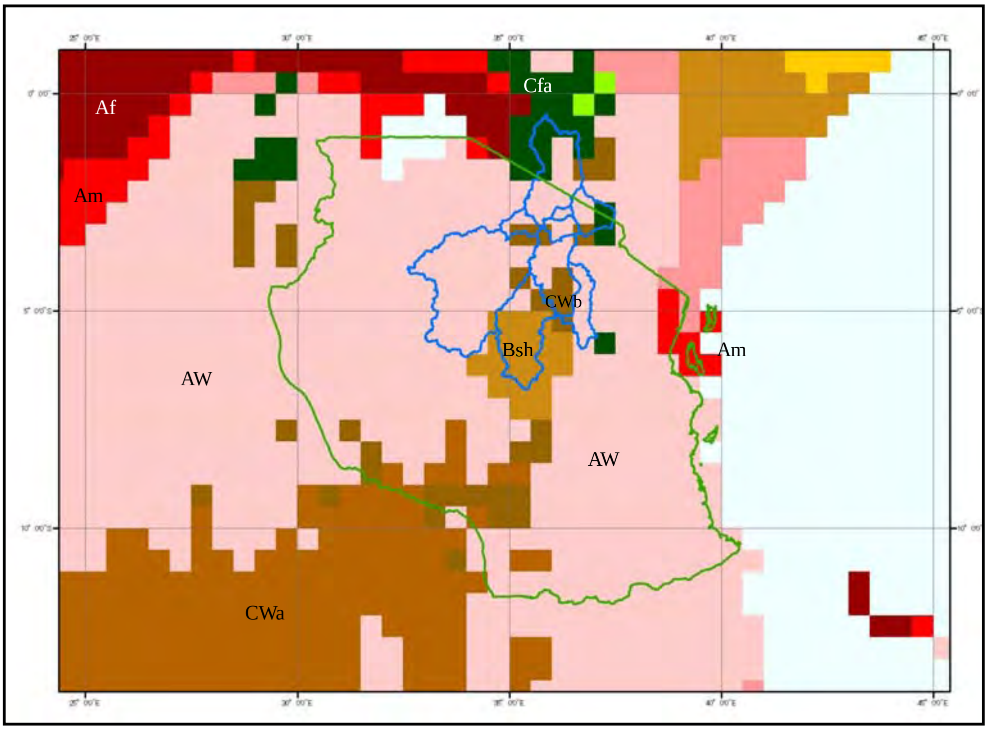
(*J, K, L sub-basins are excluded in IDB)

2.2 Meteorology and Hydrology

2.2.1 Meteorology

Climate type of Tanzania is mainly classified into "Tropical Savannah (Aw)" based on Koppen Climate Classification as shown in Figure 2-3. There are four types of climate in detail in IDB: Tropical Savannah (Aw), Steppe (Bsh), Humid Subtropical (Cwb), and Humid Subtropical (Cfa, with no dry season).

Meteorological and hydrological data such as temperature, rainfall, sunshine hours, potential evaporation humidity, wind speed, and river discharge have been collected and analyzed. These data are used for a water balance analyses in IDB.



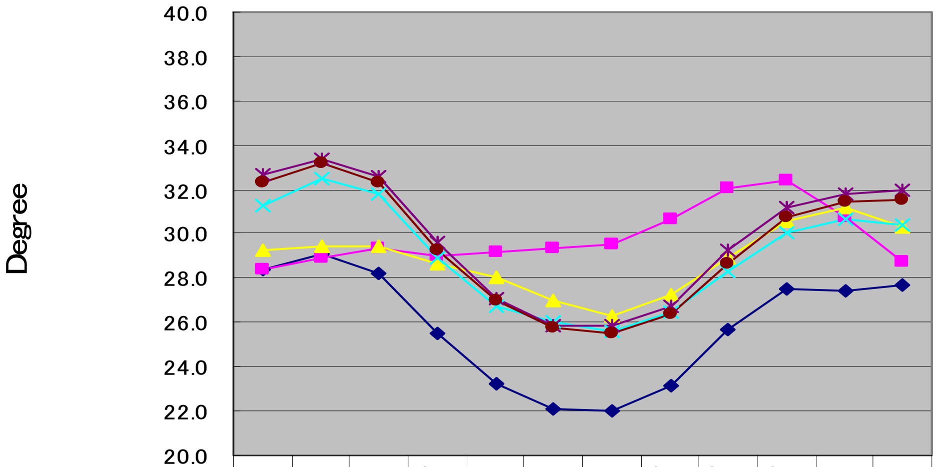
Af: Tropical Wet Climate, **Aw**: Tropical Savanna Climate, **Am**: Tropical Monsoonal Climate, **Bsh**: Steppe Climate, **Cwa/Cwb**: Humid Subtropical, **Cfa**: Humid Subtropical (No dry season)

(Source: World Map of Koppen-Geiger Climate Classification Updated, Univ. of Vienna (April 2006))

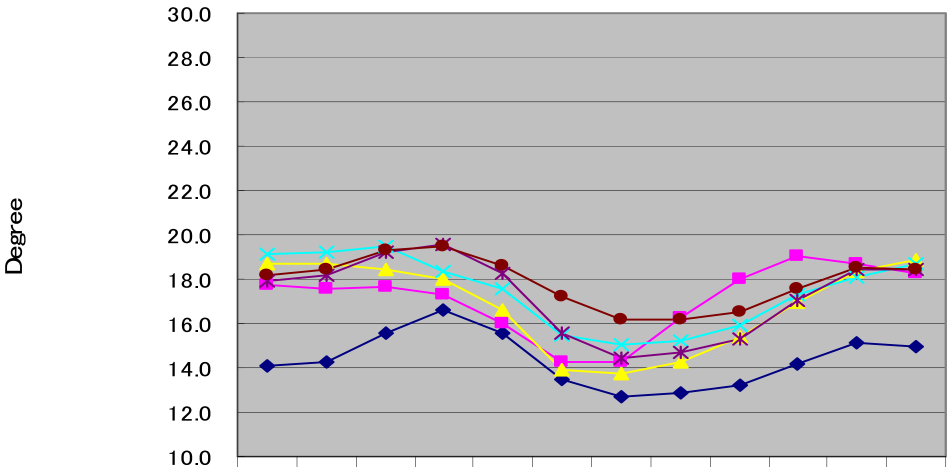
Figure 2-3 Climate Types of Tanzania and IDB

(1) Air Temperature

Air temperature of the several stations in IDB was analyzed as Figure 2-4. This figure presents average maximum and minimum temperatures at major meteorological stations in IDB or its adjacent area. Annual variation and difference of maximum temperature among the stations is larger than those of minimum temperature. The distribution pattern of Tabora is different from others.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Arusha Meteological Station	28.4	29.1	28.2	25.5	23.2	22.1	22.0	23.1	25.6	27.5	27.4	27.7
Tabora Meteological Station	28.4	28.9	29.3	29.0	29.2	29.4	29.5	30.6	32.0	32.4	30.7	28.8
Dodoma Meteological Station	29.2	29.5	29.4	28.6	28.0	27.0	26.3	27.2	28.9	30.5	31.2	30.3
Same Meteological Station	31.3	32.4	31.8	28.9	26.7	26.0	25.6	26.4	28.3	30.0	30.7	30.4
Kilimanjaro Airport	32.6	33.4	32.6	29.6	27.1	25.9	25.8	26.7	29.3	31.1	31.8	31.9
Moshi Meteological Station	32.3	33.2	32.3	29.2	27.0	25.8	25.5	26.4	28.7	30.7	31.4	31.5



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Arusha Meteological Station	14.1	14.3	15.6	16.6	15.6	13.5	12.7	12.9	13.2	14.2	15.1	14.9
Tabora Meteological Station	17.8	17.6	17.7	17.3	16.0	14.3	14.3	16.3	18.0	19.0	18.7	18.3
Dodoma Meteological Station	18.7	18.7	18.5	18.0	16.6	13.9	13.7	14.3	15.4	16.9	18.3	18.9
Same Meteological Station	19.1	19.2	19.5	18.3	17.6	15.5	15.1	15.2	15.9	17.3	18.1	18.7
Kilimanjaro Airport	17.9	18.1	19.2	19.5	18.3	15.6	14.4	14.7	15.3	17.0	18.4	18.4
Moshi Meteological Station	18.2	18.4	19.3	19.5	18.6	17.2	16.2	16.2	16.5	17.5	18.5	18.4

Figure 2-4 Maximum and Minimum Temperatures in IDB and its Adjacent Area

(2) Annual Rainfall

Annual rainfall distribution as the one of the most important items for water resources analysis needs many data in terms of as much the number of observation points in IDB and as longer their monitoring duration as possible. Since enough rain gauge stations and weather stations have not been operated so far, data from "Summary of Rainfall in Tanzania" (1975): East Africa Community, Nairobi) has been used for the purpose. The results on the annual rainfall distribution are shown as Figure 2-5. The number of rain gauge stations applied for the map is more than 100 and their monitoring duration is more than 30 years. The map indicates that the north-eastern area of IDB surrounding Mt. Kilimanjaro is relatively high rainfall area, but Dodoma area is under the most severe condition, where the rainfall is only 600 mm/year. The southern part of IDB including Dodoma area, where is covered by yellow or orange colour in Figure 2-5, coincides with Steppe Climate in Figure 2-3.

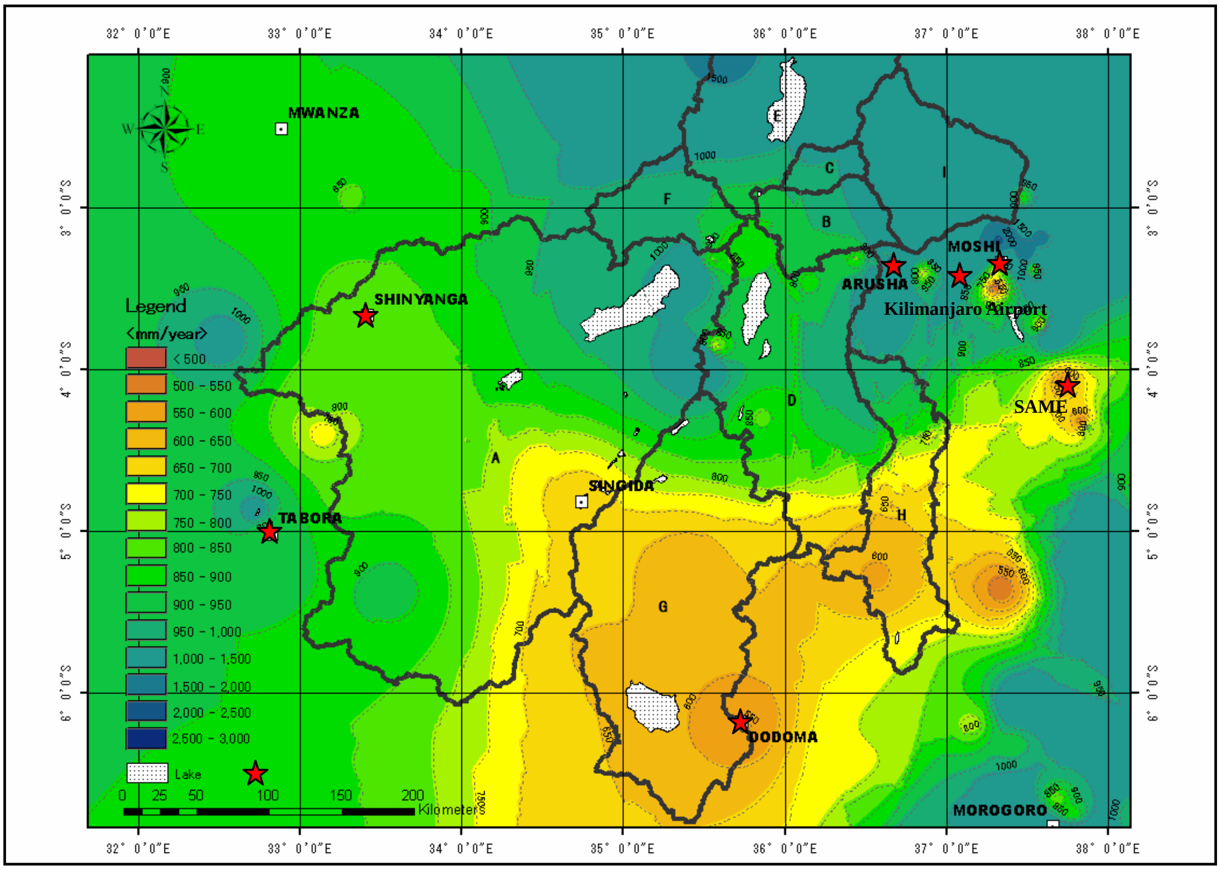
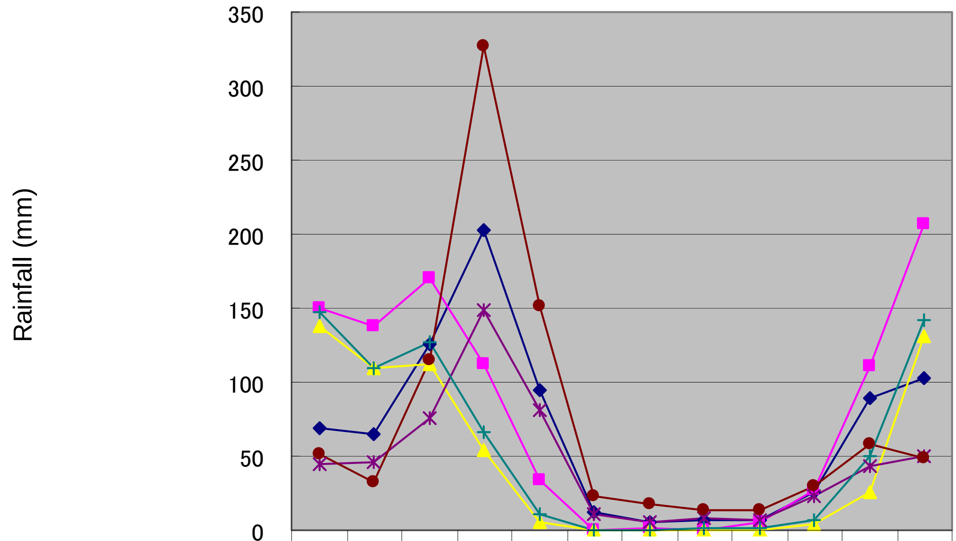


