2.4 Hydrology

2.4.1 River Systems

There are two main river systems in Zambia, namely the Zambezi River and the Zaire (Congo) River. The Zambezi river system covers three quarters of the country and can be divided into three smaller river systems, the Zambezi Main River, the Kafue River and the Luangwa River. The Zaire river system includes the rivers in the northern region, mainly the Chambeshi and Luapula rivers. The two rivers join near to Lake Bangweulu. Lake Tanganyika is on the border with Tanzania.

The basin area of the six main river systems in Zambia is shown in Table 2-25. Referring to Figure 2-22, the physical features of the six main river systems, lakes and swamps are described as follows:

Table 2-25 River Length and Basin Area of Six Main River Basins

River System	Length in Zambia (km)	Basin Area (km^2)		
		Total	In Zambia	Out of Zambia
Zambezi Main River Basin	1,700	687,049	268,235	418,814
Kafue River Basin	1,300	156,995	156,995	0
Luangwa River Basin	850	147,622	144,358	3,264
Chambeshi River Basin	560	44,427	44,427	0
Luapula River Basin	615	173,396	113,323	60,073
Lake Tanganyika Basin	* 250	249,000	15,856	233,144
Other Basin	-	-	8,658	-
Total	5,275	1,458,489	751,852	715,295

* Lufubu River

<u>Zambezi Main River</u>

The numerous tributaries of the Zambezi Main River originate in the Zambezi - Zaire watershed. Flowing in a general southward direction, they converge to form a great river just a little to north of Mongu, in the Western Province. The river flows further southwards from Mongu to Sesheke, where it turns eastwards. At Livingstone it plunges down the Victoria Falls, one of the greatest waterfalls in the world. Further down the valley it broadens out to form Lake Kariba (the largest man-made lake in the world) behind the Kariba Dam. The river flows north from Kariba to Chirundu, where it is joined by the Kafue River. Once again turning eastwards it reaches Feira, where it is joined by the Luangwa River. The Zambezi Main River forms the southern border of Zambia between Sesheke and Feira. The number of tributaries of the Zambezi river is relatively low, because they flow over a plain composed of unconsolidated sands.

<u>Kafue River</u>

The Kafue River originates at the eastern end of the Zambezi - Zaire watershed in the Copperbelt Province, and flows in a south-easterly direction to a point near Kitwe. It then turns southwards or south-westwards and flows into the Itezhi-Tezhi Dam reservoir. Afterwards it turns eastwards and travels across the Kafue Flats and into the Kafue Gorge Dam reservoir. From the hydropower station, it flows through the steep Kafue Gorge before joining the Zambezi Main River near Chirundu. The density of tributaries is high in the northern parts of the basin, and becomes lower in the southern part of the basin.

Luangwa River

The Luangwa River originates in the Mufunga Hills of the Luangwa-Malawi watershed near the extreme northeast of the country. It flows in a south-westerly direction across the eastern part of the country. It merges with the Lunsemfwa tributary upstream of the Luangwa Road Bridge and joins the Zambezi river near Feira. Between Luangwa Road Bridge and Feira, the river becomes the border between Zambia and Mozambique. The Luangwa River flows on the floor of a rift trough bordered by escarpment on both sides and a large flood plain extends along the river. The Luangwa valley is the broadest of the river valleys in the country, and the terrain is lowest. The density of tributaries is low in flood plain but high in the escarpment area.

Chambeshi River

The Chambeshi River originates in the Mbala highlands, the country's northeast boundary with Tanzania. Merging with a number of streams, it flows south-westwards in the Northern Province. Downstream of Chambeshi Old Pontoon, it is joined by the Lukulu River and reaches to Mbati. The river name changes to the Luapula River at the boundary between the Northern Province and the Luapula Province. Most of the basin is located in high plateau and mountain areas, so that the density of tributaries is relatively high and many small tributaries have developed.

Luapula River

The Luapula River originates from Lake Bangweulu and the Chambeshi River. It flows in a southerly direction to Mukuku, and turns westwards and then northwards till it falls into Lake Mweru. The Luapula River is an international river like the Zambezi River. From Mukuku to Lake Mweru, it forms the international border between Zambia and Zaire. The density of tributaries is high in the southern part of the basin, but is low in the northern parts.

Lake Tanganyika basin

The Lufubu River is a main river in the Lake Tanganyika basin which is a closed tectonic lake. This river flows into Lake Tanganyika.

Lakes

The major lakes which lie within or along the borders of Zambia are, Lake Kariba, Lake Bangweulu, Lake Mweru, Lake Mweru Wantipa and Lake Tanganyika. Of these, Lake Bangweulu and Lake Mweru Wantipa lie within the country and the rest are the country's borders. A large number of minor lakes are also found in different parts of the country.

Swamps

Great areas in some parts of the country are swamps. The largest of them lies to the east and southeast of Lake Bangweulu, namely the Bangweulu Swamp. Another major one is the Lukanga Swamp in the Kafue River basin in the Central Province.

Flood Plain

The major rivers annually inundate large areas in their valleys and plains. Great stretches of land in the Western Province, known as Barotse Flood Plain, are regularly flooded by the Zambezi River during the rainy season. Similar flooding takes place annually in the Kafue Flats and Luangwa Valleys.