Figure 2-5 Annual Rainfall in IDB and Locations of Meteorological Stations

(3) Seasonal Change of Monthly Rainfall

Seasonal change of monthly rainfall of the several meteorological stations in IDB was analyzed as Figure 2-6. This figure presents average monthly rainfalls at major weather stations in IDB. The rainy season begins in late October or November and finishes in May. There is almost no rainfall from June to September. Monthly variation patterns of rainfall among the stations are divided into two groups, which are Tabora, Dodoma and Singida group and Arusha, Kilimanjaro, Moshi group. The stations of former group are located on hillside, and the rainfall pattern does not have sharp peak of monthly rainfall. On the other hand, the stations of the latter group are located on mountainous area, and the monthly rainfall pattern has sharp peak on April.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Arusha Meteorological Station	70	65	125	203	95	13	6	7	6	26	89	103
Tabora Meteorological Station	150	139	170	112	34	0	1	0	5	27	110	207
Dodoma Meteorological Station	138	109	112	54	5	0	0	0	0	4	26	131
Kilimanjaro Airport	45	46	76	149	80	11	6	8	6	23	44	50
Moshi Meteorological Station	51	33	115	326	151	23	17	14	13	30	58	49
Singida Meteorological	147	110	126	67	11	0	0	1	1	7	49	142

Figure 2-6 Monthly Rainfall of Major Towns in IDB and its Adjacent Area

(4) Sunshine Duration

Sunshine duration of the several stations in IDB was analyzed as Figure 2-7. This figure presents average monthly sunshine duration at major weather stations in IDB. Annual variation patterns of sunshine duration among the stations are divided into two groups, which are Tabora and Dodoma group, and Arusha, Kilimanjaro, Moshi group. The distributions of these two groups show completely opposite tendencies.

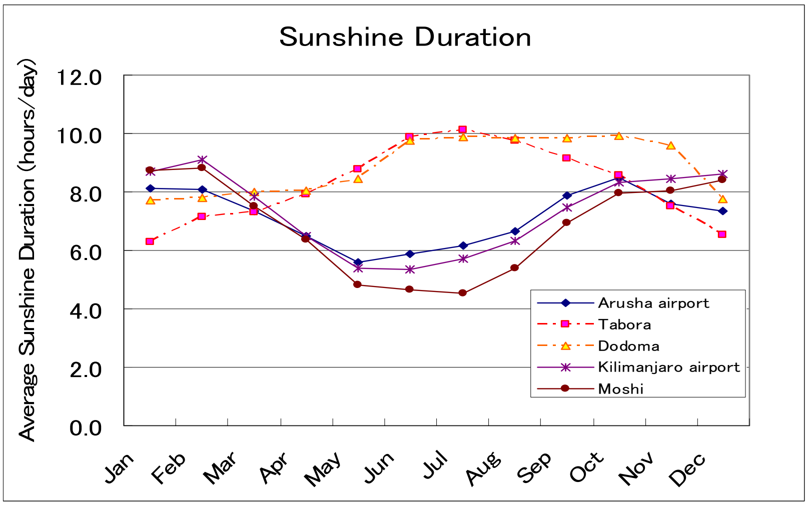


Figure 2-7 Sunshine Duration of Major Towns in IDB and its Adjacent Area

(5) Potential Evaporation (Pan Evaporation)

Pan evaporation of the several stations in IDB was analyzed as Figure 2-8. Average pan evaporation shows the highest value in October at each station. The highest value was recorded at Shinyanga weather station. The seasonal change of potential evaporation follows the temperature and the wind-run.

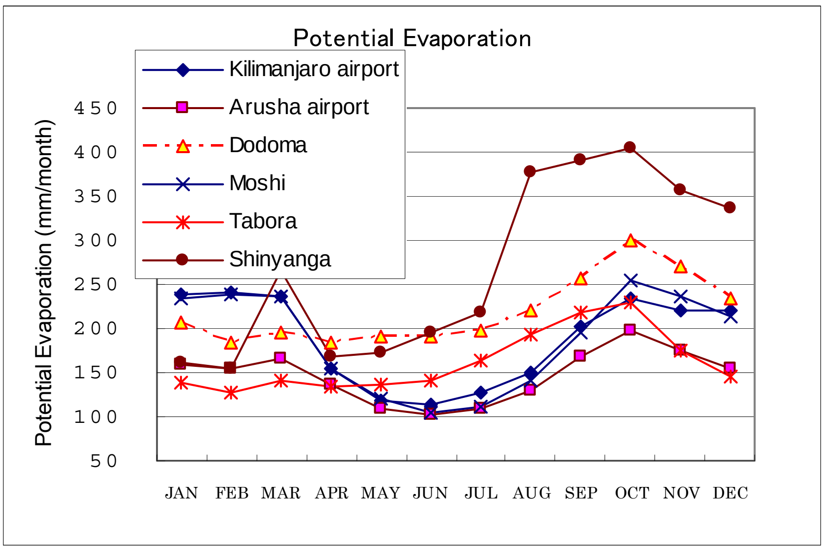


Figure 2-8 Potential Evaporation of Major Towns in IDB and its Adjacent Area

(6) Relative Humidity

Relative humidity of the several stations in IDB was analyzed as Figure 2-9. The figure presents monthly average relative humidity at 9 A.M. (the left figure) and 3 P.M. (the right figure) at major weather stations in IDB. Average relative humidity at 9 A.M. shows higher value than that at 3 P.M. at each station. Annual variation patterns of relative humidity among the stations are divided into three groups, which are Tabora and Shinyanga group, Dodoma group, and Arusha, Kilimanjaro, Moshi group. Dodoma group has intermediate value between the other two groups.

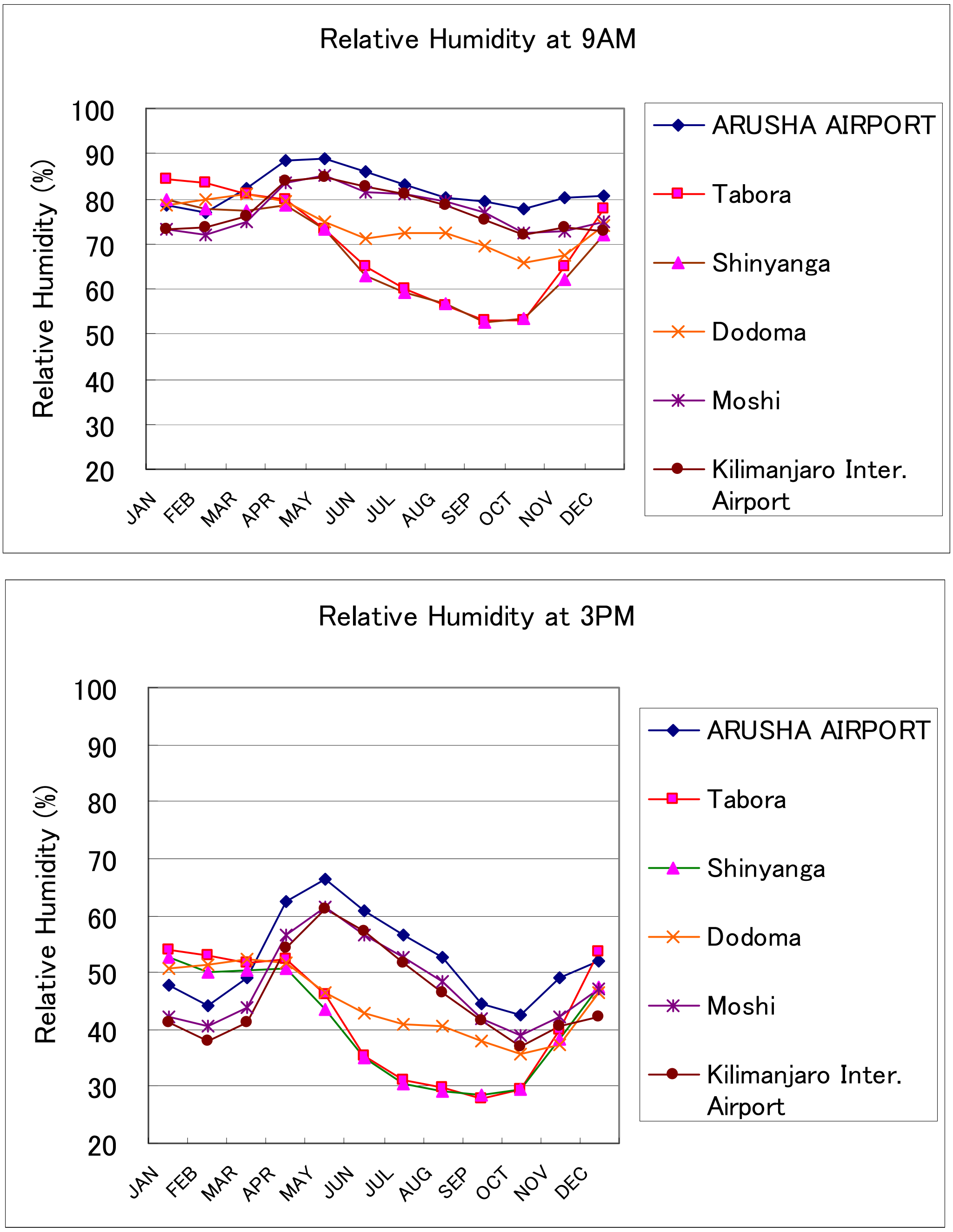


Figure 2-9 Relative Humidity of Major Towns in IDB and its Adjacent Area

(7) Wind-run

Wind-run of the several stations in IDB was analyzed as Figure 2-10. The figure presents the yearly average of appearance frequency of the wind directions at major weather stations in IDB. The appearance frequency of the wind from the east predominated except Shinyanga station.