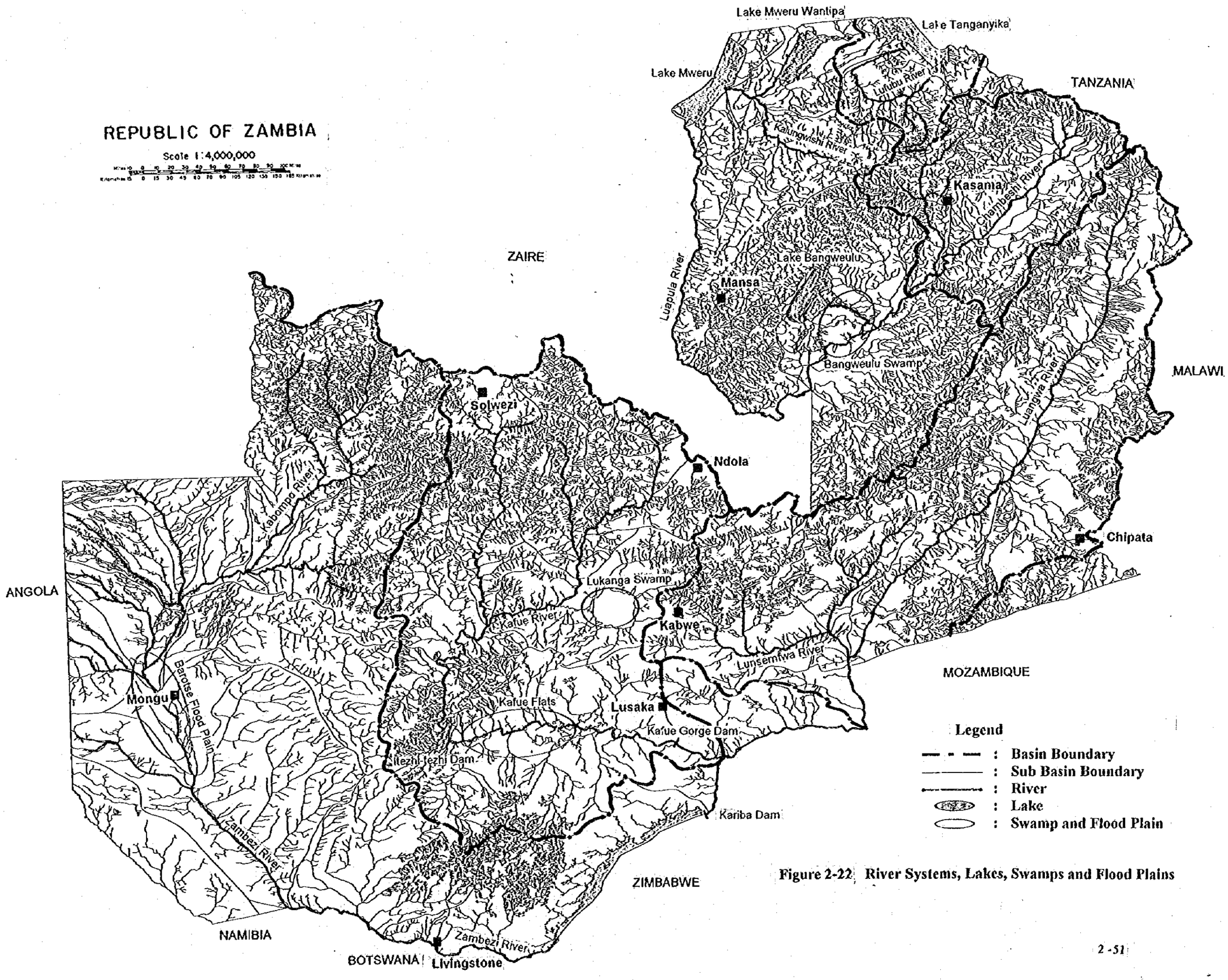

Figure 2-22 River Systems, Lakes, Swamps and Flood Plains

2.4.2 Network of Hydrometric Stations

Hydrological data in Zambia is observed, collected and archived by the Hydrological Branch, Department of Water Affairs (DWA), Ministry of Energy and Water Development (MEWD) and is available to the public.

There are 243 hydrometric stations registered in DWA and their location is shown in Figure 2-23. At 160 of these stations, water levels have been measured continuously to date and 174 stations have discharge rating curves. The number of hydrological stations by the river basin are presented in Table 2-26.

Table 2-26 Number of Hydrometric Stations by River Basin

River Basin	Hydrometric Stations Registered	Hydrometric Stations Opened	Hydrometric Stations with Discharge Rating Curve
Zambezi	64	43	45
Kafue	89	44	62
Luangwa	21	18	16
Chambeshi	27	24	26
Luapula	35	24	20
Lake Tanganyika	7	7	5
Total	243	160	174

Source : The Master Plan Study on Hydrometric Observation Systems of the Major River Basins in Zambia, JICA, March 1992

DWA collects water level and discharge measurement data. At hydrometric stations operated by DWA, all water levels are recorded on staff gauge plates calibrated mostly in feet. Autographic monitoring stations which previously existed at 12 sites have been discontinued due to operating problems (access, consumables, regular maintenance, etc.). The water level information which is collected by gauge readers employed by DWA, is returned on a monthly basis to the regional office. The data is checked and forwarded to the Hydrological Branch in Lusaka where it is entered into monthly summary sheets. All water level and flow measurement data managed by DWA are filed in the Hydrological Branch. The computerisation of data processing has advanced since the previous JICA project in 1992. DWA keeps most water level data on computer as LOTUS-123 files but only some of the flow measurement data are stored on computer.

Discharge measurements are normally carried out from bridges or boats using a current metre. Discharge rating curves for 174 hydrometric stations have been prepared from results of discharge measurements. However, existing discharge rating curves, with the exception of those made by JICA in 1992, are so old that checks and recalibration are necessary. Furthermore, the reliability and accuracy of the current metres and associated equipment needs to be evaluated.

Other agencies have operated systems of hydrometric stations either for specific area research projects (NCSR) or for specific monitoring requirements (ZRA). NCSR has 4 stations with over 20 years of records and ZRA has 5 telemetric stations in the Zambezi River basin. In terms of dam flow data and dam operation data, SADC Hydroelectric Hydrological Assistance Project Office (hereinafter SADC Project Office) has the data for Itezhi-Tezhi Dam and Kafue Gorge Dam, and ZRA has the data for Kariba Dam.