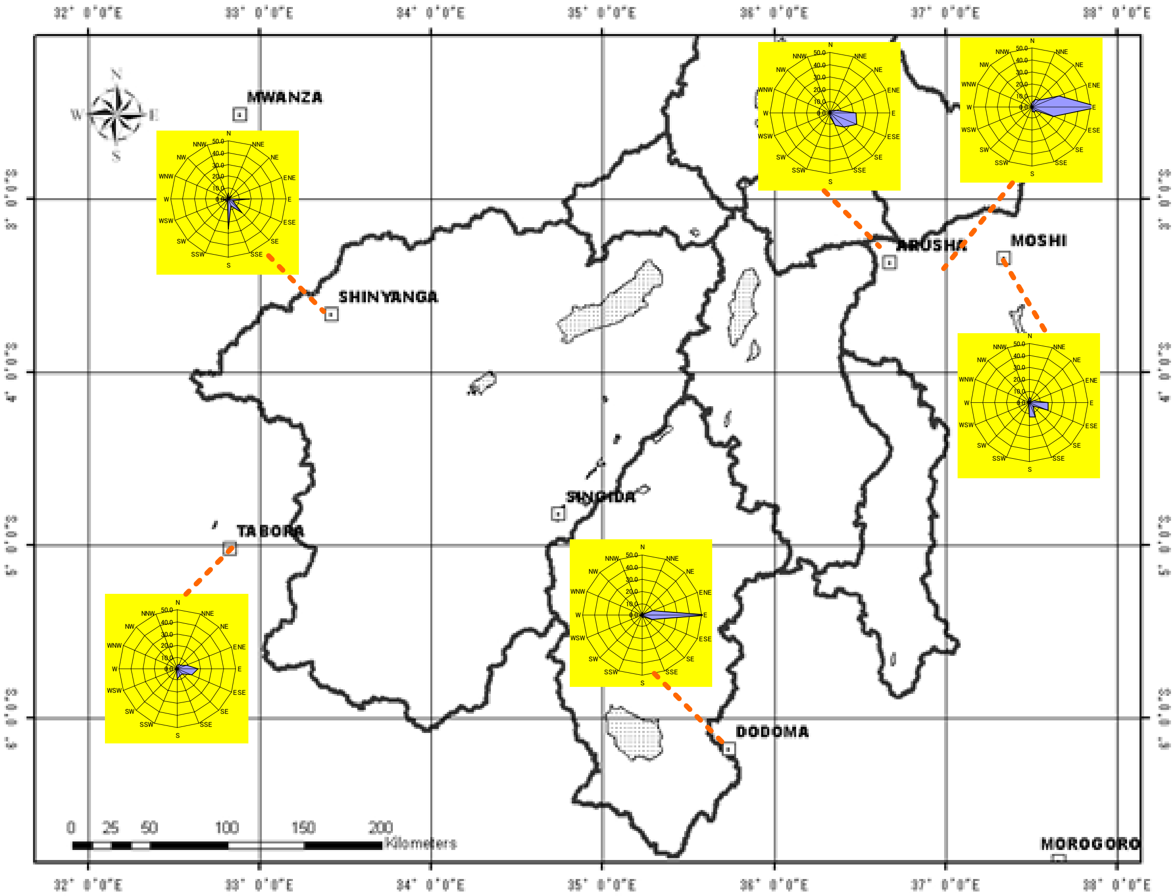


Figure 2-10 Wind Rose in IDB and its Adjacent Area

2.2.2 Hydrology

(1) River Network

River network was generated newly by using DEM (Digital Elevation Model) data and river catchments (Sub-basins) were also defined by SRTM (Shuttle Radar Topographic Mission) data as illustrated in the Figure 2-11. The areas of each sub-basin are shown in Table 2-1. On the basis of the existing definition of IDB, its area is 152,146 km2; however, the area of the newly defined basin becomes 143,100 km2.

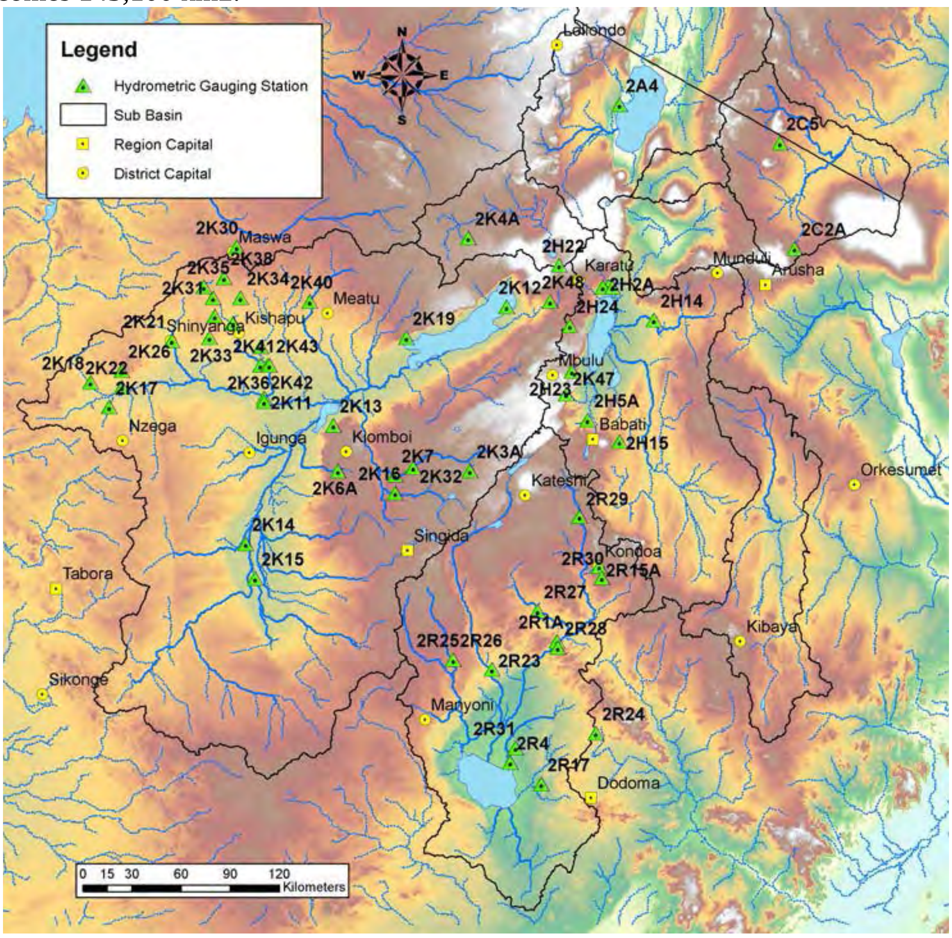


Figure 2-11 Sub-basins, River Network and Hydrometric Gauging Stations in IDB

(2) River Flow Regime

Flow duration curves of the hydrometric gauging stations in Tanzania were analyzed as Figure 2-12. Flow duration curves in IDB (Lake Eyasi sub-basin and Bahi sub-basin) show shorter flow discharge periods in a year and rapid discharge like a flash for each rainfall event compared with those in the other areas of Tanzania. This means that many rivers in IDB are ephemeral rivers and unstable for water use. In comparison with the observation periods of the collected data on river flow discharge, there is the largest number of hydrometric observation data at the year of 1974. Therefore, the monthly averaged river flow discharges at various stations in 1974 in IDB were analyzed as Figure 2-13. All observation results have almost the same tendency that the river flow discharge gradually increases from December, records the maximum value on April, and then decrease and disappears on June or July. It corresponds to the seasonal rainfall condition.

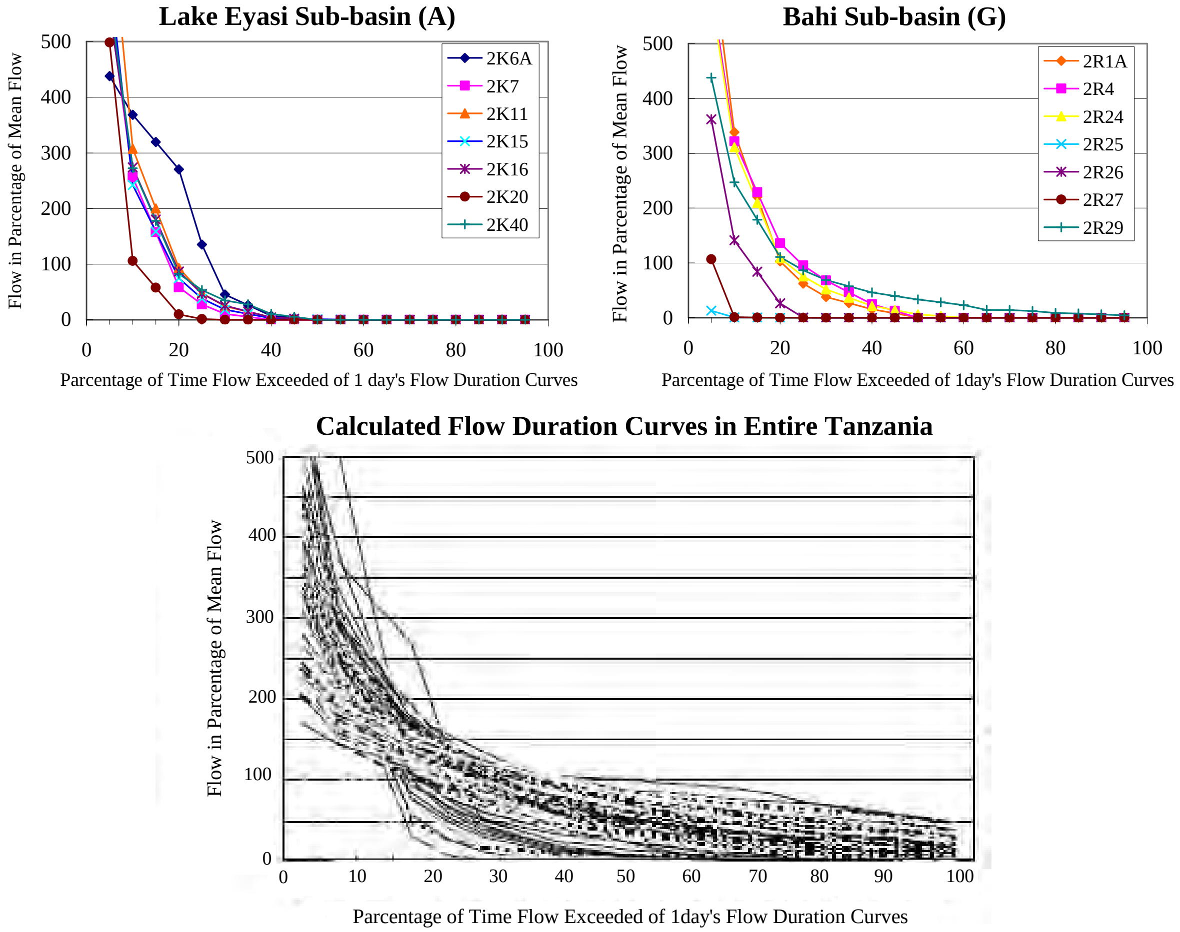


Figure 2-12 Flow Duration Curves
(Source: "The Study on the National Irrigation Mater Plan in the United Republic of Tanzania",2002 November, JICA)

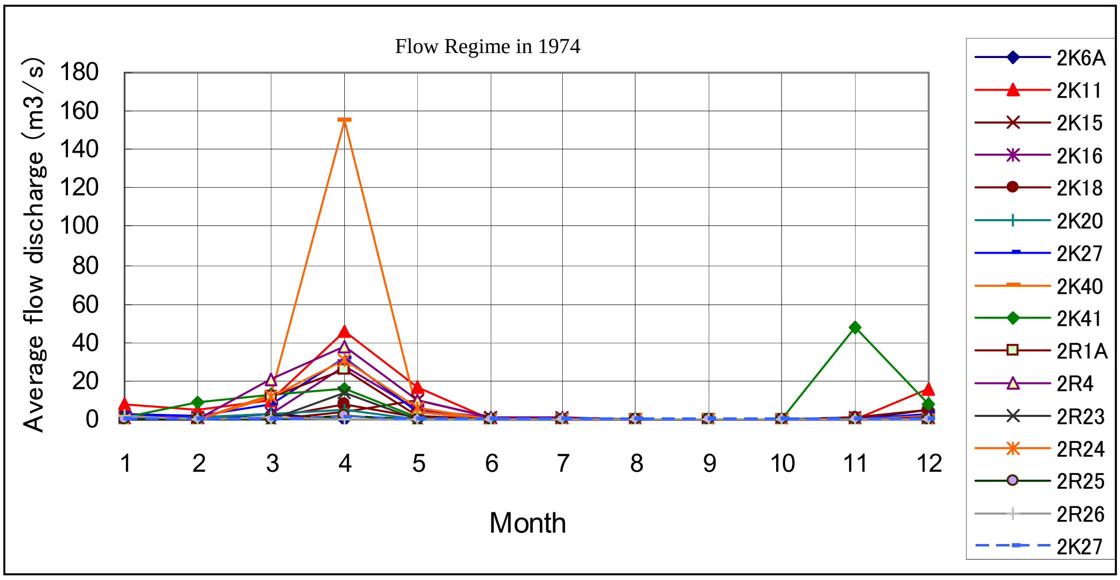


Figure 2-13 Monthly Averaged River Flow Discharges in 1974

(3) Lake Water Level

Lake water level of the 2K13 gauging station at the Kitangiri Lake in Lake Eyasi sub-basin was analyzed as Figure 2-14. The figure presents average daily water level at Kitangiri Lake. Annual trend of water level change of the station is that the water level goes up during rainy season and goes down during dry season. The difference of the water level between the beginning and the end of each year corresponds to the change of storage volume in the lake during the corresponding year. For example, the water levels at each June went down from 1979 to 1982. It means that the storage volume of the lake decreased in this period.

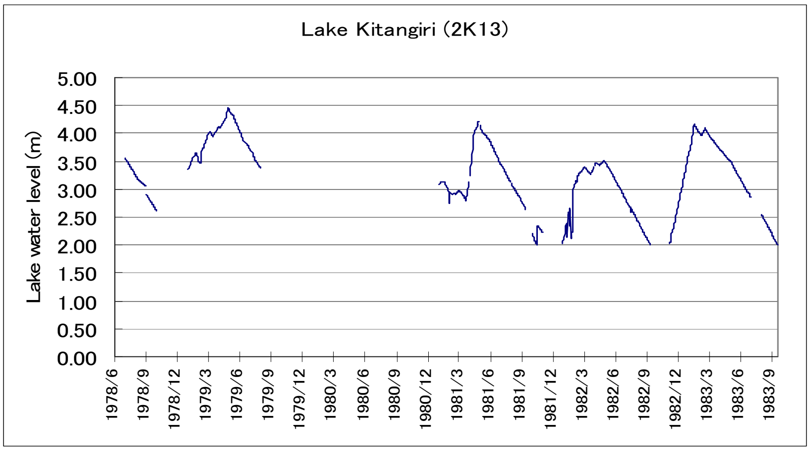


Figure 2-14 Water Level Change of Lake Kitangiri (2K13)

2.2.3 Water Use

The acquisition of data on actual water use in IDB is difficult because of the lack of systematic data collection system. Therefore, the water use was estimated by using information on registered and applied water rights as a trial. The used information was provided by IDBWO. The time stamps of the information were from 5 May 2004 to 12 January 2006. The results are shown in Figure 2-15. The perceived tendency from these figures is shown below.

(1) Arusha Region

The main water resources are river and spring water. The main purpose of the water use is domestic use. There are small water uses for irrigation, livestock and commercials.

(2) Manyara Region

The main water resource is river water. The main purpose of the water use is domestic use. There are small water uses for irrigation.

(3) Dodoma Region

In this region, the data obtained is the one for Kondoa district only. The main water resources in Kondoa district are river, dams and borehole water. The purpose of the water use is domestic use.

(4) Singida Region

The main water resource is borehole water. The main purpose of the water use is domestic use. There is small water use for livestock.

(5) Tabora Region

The main water resources are river and dam water. The main purpose of the water use is irrigation and the next is domestic use. There is small water use for mining.

(6) Shinyanga Region

The main water resource is dam water. The main purpose of the water use is domestic use. There are small water uses for commercials and mining.

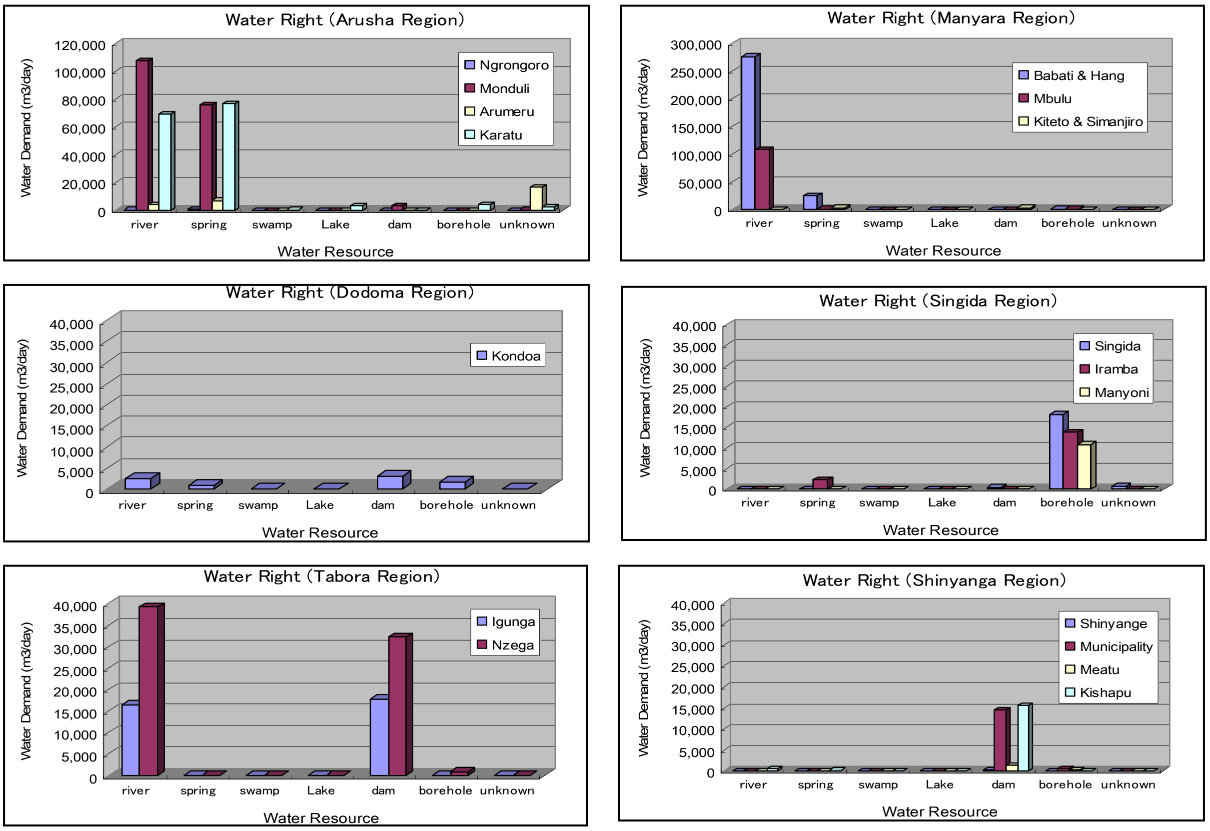


Figure 2-15 Water Use Derived from Water Right Information

2.3 Geomorphology and Geology

2.3.1 Geomorphology

The topographic image processed data of DEM (Digital Elevation Model) by SRTM (Shuttle Rader Topographic Mission) is shown in Figure 2-16, which was prepared to understand topographic features of IDB three-dimensionally. SRTM DEM data also used to extent the significant geological structure such as lineaments, faults and warping structure.

IDB is located in the southern part of “Gregory Rift Valley” as shown in Figure 2-18. In the central and north-eastern parts of the project area, there are huge volcanoes such as Mt. Hanang (EL 3,417m), Kilimanjaro (EL 5,895m) and Ngorongoro crater (EL 2,000-3,000 m). These volcanoes are closely related to rift-faulting movements, and the nine sub-basin of IDB were formed by such geological tectonic movement.

The northern to the central part of IDB, several large lakes are located in each sub-basins, such as Lake Natron (EL; about 600m), Lake Manyara (EL; about 950m) and Lake Eyasi (EL; about 1020m). Bahi swamp is spreading over the low plain in the southern part of IDB. Many linear fault scarps were found in IDB. In the central part of IDB, the areas bounded by N-S or NE-SW trending fault are gently inclining to the northwest or west.

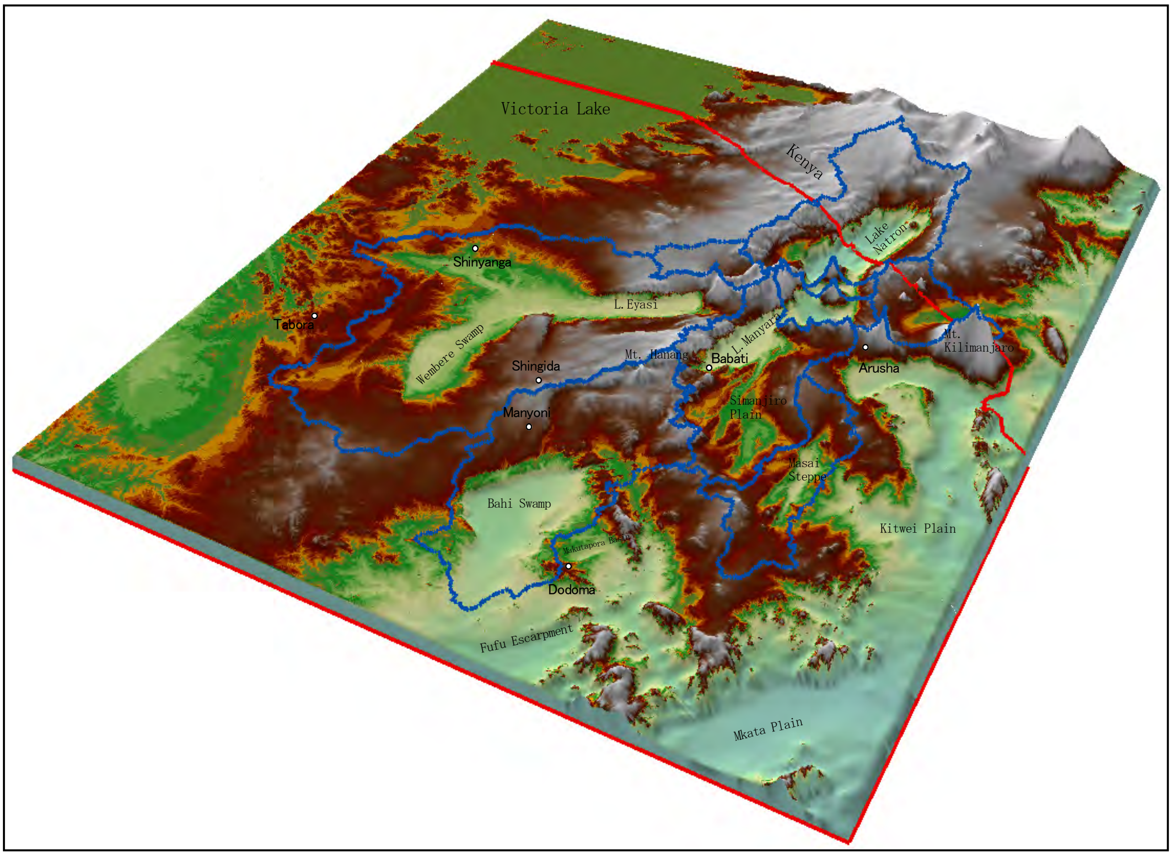


Figure 2-16 Block Diagram of IDB and Sub-basins

Land cover map was produced by the results of VSW image and SAVI image analysis as shown in Figure 2-17. SAVI (Soil Adjusted Vegetation Index) Image was used to analyze the vegetation density and activity, using LANDSAT Data, and VSW indices (Vegetation, Soil and Water) were determined by LANDSAT ETM Data.