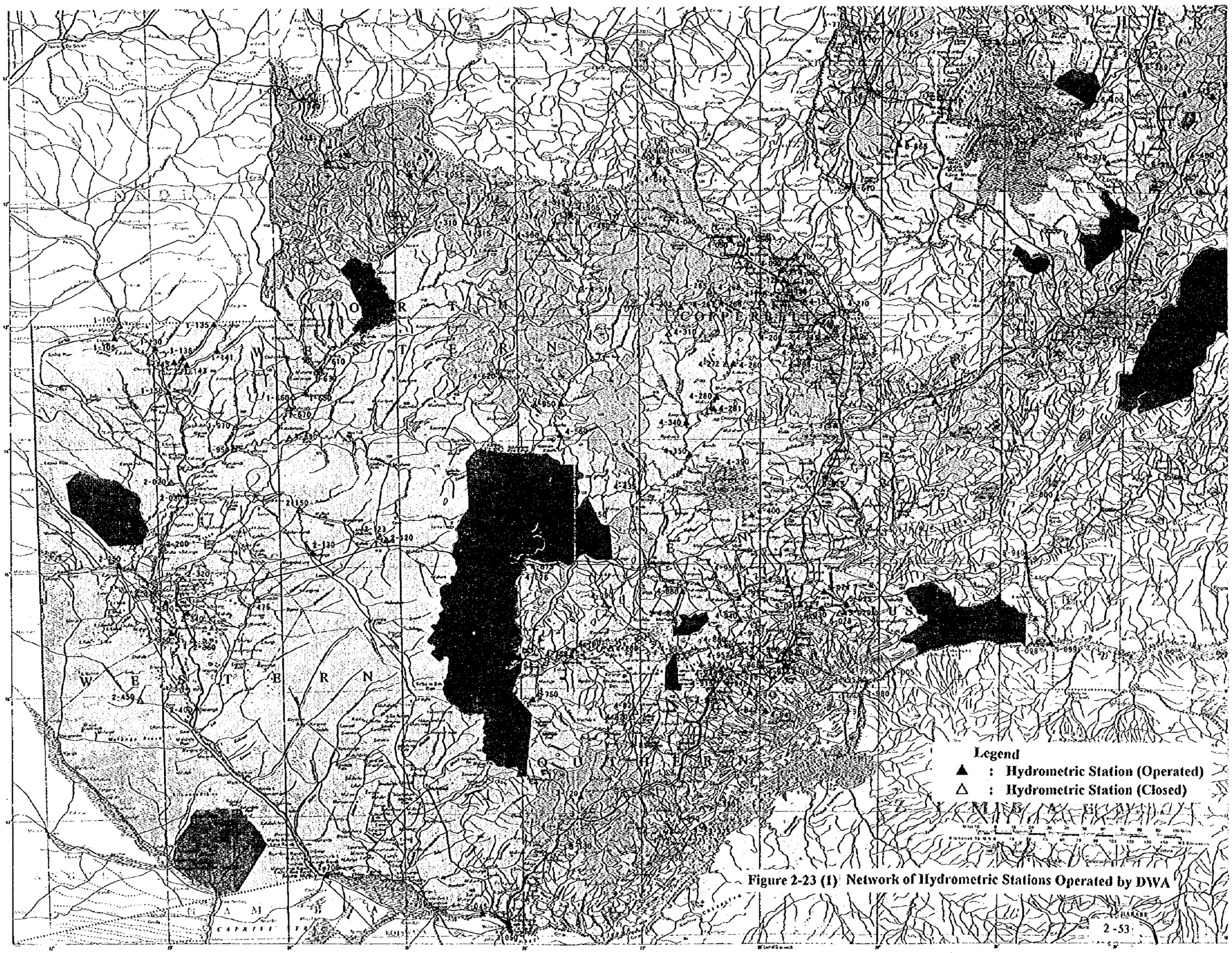

Figure 2-23 (1) Network of Hydrometric Stations Operated by DWA

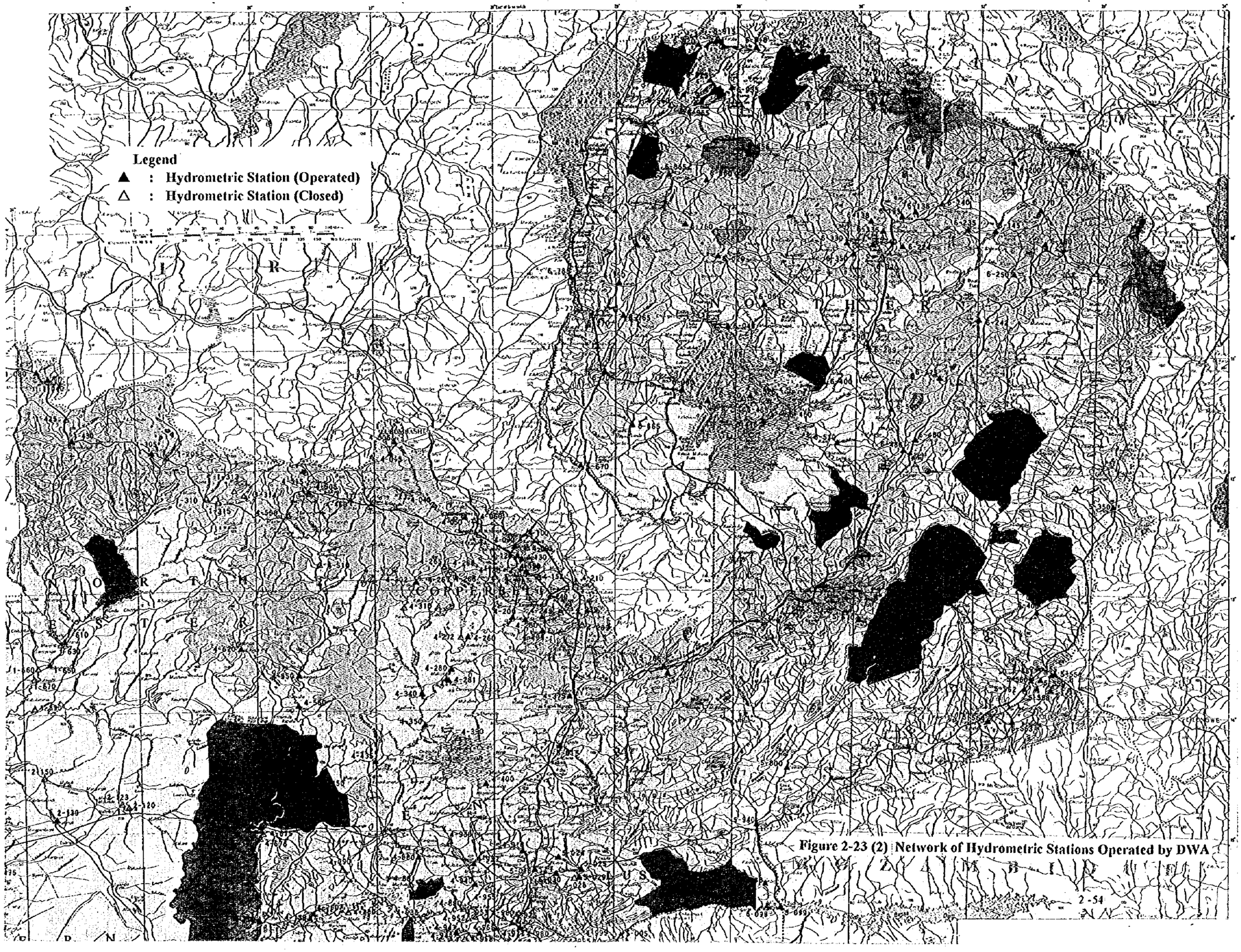

Figure 2-23 (2) Network of Hydrometric Stations Operated by DWA

2.4.3 River Flow Condition at Main Points

Average monthly mean discharge, average flow regime and runoff percentage over the last 30 years (1963/64-1992/92) at the main points of the six river systems are shown in Table 2-27 and Figure 2-24. The flow condition of the main rivers can be described as follows :

- The Zambezi Main River has the biggest catchment area in Zambia and the average discharge at Victoria Falls Big Tree is 1,187 m^3/s. The monthly mean discharge at Victoria Falls Big Tree increases from November to April and peaks in April. Runoff percentage of the Zambezi Main River has not been calculated, but that of the Kabombo River, a tributary of the Zambezi Main River, is estimated as 9.5 %.
- The Kafue River flows through the Copperbelt and Central Provinces and close to Lusaka Province, and is the most important river in Zambia. The average discharge at Kafue Hook Bridge is 308 m^3/s and the monthly mean discharge increases from November to March and peaks in March. The runoff percentage at Kafue Hook Bridge is 8.8 %.
- The Luangwa River flows through the Eastern and Central Provinces. The average discharge at Luangwa Road Bridge is 639 m^3/s and the monthly mean discharge increases from November to February and peaks in February or March. The runoff percentage at Luangwa Road Bridge is 16.7 %.
- The Chambeshi and Luapula River basin is located in the Northern and Luapula Provinces. The average discharge at Kashiba is 741 m^3/s and the monthly mean discharge increases from November to March and peaks in March and April. The runoff percentage at Kashiba is 13.8 %.
- The average discharge and runoff percentage at Keso Falls on the Lufubu River, one of the large tributaries of Lake Tanganyika, is 66 m^3/s and 19.4 %.
- The specific average discharge of the main rivers ranges from 2 to 8 $m^3/s/1000km^2$.
- The runoff percentage of the main rivers ranges from 9 % to 23 %.
- The coefficient of river regime (ratio of maximum to minimum discharge) of the main rivers ranges from 8 to 29, excluding the high value of 118 for the Luangwa river.