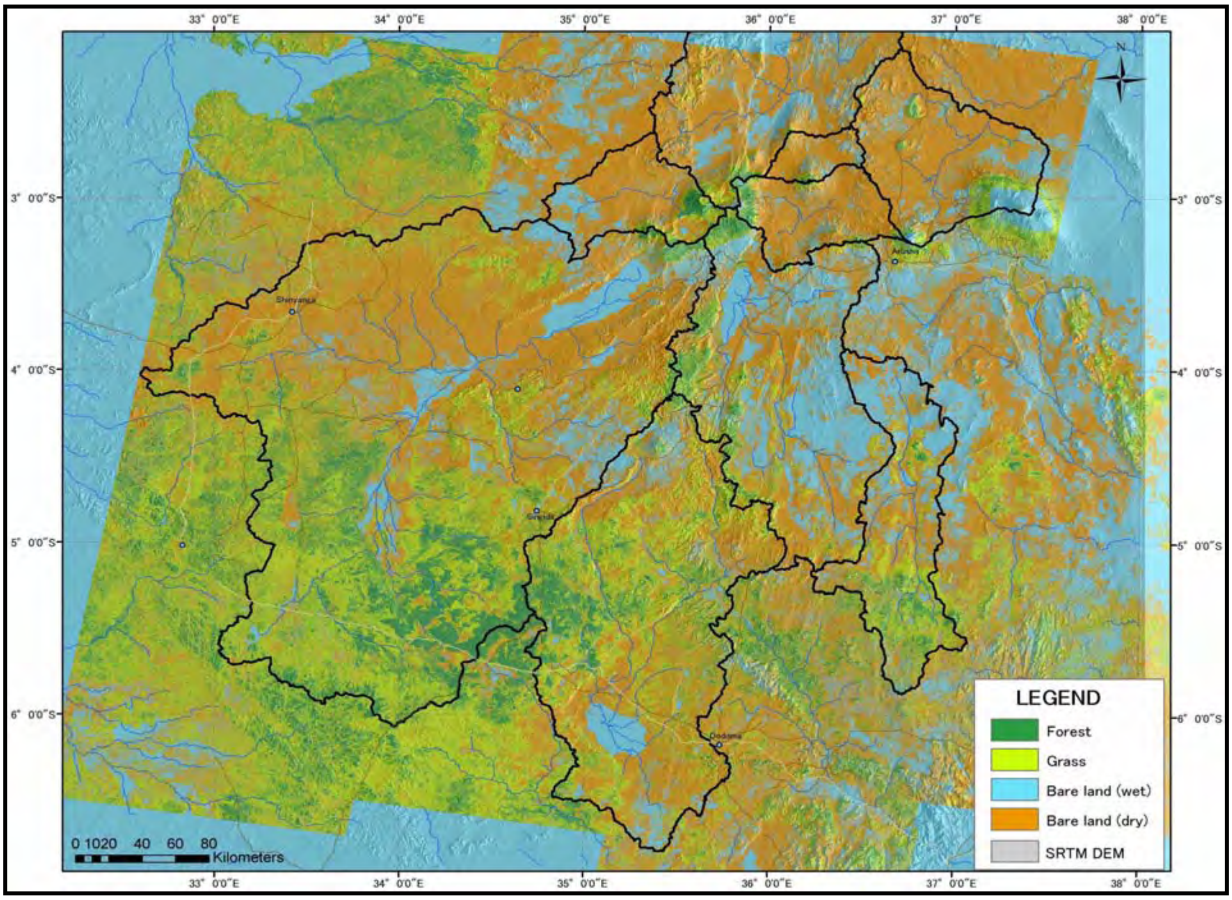


Figure 2-17 Land Cover Map

2.3.2 Geology

(1) General Geology

A continental rift zone is running through Ethiopia to Mozambique in the East Africa, which is called as "East African Rift Valley" (Figure 2-18). The study area is located at the east branch of it developing in the Tanzanian craton. Many authors have suggested that the eastern and western branches of the East Africa Rift represent an early stage of continental separation. Figure 2-18 shows distribution of Tertiary and Quaternary volcanic rocks. The eastern branch of the rift valley has wider distribution of volcanic rocks than the western branch. It is characterized by high rate crustal extension and bimodal distribution of basic and acid magma type. In general, most of continental rift zones accompany high alkali volcanic activity. The faults in the eastern branch of the rift valley appear generally belong to the Neogene. However, there is no evidence that this fault activity happened in Paleogene. In general, the faults discord from the foliation of

Precambrian metamorphic rocks. The general direction of them is N-S with related faults branching to the south-west. This suggests that these activities are regarded as block fault activity bringing tectonic basins.

The second phase of fault activity in association with tilting and warping has dominated the evolution of topography since mid-Tertiary. The ground surface in the mid-Tertiary was also warped into gentle basin structure. In case of the Internal Drainage Basin, the bottom level of IDBs is changing apparently based on their sedimentation. Therefore, the rivers tend to flow along the faults laterally and wide flood planes are developed.

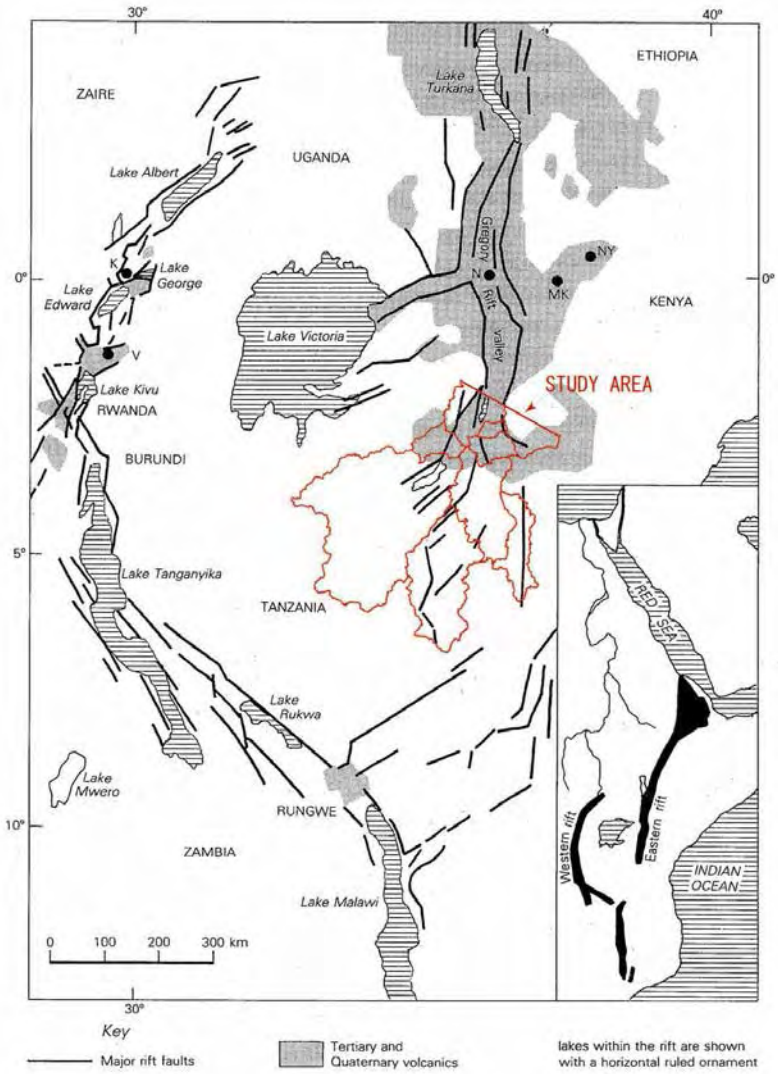


Figure 2-18 Structural Map of East African Rift System (Wilson (1989))

(2) Geological Description

The geological interpretation map and stratigraphy are shown in Figure 2-19 and Table 2-2, respectively. This interpretation map was produced using LANDSAT ETM false colour image and published geological maps of Tanzania (1:125,000). Furthermore, VSW indices, SAVI index and SRTM DEM images were also used for the interpretation. This interpretation images at a scale of 1:500,000 was conducted in order to extract lithological and structural characteristics for the hydrogeological analysis. Based on the results of field survey, the interpretation map was confirmed. As the result of interpretation, geological units were classified into 16 units (Table 2-2) and many lineaments and fault structures were extracted.

Table 2-2 Stratigraphy of the Study Area

Age	System	Lithology		Unit		Unit by LANDSAT Image Interpretation		
KAINOZOIC (CENOZOIC)	QUATERNARY – NEOGINE (-23.3Ma)	Aluvial; sand, gravel, silt; mud. Undifferentiated.	Typically alkaline volcanics: Olivine basalt, alkali basalt, phonolite, trachyte, nephelinenite and pyroclastics.		Nv	**N** / **E**	**Nv, Nvd**	**N: Undiferentiated** **E: Evapolite** **Nv: Lave and Pyroclastics** **Nvd: Mainly Pyroclastics**
		Lacustrine; sand, silt, limestone, tuff		NI		**NI**		
		Terrestrial: sand, gravel, laterite, silcrete, calcrete.		Nt		**-**		
		Fluviatile; -marine; sand;gravel; silt; limestone.		Nf		**Nf**		
		Unconformity						
PROTERO-ZOIC (570-2450Ma)	BUKOBAN	Mudstone; shale and phyllite; sandstone; arkose; quartzite; conglomerate; limestone.		B		**B**		-
ARCHEAN (2450-4600Ma)	USAGARAN	Marble; quartzite; graphitic schist; chlorite, amphibole, mica and kyanite schist; hornblend biotite and garnet gneiss; acid gneiss; granulite; charnockite.		Xs		**Xs**		**Topographic rough texture**
						Xs-a		**Topographic intermidiate texture**
						Xs-l		**Topographic smooth texture**
	KAVIRONDIAN	Quartzite; phylite.		V		**V**		-
	NYANZIAN	Banded Ironstone; metavolcanics; chlorite schist; pseudo-porphyry.		Z		**Z**		-
	DODOMAN	schist; gneiss; quartzite; amphibolite and hornblend gneiss; acid gneiss; migmatite.		D		**D**		-

Plutonic Rocks

Age	Lithology	Unit	Unit by LANDSAT Image Interpretation	
Mainly ARCHEAN	Granite and granodiorite, foliated, gneissose or migmatitic, some massive porphiyroblastic, includes intimately related regional migmatite.(Syn-orogenic)	gs	**gs**	**Topographic rough texture**
			gs-a	**Topographic intermediate texture**
			gs-b	**Topographic smooth texture. Strong weathered granite**

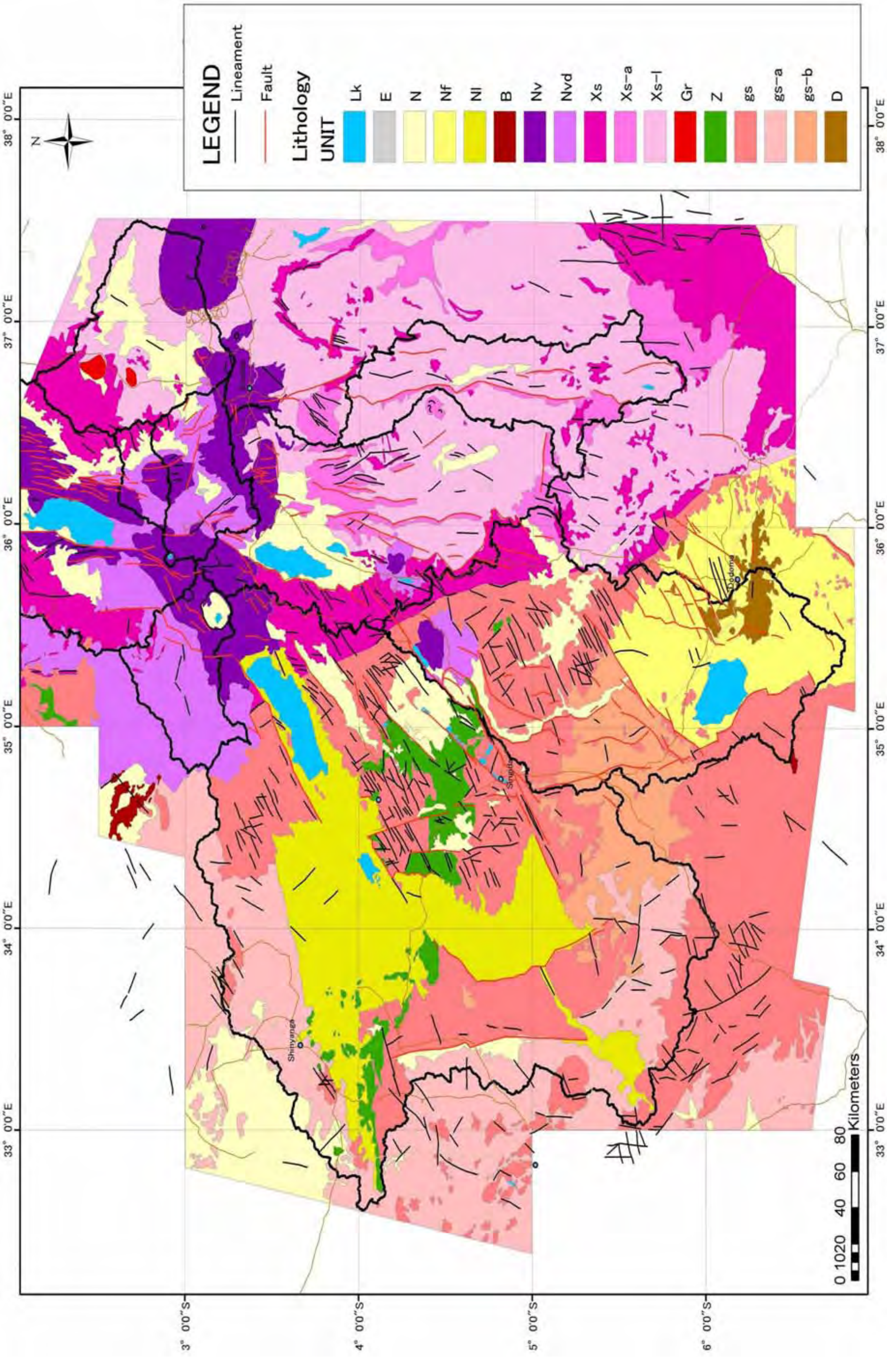


Figure 2-19 Geological Map of Internal Drainage Basin

1) Precambrian Basement Rocks

i) Dodoman System (Archean): D

The Dodoman system is the oldest formation in Tanzania, which consists of schist, gneiss and migmatite. It is distributed around Dodoma.

ii) Nyanzian System (Archean): Z

The Nyanzian system consists of banded ironstone, metavolcanics and chlorite schist. They are distributed in Shinyanga, Nzega, Igunga and Iramba district.