Table 2-27 Flow Characteristics at Main Points

River Basin	Zambezi		Kafue		Luangwa	Chambeshi	Luapula	Tanganyika
C.A. : km² (from abroad)	687,049 (418,814)		156,995 (0)		147,622 (3,264)	44,427 (0)	173,396 (60,073)	15,856 -
Station No. (C.A. : km²)	Lukulu 2-030 (206,531)	Victoria F (ZRA) (513,780)	Smith's B 4-130 (8,914)	Kafue H/B 4-669 (96,239)	Luang. R/B 5-940 (140,922)	Chamb. OP 6-289 (34,745)	Kashiba 6-785 (161,275)	Keso Falls 7-750 (9,027)
Monthly Mean Discharge (m³/s)								
October	296	337	12	66	56	40	237	17
November	336	354	16	70	67	40	195	20
December	498	507	46	142	424	75	265	41
January	863	777	100	338	1,32	170	536	77
February	1,3	1,2	157	619	1,91	307	1,0	112
March	1,7	1,9	186	774	1,86	461	1,7	161
April	1,6	2,7	156	709	1,12	471	1,7	149
May	957	2,5	89	428	420	294	1,2	77
June	569	1,7	50	229	214	155	931	48
July	428	949	33	147	146	96	712	34
August	358	579	24	113	104	68	488	25
September	312	423	17	86	73	51	323	19
Flow Summary (m³/s)								
Maximum	2,1	3,2	251	1,1	4,23	582	2,0	301
High	1,0	1,7	116	469	849	280	1,0	89
Usual	503	777	46	173	202	108	606	41
Low	342	449	21	95	87	55	294	23
Drought	282	316	10	55	39	35	190	15
Minimum	270	298	9	49	36	33	174	14
Average	777	1187	74	308	639	185	741	66
Runoff Depth	119mm	74mm	266mm	101mm	139mm	168mm	161mm	221mm
Rainfall	-	-	1,251m	1,184m	877mm	1,323mm	1,167m	1,141m
Runoff Percentage	-	-	22.6%	8.8%	16.7%	12.7%	13.8%	19.4%

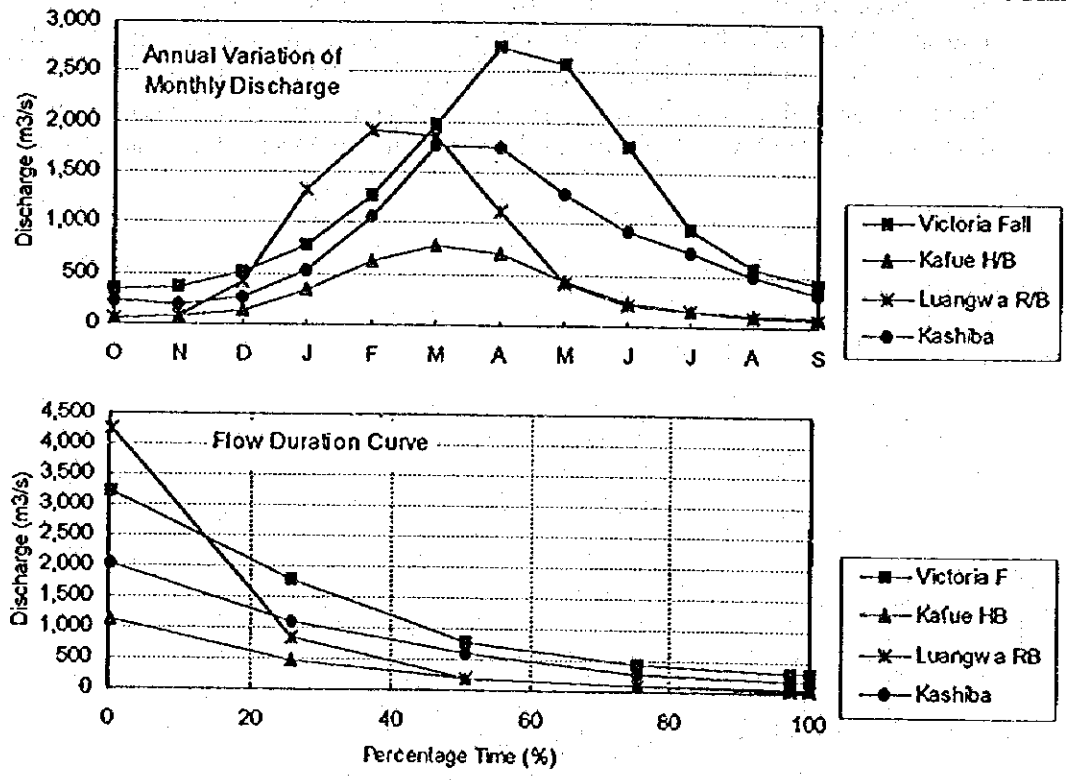

Figure 2-24 Flow Characteristics at Main Points

CHAPTER 3 CURRENT SITUATIONS AND FUTURE DEMAND FOR WATER RESOURCES DEVELOPMENT

3.1 Projected Conditions of Socio-economic Structure

3.1.1 Development Policy and Plans

(1) National Development Plans

Since the MMD government was voted into office in October 1991, the government made an economic recovery programme to show the people the new economic and financial policy framework. This recovery programme is called as "Policy Framework Paper (PFP)". In 1992 when the new government started, the "Fourth National Development Plan, 1989-1993" was effective as economic development policy. By PFP instead of the Fourth Plan, however, the government adopted the comprehensive reform plan aimed at bringing the budget into balance, encouraging exports, liberalising the economy, cutting back the civil services, and starting the privatisation process. This policy was reflected in the budget programme of the central government, so called as "Public Investment Programme (PIP)". Although the government revises PFP and PIP annually as rolling plan, the government has not announced to make a new five-year national development plan so far.

The government has not presented a long-term national development plan. Since the World Bank published a long-term perspective study of development in Africa south of the Sahara in 1989, African countries were strongly urged to prepare national long-term perspective studies. Taken this background into account, the new government undertook to establish a vision of what the economy of Zambia should be in the year 2020. The study, named as "National Long-Term Perspective Study for Zambia", has been launched in June 1994. The study will be conducted for two years, originally scheduled from March 1994 to February 1996. The study is being implemented on financial support of UNDP.

Zambia's pre-drought objective was to achieve real GDP growth rates of 2% in 1992, 3% in 1993 and 4% in 1994. It implies a positive real per capita growth by the end of 1994. The favourable weather conditions in 1993 could offset the drought of 1992. In fact, GDP in 1993 changed 9.2% at real term over 1992, according to "Economic Report 1993". The 4% growth remains the target for GDP growth in 1994. The new programme for 1994-1996 says to achieve growth rates of 5% in 1995 and 1996. With these growth rates, per capita income will be expected to rise because these rates exceed population growth.

(2) Sectoral Development Plans

(a) Agricultural Sector Investment Programme

This programme is an agricultural investment programme, named as "Agricultural Sector Investment Programme (ASIP)". It was just finalised by MAFF in July 1994, supported by the World Bank. The programme presents the three main policies in the sector for the coming five years. They are: 1) institutional reforms, 2) support for private sector investment and 3) rehabilitation and strengthening public sector agriculture services. The programme expects to achieve a rate of annual 6% growth in agricultural sector, while the nation is expected to grow at 5% annually. This sectoral growth is attained mostly by the private sector's investment, since donor aid and GRZ's public expenditure for the sector will be reduced gradually during

the planning period, from 1995 to 1999. Thus, the public sector must facilitate the private sector by means of giving attractive investment environment to investors. The public sector itself rehabilitates its own existing agricultural facilities, improves productivity and increases production of beneficiaries in the facilities.