Since their surface soil characteristically shows dark reddish brown in colour, this system can be easily distinguished on LANDSAT Images. At the north of Singida Town, outcrops of gabbros were observed.

iii) Kavirondian System (Archean): V

The Kavirondian system consists of quartzite and phyllite. Outcrops of the rocks are confined at the limited area near Nzega.

iv) Usagaran System (Archean): Xs, Xs-a and Xs-l

The Usagaran system consists of marble, schist, gneiss and migmatite. These rocks crop out the large area of the eastern part of IDB

This formation can be classified into three units; "Xs", "Xs-a" and "Xs-l" based on their topographic features.

Some migmatite distributed in "Xs-a" and "Xs-l" units can be delineated on the LANDSAT images.

v) Bukoban System (Proterozoic): B

The Bukoban system consists of sedimentary rocks; mudstone, shale, sandstone, etc. Exposures of the rocks are confirmed at the limited area in the southern part of the Bahi Swamp.

vi) Plutonic Rocks (mainly Archean); gs, gs-a, gs-b and Gr

Plutonic rocks consist of granite and granodiorite, gneissose or migmatitic rocks. Plutonic rocks are widely distributed from the central to the western part of IDB.

Plutonic rocks can be classified into three units based on degree of weathering zone analyzed by their topographic features.

Unit "gs" widely distributed in almost whole area of plutonic rocks is characterized rough texture on the Landsat images and high altitude. Unit "gs-b" distributed along Tanzanian Railroad at Manyoni to the northwest is characterized very smooth texture. Unit "gs-b" corresponds to the thick weathered zone which are named as "Kilimatinde cement" in the published geological map.

Unit “gs-a” has intermediate feature between “gs” and gs-b. Unite “Gr” located near the country border at the north of Arusha forms raise being surrounded by USAGARAN system (Xs-l).

2) Kainozoic (Cenozoic) Formations: N, E, Nl and Nf

During late Neogene, lacustrine sediments, terrestrial sediments, fluviatile sediments, marine sediments and alluvial sediments deposited in the lakes and shallow basins formed by the warping of the surface that accompanied rift-faulting movements. These sediments are distributed in the centre of each basin and characterized by low plane in topography. Based on published geological map, these Cenozoic sediments were classified into four units (N, Nl, Nf and E). Since it is very hard to differentiate these units except evaporite in topographic features and also spectral features, their classification was adopted to Figure 2-19.

3) Volcanic Rocks: Nv and Nvd

From the central to the north-western part of IDB, extensive volcanic activity in association with rift-faulting movements can be seen from Mt. Hanang, Mt. Kilimanjaro and northward into Kenya. These huge volcanic massifs consisting of extensive alkaline lava and pyroclastics are accumulated. These volcanic activities have been continuing in small scale. In general, alkaline type volcanic rocks have high volatile contents such as H_2O, CO_2, F and so on. Distribution of volcanic lavas and pyroclastics can be delineated on the LANDSAT false colour image. In interpretation map, Cenozoic volcanic rocks are divided into “Nv” and “Nvd”. “Nv” consists of lava and pyroclastic rocks and forms volcano body.

(3) Geological Structure

Distribution map of faults and lineaments is shown in Figure 2-20. A lineament is defined to be “straight and/or semi-curve linear features on the surface, which seems to reflect subsurface geological structures such as fracture. In this study, fault can be distinguished from the presence of step structure along lineament.

A large number of lineaments and faults in association with rift-faulting movements were extracted from the almost whole of all the study area. From the eastern to northern part of IDB, N-S trending lineaments and faults are well developed. From the central to southern areas, a great number of NE-SW and N-S trending lineaments and faults were extracted. In the western area, N-S trending faults can be seen on the image however, lineaments are distributed sparsely and disorderly.

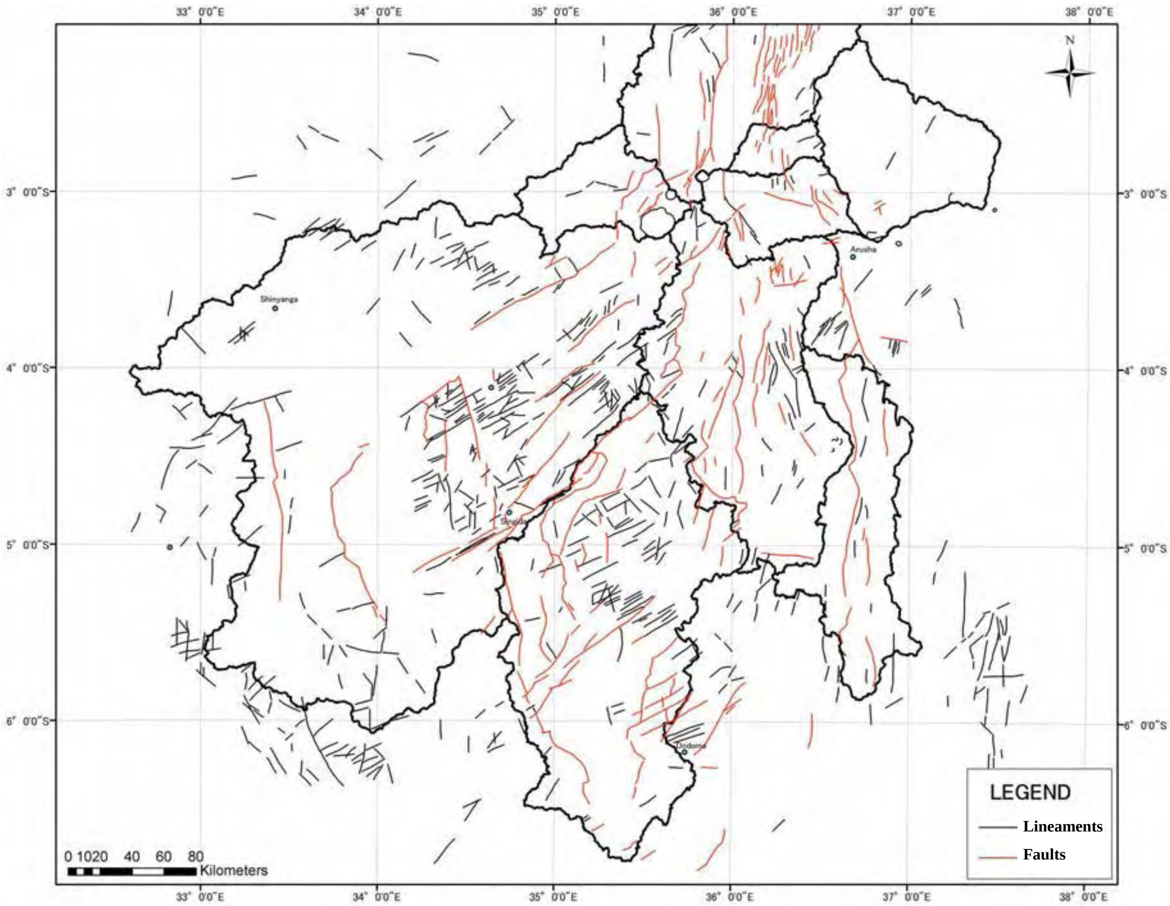


Figure 2-20 Distribution of Faults and Lineaments

2.4 Socio-economic Conditions of IDB

Socio-economic conditions of IDB are descried below. (Refer to Chapter 10 of Supporting Report for details) There are two kinds of contents: namely, overview of IDB's socio-economic conditions using existing statistic data in regional or district level, and another based on socio-economic survey by the Study Team.

2.4.1 General Socio-economic Conditions of IDB

(1) Administrative Setup and Population

- Administrative set up: 6 Regions, 24 Districts and 3 Municipalities, 432 Wards, and 1,606 Villages (Refer to Table 2-3)
- Total Population: Approximately *6.7 Million
- Population Density: 28 persons /km^2 (39 persons / km^2 in Tanzania)
- Average Household Number: 5.3 persons (4.9 persons in Tanzania)
- Urban Population: 11.3% (23.1% in Tanzania), Rural Population: 88.7% (76.9% in Tanzania)

(*This figure was calculated by district-wise data related to IDB. Most probable number of villages and total population within IDB were examined in Chapter 13 of Supporting Report.)

Table 2-3 Administrative Setup of IDB

Region	Total				IDB *3		
	Name of District/ Municipality	No. of Divisions	No. of Wards	No. of Villages	No. of Divisions	No. of Wards	No. of Villages
Arusha	Arumeru (Arusha & Meru) *1	6	37	169	1	11	24
	Karatu	4	13	45	4	13	52
	Monduli & Longido *1	6	20	86	6	20	69
	Ngorongoro	3	14	59	3	14	42
Manyara	Babati	4	21	92	4	21	92
	Hanang	5	22	63	5	22	63
	Kiteto	7	15	57	–	13	29
	Mbulu	5	16	78	5	16	78
	Simanjiro	6	12	45	–	5	12
Dodoma	Dodoma Municipality	4	30	119	–	13	13
	Dodoma Rural (Bahi & Chamuino) *1	8	48	147	–	25	60
	Kondoa	8	35	176	8	35	154
Shinyanga *2	Maswa	3	18	87	2	11	37
	Meatu	3	19	77	3	17	56
	Kishapu	3	20	111	3	20	70
	Shinyanga Municipality	3	13	70	3	13	70
	Shinyanga Rural	3	16	108	3	13	77
Singida	Singida Municipality	2	13	43	2	13	43
	Singida Rural	7	28	155	7	28	155
	Iramba	7	26	135	7	26	135
	Manyoni	5	21	82	–	19	66
Tabora	Nzega	4	37	144	3	27	68
	Igunga	4	26	113	4	26	113
	Uyui	3	17	98	2	6	21
	Sikonge	2	11	66	1	5	7
Total		115	548	2,425	>72	432	1,606

Note: *1: Dodoma Rural, Arumeru, and Monduli were separated.
*2: Bariadi and Kahama are out of IDB area in JICA Study.
*3: IDB is area within the Boundary of Internal Drainage Basin or area including Boundary Line.
Source: Socio-Economic Profile, National Bureau Statistics (NBS) and Regional Commissioner's Offic of Singida, Dodoma, Arusha, Shinyanga, Manyara and Tabora (Singida, 2005/Tabora, 2005/ Arusha, 2003/Dodoma, 2003/Manyara, 2005/Shinyanga, 1999)
Interview Survey Result by Each District/Municipal Council in 2005 by JICA Study Team

(2) General Economic Conditions

1) Agriculture

- Main Food Crops: Maize, Sorghum, Paddy, Millet etc.
- Main Cash Crops: Coffee, Cotton, Tobacco, Wheat etc which are cultivated in Arusha, Shinyanga and Tabora mainly. Seventy five percent of it is exported.
- Cultivated Land: Only 33.6% of arable area is utilized.
- Irrigated Land: Only 33% of Irrigation potential area is utilized.