(b) Power System Master Plan

The former mater plan was provided almost ten years ago. The new plan is studied on the basis of the former plan. The plan is implemented by ZESCO, supported by FINNIDA. The new planning study was launched in March 1994 and will be finalised by July 1995. Accordingly, the policy and strategies for power development are not able to be reflected in this current master plan study.

3.1.2 Population Projection

(1) National Total Population

The report of "1980 Population and Housing Census of Zambia, Analytical Report Volume V, Demographic Projections" by CSO officially presents the future population up to the year 2000. The report shows the future population on the basis of the 1980 census figures. The new report of population projection based on the 1990 census results is being provided by Demography Division of CSO. It has not come out so far. Thus, the new official projection is not available for this current study. Accordingly, the future population has to be projected by the Study Team, referring to the previous projection report mentioned above.

The population growth rate during the latest two censuses dropped down to 2.69% per annum on average from 3.08% of the previous censuses. For this background, the central government has made an endeavour to mitigate population pressure by means of family planning. This policy of population control will be succeeded continuously for the future, because the government has a correct understanding of population pressure to economic growth in the country. In addition to that, it is said that the impact of AIDS will bring about potential long term demographic change in the future. Thus, the population growth rate will be expected to decrease continuously.

Taking this background into account, the total populations in the country are projected on the basis of the following simple three projections in this study:

1) High Projection: The future population is assumed to increase at the growth rate derived from the 1980 and 1990 censuses' data.
2) Medium Projection: The growth rate after 1990 will decrease at an annual rate of 1.34% which is calculated from the growth rate between the two censuses.
3) Low Projection: The growth rate after 1990 will decrease at an annual rate of 2.69%, which is a double of the decreasing rate of Medium Projection.

The estimated growth rates and the projected total populations based on the growth rates were shown in the following Table 3-1 and Figure 3-1:

Table 3-1 Projected National Population: 1995-2015

Year	High Projection		Medium Projection		Low Projection	
	Growth Rate (%)	Population (1000)	Growth Rate (%)	Population (1000)	Growth Rate (%)	Population (1000)
1980	3.08*	5,662*	3.08*	5,662*	3.08*	5,662*
1990	2.69*	7,383*	2.69*	7,383*	2.69*	7,383*
1995	2.69	8,431	2.51	8,359	2.35	8,291
2000	2.69	9,628	2.35	9,388	2.05	9,176
2005	2.69	10,994	2.20	10,465	1.79	10,025
2010	2.69	12,555	2.05	11,584	1.56	10,832
2015	2.69	14,336	1.92	12,738	1.36	11,589

Remark: * Actual figures

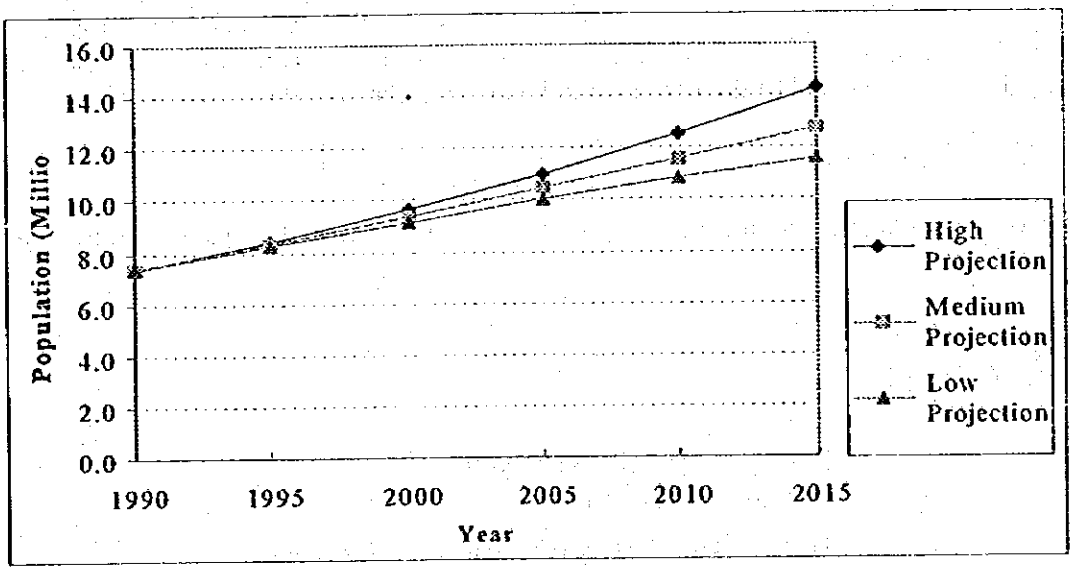

Figure 3-1 Population Projection: 1995-2015

Incidentally, Ministry of Health (MOH) provided a paper of "the Socio-economic Impact of AIDS, Zambia: The Current HIV/AIDS Situation and Future Demographic Impact, Background Paper I" in July 1994. It describes the current HIV/AIDS situation in Zambia and shows two scenarios indicating potential long term demographic changes. The first scenario shows that the growth rate drops from the 1990 estimated of 3.1% to 2.4% in 2000-2004. Then, it starts increasing again and reaches 3.2% in 2025. The second scenario shows a more significant decline of growth rate for the projection. By the year 2025-29, the growth rate could be below 1%. In this scenario, the growth rates of 2005-09 and 2015-19 are estimated as about 1.5% and 1.3% respectively, in spite of the fact that the growth rate in 1990 was assumed to be 3.1% which was derived from the two censuses of 1969 and 1980. At any rate, these figures are somewhat smaller than those in the above Low Projection.

(2) Projection Procedure of Urban/Rural Population

Population distribution by administrative unit is prerequisite to consider a water balance of demand and supply in the National Water Resources Master Plan. The population distribution by District is based on the District populations in the 1980 and 1990 censuses. Furthermore, taking account of the difference in water demand between urban and rural areas, the

distribution of urban and rural population is also required as fundamental information. The distribution of population in the future is estimated by the following procedure. Figure 3-2 illustrates the projection procedure in flow diagram form.

(a) Total Population and District Population

The total population of the country is estimated using the data and assumptions mentioned in the previous section. The total population of the respective Districts are estimated in consideration of (i) trend of District population growth, and (ii) balance of district distributions in the total national population. The district population is assumed to grow at the rate of between the two censuses of 1969 and 1990. In the former decade between the two censuses of 1969 and 1980, the population migration showed the urbanisation to large urban areas. In the latter decade between 1980 and 1990, it showed the modest urbanisation. In this projection, thus, the district populations are assumed to grow at the medium urbanisation rate of between the censuses of 1969 and 1990. Afterward, the total population of the all districts are arranged to become equal to the national total estimated through the above procedure.