2) Livestock:

- Cattle 7.6 million(50.6%), Goat 4.2 million(28.1%), Sheep 2.2 million (14.7%), Pig 0.1 million (0.7%), Poultry 0.7 million (4.6%) and Donkey 0.2 million (1.3%).
- Forestry, fisheries, beekeeping, hard wood and charcoal are popular in Tabora.

3) Industrial Sector

This sector is less developed in IDB except gold and diamond mining in Shinyanga and Tabora Region.

4) Tourism

Tourism industry is important in IDB for example Lake Manyara National Park, Arusha National Park and Ngrongoro Crater in Arusha Region.

5) General Economic Conditions

- GDP: Tsh 2,683 billion in six regions
- GDP/Capita: Tsh 279,124
- Economic contribution of IDB: 31.1% of National GDP.

Approximately 50% of GDP from agricultural sector.

(3) Social Service Conditions

1) Water Supply & Sanitation

- Coverage of water supply: 37.5% (Tanzania: 53.1%) (Refer to Table 2-4)
- Coverage of latrine: 77.2% in IDB. Rural area or mountainous area of IDB is less than 50% (Tanzania: 79.1%)

2) Health

- Health facility: 33 Hospitals (Tanzania: 217), 64 Health Centres (Tanzania : 402), 825 Dispensaries (Tanzania : 4,179)
- Main water-borne diseases in 2003: Choleras: 1,254 cases (33 deaths), Dysentery: 20,012 cases (10 deaths), Diarrhoeas<5 years old: 108,366 cases (94 deaths), Typhoid: 8,285 cases (14 deaths)

3) Education

- Literacy rate: 54% (Tanzania: 62%)
- Public primary school: 3,269 schools, enrolment: 1.6 million (Tanzania: 12,152 schools, Enrolment: 6 million)

(4) Economic Infrastructure

1) Transportation System

- Total road length in IDB: 25,984.5 km, 36% of national road network (Tanzania: 71,898.5 km)
- Paved road length in IDB: 834.1 km which is only 3% of total road length.
- One railway system: Tanzania Railway Corporation (TRC) in IDB.
- Two domestic airports have regular flight services: Shinyanga and Arusha Airport.

Singida is transit point for trucks and trailers from Dar es Salaam port to Mwanza port & Kigoma port.

2) Energy

- Ninety seven percent (97 %) of households use firewood and charcoal for cooking in IDB (Tanzania: 95%)

- Five percent (5 %) of electricity energy for lighting in IDB (Tanzania: 10%)

Table 2-4 Water Supply Coverage in IDB

Region	District/ Municipality	Total Population	Water Coverage Population	Piped, protected well/spring as source for drinking water (%)
Arusha	Arumeru (Arusha & Meru) *1	514,651	437,402	85.0
	Karatu	177,951	114,405	64.3
	Monduli (North Monduli & South	184,516	89,656	48.6
	Ngorongoro	129,362	43,776	33.8
Manyara	Babati	302,253	168,053	55.6
	Hanang	204,640	92,088	45.0
	Kiteto	152,296	35,028	23.0
	Mbulu	237,280	55,998	23.6
	Simanjiro	141,136	51,091	36.2
Dodoma	Dodoma Municipality	324,347	208,231	64.2
	Dodoma Rural (Bahi & Chamuino) *1	438,866	224,699	51.2
	Kondoa	428,090	166,099	38.8
Shinyanga	Maswa	304,402	110,802	36.4
	Meatu	248,214	86,130	34.7
	Kishapu	239,305	30,152	12.6
	Shinyanga Municipality	134,523	92,417	68.7
	Shinyanga Rural	276,393	74,350	26.9
Singida	Singida Municipality	114,853	69,945	60.9
	Singida Rural	400,377	157,749	39.4
	Iramba	344,000	103,200	30.0
	Manyoni	160,000	58,240	36.4
Tabora	Nzega	415,203	104,216	25.1
	Igunga	324,094	29,168	9.0
	Uyui	281,101	30,078	10.7
	Sikonge	132,733	6,106	4.6
Related Districts/Municipalities of IDB Total		6,286,239	2,358,675	37.5
Tanzania Average		34,569,232	18,342,434	53.1

Note: *1: Dodoma Rural, Arumeru, and Monduli were separated.
*2: Bariadi and Kahama are out of IDB area in JICA Study.
Source: Regional Profiles, 2004, NBS (http://www.nbs.go.tz./)
2002 Population and Housing Census General Report (NBS,Janualy, 2003)
2002 Population and Housing Census Village and Street Statistics Volume Ⅶ (NBS,June, 2005)
2002 Population and Housing Census District Profile Ⅳ(NBS,May, 2004) of Singida Region
The Result of Interview Survey in Kishapu District.

2.4.2 Socio-economic Survey Results

The main objectives of socioeconomic survey are to understand socioeconomic conditions, water sources and Operation and Maintenance (O&M) conditions of existing water supply facilities in IDB by using original data from the sample villages. The contents of the survey are summarized in Table 2-5 and the location of the surveyed villages is shown in Figure 2-21.

Table 2-5 Contents of Socio-economic Survey

Type of Survey	Method	Target	Item of Survey	
Village Survey	Questionnaire Survey	100 villages (one person per each village)	1. General Information	Populaation, number of households, tribes, road accessibility, power supply, telecommunication, village pattern, infrastructure, economic activity
			2. Water Sources Condition	Type/number/utilization of water resources, distance/time of main water source (rainy season/ dry season), facility of fetching and storing of water, main problem of water
			3. O&M conditions of Existing Water Supply Facilities	Existing water users organization and their activities, initial cost for construction, of water supply facilities, O&M cost, consciousness of O&M etc.
			4. Conditions of Health and Hygiene/ Sanitation	Ratio of water borne diseases, consciousness of prevention of water borne diseases, coverage rate of latrine, consciousness of hygiene/sanitation, supporting of hygiene/sanitation education etc.
			5. Condition of Fluoride Problem	Experience of fluoride problem, knowledge of fluoride problem, Idea for prevention of fluoride problem, Magadi condition and utilization of Magadi etc.
Household Survey	Questionnaire Survey	400 households (100 villages x 4 households, two men and two women)	1. General Information	Number of families, economic condition (income/expenditure), work shearing for housekeeping, load of housekeeping in women
			2. Water Sources Condition	Type/number/utilization of water resources, distance/time of main water source (rainy season/ dry season), distance to water sources, fetching time, person for fetching water, storage of water, times of fetching water a day, time zone of fetching water, main problem of water/ sanitation
			3. O&M conditions of Existing Water Supply Facilities	Existing water users organization and their activities, initial cost for construction, acknowledgement of O&M, support from village for water sector etc.
			4. Conditions of Health and Hygiene/ Sanitation	Ratio of water borne diseases, consciousness of water borne diseases, existence of latrine, consciousness of hygiene/sanitation, supporting of hygiene/sanitation from village etc.
			5. Condition of Fluoride Problem	Experience of fluoride problem, knowledge of fluoride problem, Idea for prevention of fluoride problem, Magadi condition and utilization of Magadi etc.
Supplemental Survey	Interview Survey/ Group Discussion	(1) Interview Survey 18 villages x two households (two men and two women)	Economic condition, water resources conditions, O&M conditions of existing water supply facilities, conditions of health and hygiene/ sanitation, and fluoride problem etc.	
		(2) Group discussion 2 villages (Leader, VEO*, Community members)	Economic conditions of village, water resources conditions in village, conditions of health and hygiene/ sanitation of people, O&M conditions of existing water supply facilities in village, fluoride problem, Utilization of Magadi by people, conditions of water rights & water user fee etc.	

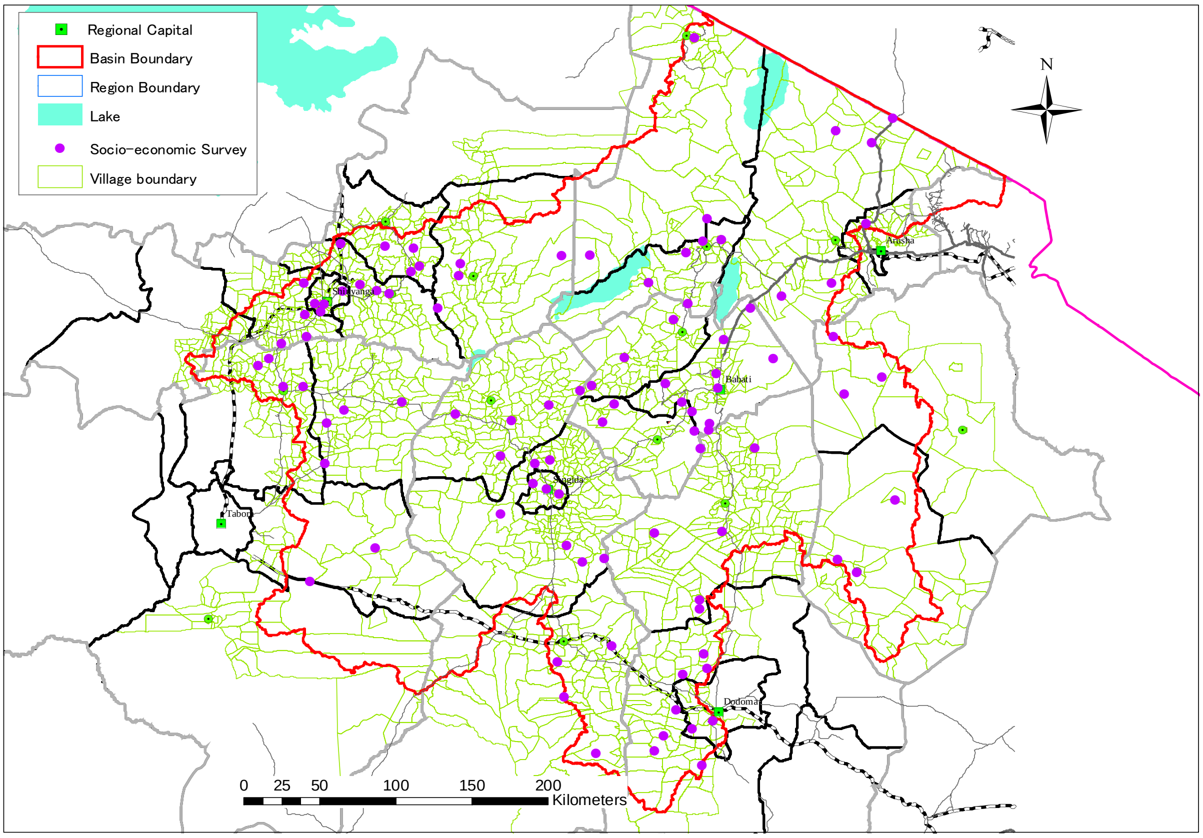


Figure 2-21 Distribution of Village for Socioeconomic Survey

(1) Economic Activities and Balance of Households

Agriculture is the main economic activity in IDB and people earn the income for their living by practicing agriculture in combination with livestock, labour work, making/selling of charcoal, employment and others. (Refer to Figure 2-22) Since there is insufficient water in the rivers of IDB, agricultural production is limited in the rainy season. Therefore, almost of all villagers can earn their income only once in a year during the harvest season. Their average income is approximately Tsh920,000/year/household. As for profitability of each economic activity, villagers think higher profitability from livestock than agriculture although livestock occupies small proportion of regular income source as shown in Figure 2-24. Villagers continue to rear livestock

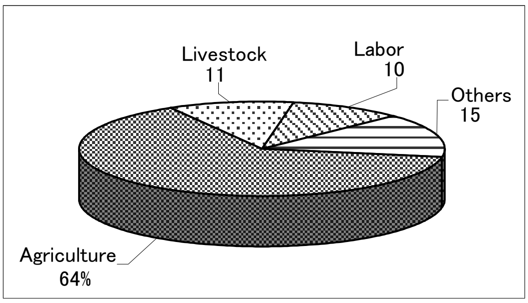


Figure 2-22 Main Economic Activity of Households

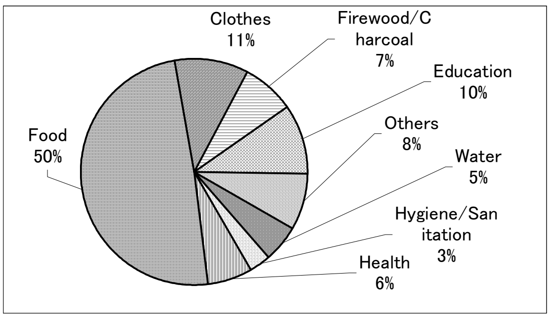


Figure 2-23 Average Annual Expenditure

until they need a large amount of money for any specific purpose. On the other hand, the average annual expenditure is equivalent to 70 % of income as shown in Figure 2-23. The ratio of expenditure for water related matters is 5 %, sanitation and hygiene is about 3 %.

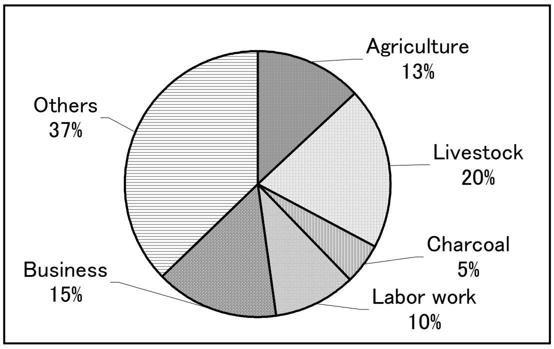


Figure 2-24 Profitability of Each Economic Activity

(2) Water Source and Usage

Seasonal difference of water usage by water sources is shown in Figure 2-25. Traditional dug well is high ratio in both seasons. As for borehole, the ratio of it becomes twice in dry season. Villagers intend to use traditional dug well, regardless borehole is stable and safety as water source. This means their intention trends to more easily fetching of water and economical reason yet.

Daily water consumption of household is shown in Figure 2-26. More than 25% of them consume 60-120 L/day. The National Water Policy 2002 of Tanzania sets up 25 L /person/day for rural water supply as the standard unit consumption. Since average family size is 6 people based on household survey, the average unit consumption is less than the standard value. Most of the villagers usually fetch water twice a day: namely, 6 to 9 am and 3 to 5 pm.

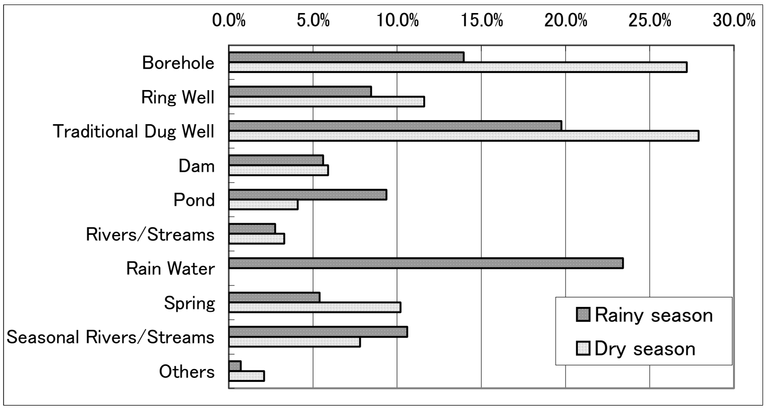


Figure 2-25 Main Water Source in Village

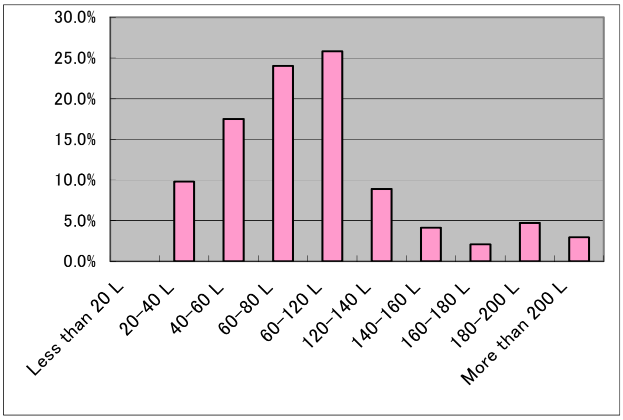


Figure 2-26 Daily Water Consumption

(3) Fetching Water

1) Distance from Water Source

A distance from water source to fetch water in rural area is set up within 400m in "National Water Policy 2002". According to the result of the household survey, 43.5% of villagers have water sources within 500m from their houses in the rainy season and 18.2% of them are obliged to go more than 2,000m away even in the rainy season. (Refer to Table 2-6) However, the ratio of villagers whose water sources are located within 500m decreases to 20.4% on average in the dry season and the ratio of villagers whose water sources are located over 2,000m away increases to 33.6% in the dry season. It is assumed that the quantity of water used by villagers are not enough or not at all available in the dry season. Therefore, the ratio of villagers who have water source within 500m decreases from 43.5% in the rainy season to 20.4% in the dry season. On the contrary, the ratio of villagers who have water source over 500m away increases from 56.5% in the rainy season to 79.6% in the dry season.

Table 2-6 Distance from Water Source to Household

<Rainy Season> (%)

Water Source	Distance from Water Source to Household (m)						Distance from Water Source to Household(m)	
	< 200	200～500	500～1000	1000～1500	1500～2000	> 2000	**< 500**	**> 500**
Borehole	16.1	23.4	18.2	14.6	10.9	16.8	**39.4**	**60.6**
Ring well	7.2	26.5	14.5	20.5	14.5	16.9	**33.7**	**66.3**
Traditional Dug well	15.5	10.8	15.5	17.0	17.5	23.7	**26.3**	**73.7**
Dam	7.3	7.3	14.5	18.2	12.7	40.0	**14.5**	**85.5**
Pond	10.9	25.0	19.6	14.1	14.1	16.3	**35.9**	**64.1**
Stream/River	3.7	3.7	37.0	11.1	14.8	29.6	**7.4**	**92.6**
Rain water	87.4	9.1	1.3	0.9	0.9	0.4	**96.5**	**3.5**
Spring	11.3	3.8	18.9	13.2	17.0	35.8	**15.1**	**84.9**
Seasonal Stream/River	4.8	8.7	15.4	20.2	21.2	29.8	**13.5**	**86.5**
Other	28.6	71.4	0.0	0.0	0.0	0.0	**0.0**	**0.0**
All Water Sources	29.2	14.3	13.4	12.8	1.1	18.2	**19.3**	**56.5**

<Dry Season> (%)

Water Source	Distance from Water Source to Household (m)						Distance from Water Source to Household(m)	
	< 200	200～500	500～1000	1000～1500	1500～2000	> 2000	**< 500**	**> 500**
Borehole	13.0	20.3	14.6	17.2	10.4	24.5	**33.3**	**66.7**
Ring well	12.2	20.7	13.4	13.4	13.4	26.8	**32.9**	**67.1**
Traditional Dug well	8.6	6.1	12.2	17.8	18.8	36.5	**14.7**	**85.3**
Dam	2.4	4.8	9.5	16.7	23.8	42.9	**7.1**	**92.9**
Pond	3.4	3.4	20.7	27.6	20.7	24.1	**6.9**	**93.1**
Stream/River	0.0	8.7	26.1	39.1	17.4	8.7	**8.7**	**91.3**
Rain water	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Spring	6.9	2.8	16.7	12.5	12.5	48.6	**9.7**	**90.3**
Seasonal Stream/River	1.8	7.3	7.3	20.0	12.7	50.9	**9.1**	**90.9**
Other	7.1	28.6	0.0	14.3	7.1	42.9	**35.7**	**64.3**
All Water Sources	8.6	11.8	13.5	17.7	14.9	33.6	**48.4**	**79.6**

2) Time for Fetching Water

In case of rural water supply scheme of Tanzania, target time for fetching water is set up within 30 minutes in "National Water Sector Development Strategy 2005". According to the result of the household survey, approximately 55.4% of the villagers are in the category in the rainy season.

However, it decreases to 18.4% in the dry season and besides, 81.6% of villagers take time over 30 minutes in the dry season. (Refer to Table 2-7)

As a matter of course, the fetching time is related to distance from water source but it should be paid attention to waiting time caused by congestion of water users at water source. Water supply problem in rural area is not only the distance to water source but also water supply volume.

Table 2-7 Time for Fetching Water

<Rainy Season> (%)

Water Source	Time for Fetching Water (minute)						Time for Fetching Water (minute)	
	< 10	10～20	20～30	30～40	40～50	> 50	**< 30**	**> 30**
Borehole	13.9	19.0	13.1	21.2	9.5	23.4	**46.0**	**54.0**
Ring well	9.6	9.6	33.7	14.5	13.3	19.3	**53.0**	**47.0**
Traditional Dug well	9.3	12.4	15.5	15.5	15.5	32.0	**41.8**	**58.2**
Dam	7.3	10.9	16.4	14.5	10.9	40.0	**29.1**	**70.9**
Pond	9.8	19.6	14.1	20.7	7.6	28.3	**55.4**	**44.6**
Stream/River	7.4	7.4	18.5	22.2	18.5	25.9	**44.4**	**55.6**
Rain water	74.8	12.6	8.3	1.3	1.3	1.7	**97.8**	**2.2**
Spring	1.9	7.5	28.3	11.3	20.8	30.2	**34.0**	**66.0**
Seasonal Stream/River	4.8	9.6	13.5	19.2	12.5	40.4	**28.8**	**71.2**
Other	0.0	28.6	28.6	0.0	14.3	28.6	**55.4**	**44.6**
All Water Sources	28.9	11.9	14.6	13.2	11.8	19.6	**44.6**	**44.6**

<Dry Season> (%)

Water Source	Time for Fetching Water (minute)						Time for Fetching Water (minute)	
	< 10	10～20	20～30	30～40	40～50	> 50	**< 30**	**> 30**
Borehole	8.9	5.2	10.4	9.4	8.9	57.3	**24.5**	**75.5**
Ring well	4.9	9.8	15.9	7.3	12.2	50.0	**30.5**	**69.5**
Traditional Dug well	4.6	6.6	7.1	4.1	8.6	69.0	**18.3**	**81.7**
Dam	0.0	2.4	4.8	11.9	19.0	61.9	**7.1**	**92.9**
Pond	0.0	6.9	3.4	13.8	13.8	62.1	**10.3**	**89.7**
Stream/River	0.0	0.0	21.7	8.7	30.4	39.1	**21.7**	**78.3**
Rain water	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Spring	0.0	4.2	1.4	6.9	12.5	75.0	**5.6**	**94.4**
Seasonal Stream/River	0.0	7.3	0.0	9.1	14.5	69.1	**7.3**	**92.7**
Other	0.0	14.3	7.1	0.0	0.0	78.6	**21.4**	**78.6**
All Water Sources	4.2	6.1	8.1	7.5	11.3	62.7	**81.6**	**81.6**

(4) Organization for O&M of Water Supply Facility

In Tanzania, people are bound to establish an organization called WUG (Water User Group) or WUA (Water User Association) for each water supply facilities and they have to operate and maintain by themselves. WUG is the community organization for O&M of each water supply facility, and WUA are formed of several WUG, water supply vendors, and water users in town etc. During the supplemental survey, it was seen in some villages where some boreholes were broken. The villagers in there use water sources such as traditional dug wells, rivers/streams, and ponds without repairing the existing water supply facility. The reasons why they don't repair their water supply facilities is “no money for maintenance of water supply facilities” or “saving money for new water supply facilities instead of maintenance”.

According to the village survey, more than half of the 57 villages which have activated WUG/WUA answer that “more than Tsh 1,000 was collected from each household as contribution” for initial cost of water supply facility in their villages. If villagers could not pay for it, they provide their labour for construction work. Approximately 40 % (23 villages) of 57 villages, which have WUG/WUA, do not collect O&M cost of water supply facility and 25 % (14 villages) of them collect more than Tsh 50 per 20 L. There are 12 % (7 villages) of them which collect “Tsh 20 per 20 L as the same as Tanzanian average value. In Tanzania, each community has to make a rule and to manage O&M based on the rule. Therefore, each community has to decide the amount of initial cost or O&M cost, and manage the money collection from villagers, preparation of spare parts for maintenance. The person in charge of managing the money is either the leader of WUG/WUA, accountant of WUG/WUA, or village leader based on their rule.

There are villages with WUG/WUA but some of them were not functioning due to lack of knowledge of O&M for water supply facility, lack of support/service provided by the government (District council etc), and insufficient funding for O&M”.

As to water right fee, most villagers or village leader/chair person did not know that all users have to pay water right fee to IDB Water Office. They understand the initial cost to construct water supply facility and O&M cost for repair of water supply facility. However, they do not understand why they have to pay water right fee. Therefore, sustainable sensitization or education is needed to all users.