(b) Urban Population

The total urban population in the years 1995 to 2015 is estimated using the following urbanisation model.

$$P_u = \frac{P_t \bullet Y_u}{G \bullet Y_r + Y_u}$$

Where P_u = Urban population in a given year
P_t = Total national population
Y_u = That portion of GDP produced in the urban sector
Y_r = That portion of GDP produced in the rural sector
G = Gradient or ratio between urban product per capita and rural product per capita

The basic idea of this formula is that people move from economically depressed rural area to urban economically developed area. The gradient (G) indicates an economic disparity between urban and rural. The population migration to urban areas causes to mitigate the disparity between urban and rural.

(c) Population Projection Scenarios

Since there are three scenarios of the population projection mentioned above. Regarding economic growth in the future, on the other hand, three scenarios are proposed as discussed later in Section 3.1.3. Thus, the projection scenarios of total urban population are considered simply to exist the following nine cases.

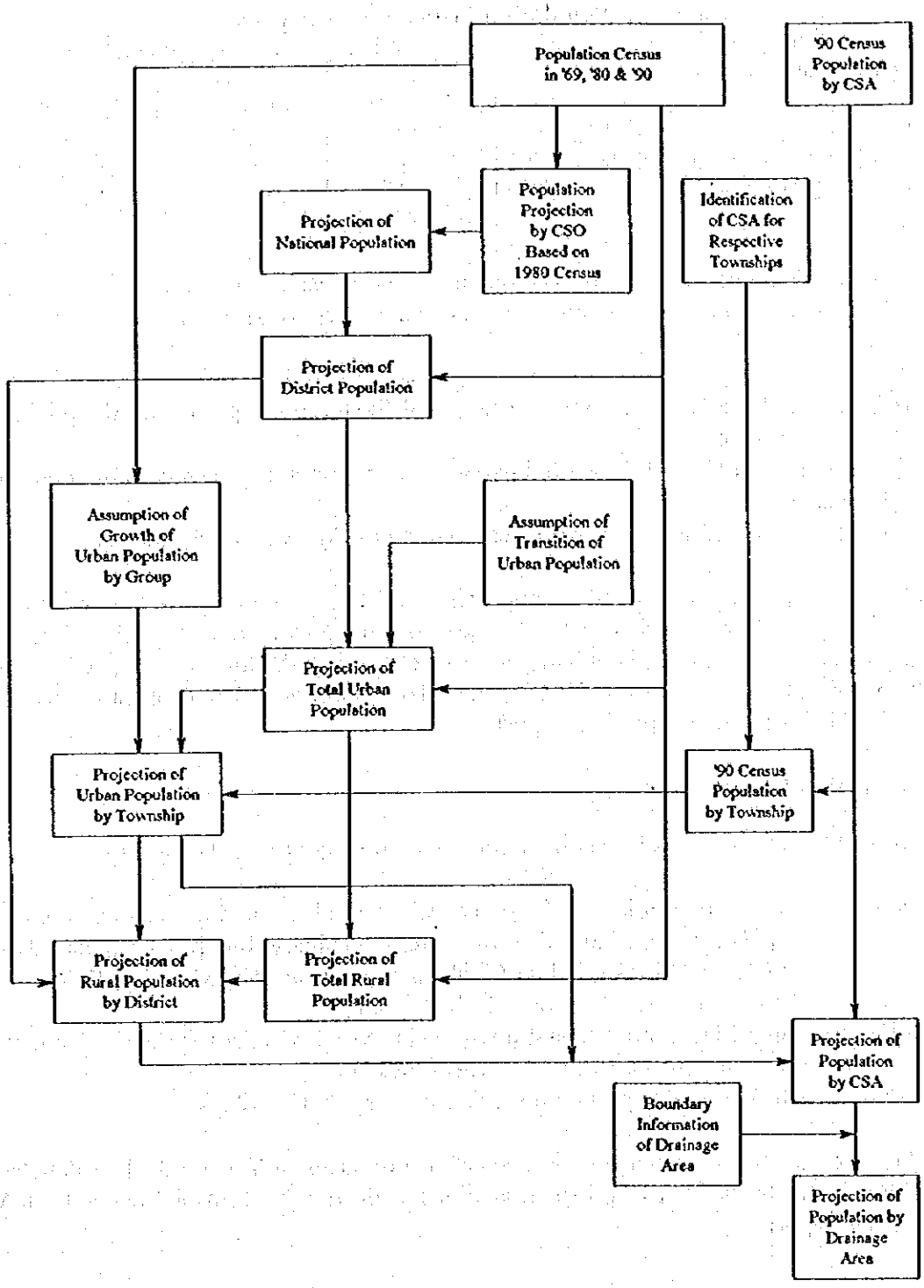

Figure 3-2 Procedure of Population Projection by District and Urban/Rural

Table 3-2 Population Projection Scenarios

Economic Growth Scenarios (Refer to Table 3-10)	Population Projection Scenarios (Table 3-1)		
	High Projection	Medium Projection	Low Projection
Base Growth Case - Industrialisation	Case 1	Case 2	Case 3
Base Growth Case - Agricultural Expansion	Case 4	Case 5	Case 6
Conservative Growth Case	Case 7	Case 8	Case 9

Hence, from the point of view of urbanisation and water demand of domestic and industrial sectors, the following three cases among the above nine cases are selected as representative projections:

(a) Case 5 as Base Growth Case - Agricultural Expansion, representing the medium water demand case;
(b) Case 1 as Base Growth Case - Industrialisation, representing the high water demand case; and
(c) Case 9 as Conservative Scenario, representing the low water demand case

In 1993, "G" in the formula stood at approximately 4.45, according to the results of calculation based on the statistical data. The government policy states that the disparity between urban and rural standards of living must be reduced in the future. Then, "G" in the years 2005 and 2015 was assumed to be 4.20 and 4.10, respectively. The detailed procedure was explained in Part-A of Supporting Report.

(d) Township Classification

Urban areas of 92 townships were classified into the following three ranked groups:

Group 1, comprising ten large urban areas which are identified in "1990 Census of Population, Housing and Agriculture, Preliminary Report, December 1990, CSO", i.e., Lusaka, Ndola Chililabombwe, Chingola, Mufulira, Kalulushi, Kitwe, Luanshya, Kabwe and Livingstone;
Group 2, comprising district capital towns and townships in the Districts which have the large urban areas, i.e., 53 townships; and
Group 3, which is made up of rural settlements, i.e., 29 townships.

These three groups are tabulated for the respective Provinces in Table 3-3. The detailed distribution of townships and basic urban populations by district was broken down in Part-A of Supporting Report.

Table 3-3 Township Classification and Base Urban Population by Province: 1990

Province	Group 1		Group 2		Group 3	
	No.	Population	No.	Population	No.	Population
Lusaka	1	769,353	3	48,777	2	11,343
Copperbelt	7	1,087,920	3	13,880	1	10,837
Central	1	161,456	5	44,682	2	7,060
Northwestern	0	0	6	52,522	1	1,798
Western	0	0	6	61,922	6	13,819
Southern	1	76,875	8	92,395	13	42,714
Luapula	0	0	5	73,844	2	9,282
Northern	0	0	10	115,562	1	2,739
Eastern	0	0	7	81,305	1	1,445
Total	10	2,095,604	53	584,889	29	101,037

(e) Growth Rate of Urban Population

It is assumed that the urban population will grow at the rates tabulated in Table 3-4 in Groups 1, 2 and 3, taking into consideration of the total national population and total urban population analysis. In cases where the growth rate of the District is negative, such as Mufulira, the growth rate of its urban areas is assumed to be the same as that of the District having the smallest positive growth rate among all Districts with in the same Province.

Table 3-4 Assumed Growth Rates of Urban Population

Urban Population Projection	Group 1	Group 2	Group 3
High Projection	Rate A	Rate B	Rate C
Medium and Low Projections	Rate A	Rate A	Rate A

Remark:
Rate A : at the same rate as District
Rate B : at a double rate of the District
Rate C : at 50% higher rate than the District

(f) Rural Population and River Basin Population

Rural population in a District is estimated as the difference between urban population and total population of the District. The population distribution by drainage area is estimated on the basis of Census Supervisory Area (CSA) distribution. This distribution is made by the "ratio method". Then, the projected populations by drainage area in respective years to 2015 are also estimated in the same procedure.

(3) Projected Population

(a) Urban Population

Urban population is projected for three ranked groups individually, using the projection methodology mentioned in the previous section. Appendix 6 in Part-A of Supporting Report shows the projected urban population by township between 1995 and 2015 for the three projections, i.e., Medium, High and Low Projections. Table 3-5 summarised the projected urban population by province for the Medium Projection.

The total urban population of the Medium Projection is estimated as 4.25 million in 2005 and 5.46 million in 2015. There are 59 townships in 2005 and 63 townships in 2015, which have a population of more than 5,000, i.e., small urban areas. Of these townships, 13 townships in 2005 and 17 townships in 2015 have a population more than 50,000, i.e., large urban areas.

Table 3-5 Urban Population of Medium Projection by Province: 1995-2015

(Unit: 1000)

Province	1995	2005	2015
Lusaka	1,041	1,584	2,315
Copperbelt	1,236	1,484	1,720
Central	253	347	458
Northwestern	62	80	98
Western	83	97	110
Southern	236	283	327
Luapula	91	107	122
Northern	130	152	172
Eastern	94	118	142
Total	3,227	4,253	5,465

Urban population of 10 large urban areas was projected in the case of the Medium Projection as shown in Table 3-6. Figure 3-3 illustrated the total urban population by township.

Table 3-6 Ten Large Urban Areas' Population of Medium Projection: 1995-2015

(Unit: 1000)

Province	1995	2005	2015
Lusaka	968	1,483	2,181
Ndola	388	507	635
Chililabombwe	51	54	56
Chingola	154	175	190
Mufulira	131	139	142
Kalulushi	37	48	60
Kitwe	321	383	440
Luanshya	126	139	148
Kabwe	195	273	369
Livingstone	85	100	113

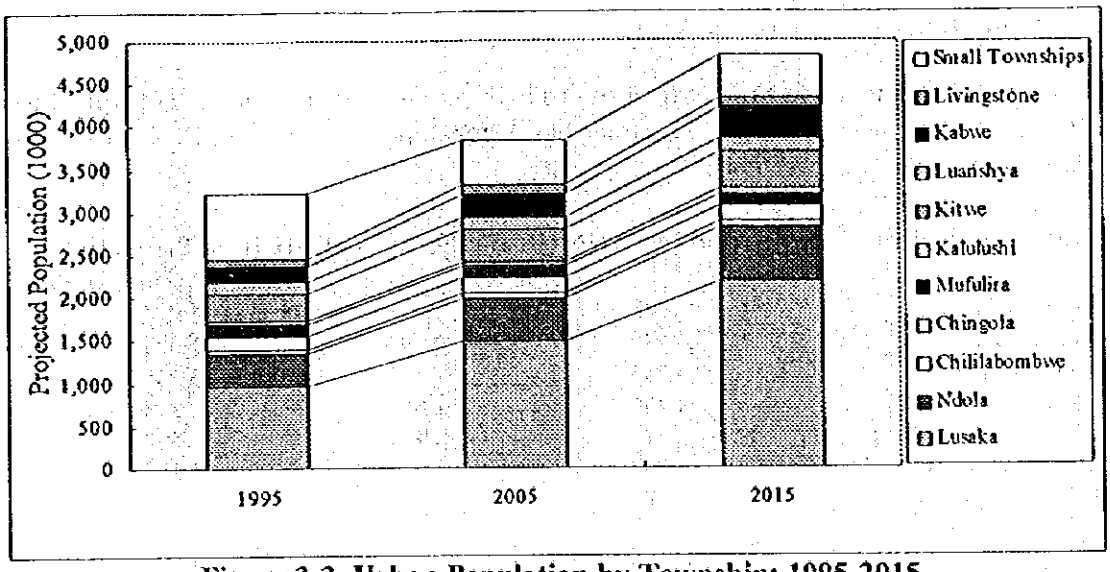

Figure 3-3 Urban Population by Township: 1995-2015

(b) Total Population by District and by Urban/Rural Area

The national population by urban/rural area of Medium Projection is summarised in Table 3-7. The detailed populations for respective districts are broken down in Appendix 7 in Part-A of Supporting Report. Figure 3-4 illustrated the projected urban/rural population by province in 2015.

Table 3-7 Projected Population by Urban/Rural of Medium Projection: 1995-2015

(Unit: 1000, %)

	1990 (Census)		1995		2005		2015	
Area	Number	%	Number	%	Number	%	Number	%
Urban	2,764	37	3,227	39	4,253	41	5,465	43
Rural	4,619	63	5,132	61	6,212	59	7,273	57
Total	7,383	100	8,359	100	10,465	100	12,738	100

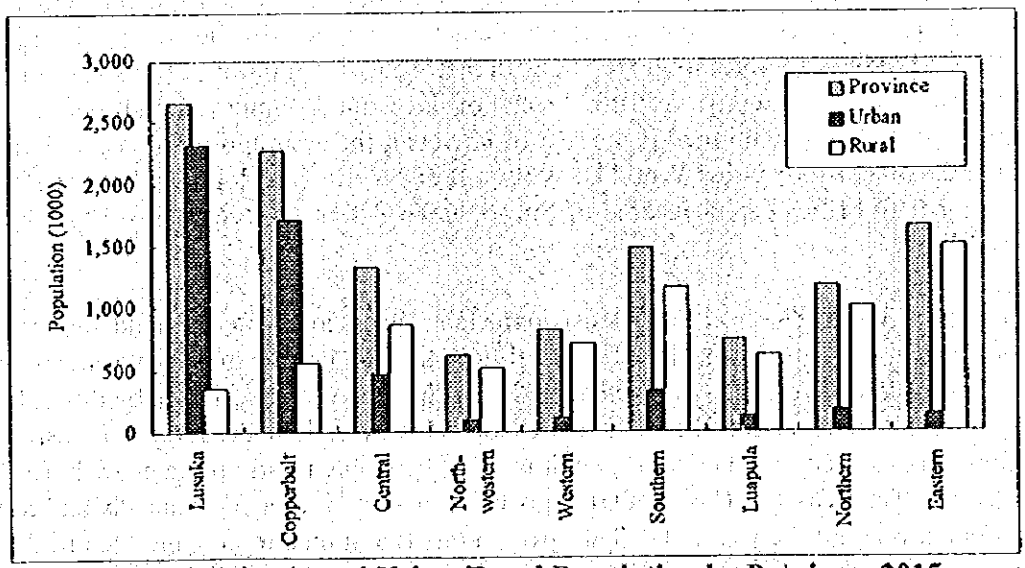

Figure 3-4 Projected Urban/Rural Population by Province: 2015

(c) Population by River Basin Area

The basin population in the five major river basins in the country are enumerated in Appendix 8 in Part-A of Supporting Report. The total basin population of Medium Projection was summarised in Table 3-8.

Table 3-8 Projected Population by Major Drainage Area of Medium Projection

(Unit: 1000)

River Basin	1995	2005	2015
Zambezi river basin	1,917	2,396	2,929
Kafue river basin	3,296	4,265	5,365
Luangwa river basin	1,496	1,889	2,298
Chambeshi river basin	410	474	527
Luapula river basin	907	1,046	1,167
Lake Tanganyika basin	86	93	98

3.1.3 GDP Projection

(1) Assumption and Prospect

Economic performance for the latest nine years was analysed in Section 2.1.3 and was summarised as figures and indices in Table 3-9. The national economy seems to attain some recovery gradually since 1985 against economic stagnation before 1985. However, it does not recover a sufficient economic output growth yet, because an average per capita GDP growth is still negative. Gross investment seems to grow at low pace but its share to GDP is still low.

According to "Economic Report 1993" and Policy Framework Paper (PFP) for 1994-1996, the national economy is expected to achieve growth rates of 4% in 1994 and 5% in both 1995 and 1996. With these growth rates, per capita income will be expected to rise to 1.4% in 1994 and 2.4% in both 1995 and 1996, as shown in Table 3-9. Agricultural Sector Investment Programme (ASIP) also expects to grow at 5% during its planning period from 1995 to 1999.

The World Bank Report of "Zambia: Prospects for Sustainable and Equitable Growth, August 1993" presented economic projection of Zambian economy for the coming decade of 1993 to 2002. The base scenario in the report says that the national output grows at over 5% for the decade, in considering realistic levels of investment, imports and per capita consumption growth. As mentioned in the report, however, the assumptions are optimistic in general. On the other hand, anther World Bank Report of "World Development Report 1992" says that a growth of per capita income of Sub-Saharan Africa will grow at 0.3% for the decade of 1990's.

Supposing that ICOR of Zambia is 5.3 as seen in the table, gross investment should increase to 26.5% of GDP in order to attain the 5% annual growth. The largest gross investment was 23.8% in 1986 and its average was less than 15% for the nine years, so it will be difficult to keep this investment level for the coming decade. However, if a favourable investment circumstance is expected in the next decade, it might be possible to attain the growth. In this study, thus, the "Base Growth Case" of GDP growth is assumed to be 5% annually and to be kept the same level until the year 2000. This growth rate is assumed to be converted to 2.5% per annum of per capita GDP since GDP growth rate is offset by population growth.

Table 3-9 Economic Figures and Indices for Economic Growth Projection

Item	1985 - 1993 Record			
	Maximum	Minimum	Average	Regression Slope
I. Economic Performance: 1985-1993				
1. GDP				
Price (US$ million)	4,277 (in 1989)	1,755 (in 1986)	3,197	289
Growth Rate (%)	6.3% (in 1988)	-3.8% (in 1992)	1.2%	-0.22
2. GDP per Capita				
Price (US$)	596 (in 1989)	267 (in 1986)	439	30
Growth Rate (%)	3.5% (in 1988)	-6.2% (in 1992)	-1.3%	-0.18
3. Gross Investment				
Price (US$ million)	676 (in 1990)	423 (in 1986)	450	32
Growth Rate (%)	47.5% (in 1986)	-48.7% (in 1993)	6.6%	-3.63
4. GFCF				
Price (US$ million)	527 (in 1990)	190 (in 1986)	321	36
Growth Rate (%)	38.1% (in 1992)	-23.0% (in 1989)	-1.5%	-0.57
5. ICOR	49.7	-21.4	5.3	0.71
6. Gross Saving				
Price (US$ million)	695 (in 1990)	165 (in 1992)	444	16
Growth Rate (%)	65.1% (in 1993)	-35.7% (in 1987)	16.1%	6.94

II. Economic Development Reports

1. Economic Report 1993

Economic Growth

Item	1994	1995	1996
Real GDP	4.0%	5.0%	5.0%
GDP per Capita	1.4%	2.4%	2.4%

2. LTPS — The Study started in June 1994 and will be finalised by the end of 1995. Accordingly, the economic growth projection and prospects have not been worked out yet so far.

3. ASIP — During the programme period of 1995 to 1999, the national economy is expected to grow at 5% annually.

4. Power System Master Plan: 1994-2014 — The Study started in March 1994 and will be finalised by July 1995. Accordingly, the economic growth projection and prospects have not been worked out yet so far.

5. World Bank: Zambia, Prospects for Sustainable & Equitable Growth, August 1993

GDP Growth

Country Group	1993	1994	1995-1999	2000-2002
Base Case	14.8%	6.3%	4.7%-5.3%	5.9%-6.1%
National output grows at over 5% a year for the next decade (1993-2002).				
High Case	14.8%	7.8%	6.3%-6.7%	6.8%-7.1%
High case has GDP growth at about 1% a year higher than Base case.				

6. WDR Economic Growth --Long-Term Trends & Prospects

Growth of Real Per Capita Income

Country Group	1980-90	1991	1990-2000
High-income countries	2.4%	0.7%	2.1%
Developing countries	1.2%	-0.2%	2.9%
Sub-Saharan Africa	-0.9%	-1.0%	0.3%

Remark:
GDP: Gross Domestic Product
GFCF: Gross Fixed Capital Formation
ICOR: Incremental Capital Output Ratio
ASIP: Agricultural Sector Investment Programme, MAFF & World Bank
LTPS: Long-Term Perspective Study, UNDP
WDR: World Development Report 1992, World Bank

Regarding the minimum case of GDP growth named as "Low Growth Case", the 0.3% growth is applied for per capita GDP in reflecting "World Development Report" of the World Bank. This growth rate connotes the around 2.8% growth of GDP, which corresponds almost 60% of the "Base Growth Case".

Beyond the year 2000, the over all growth rates were assumed to be a half of those between 1995 and 2000. There are no references which projects the economic growth after the year 2000. The economic growth projection between 1995-2000 seems to be much larger than the past trend as seen Table 3-9. Between 1985 and 1993, the average GDP growth was 1.2% per annum, which was almost a quarter of the GDP projection (5%). Taking into account of this past trend, it would be difficult to keep this continuous high growth. Thus, it would be reasonable that the pace of economic growth could be slow down after high growth like that before 2000.

Sector distribution and growth of respective sectors were assumed as follows:

1) Base Growth Case

In Base Case, the following two scenarios were assumed:

a) Base Growth Case - Agricultural Expansion

As proposed in ASIP, the agricultural sector grow at 6% annually. Other sectors except manufacturing are assumed to grow at the average growth rate. The rest of VA to attain the expected growth of GDP is assumed to be covered by manufacturing sector.

b) Base Growth Case - Industrialisation

Value added (VA) of the agricultural sector grows at 10% higher than the rate of population growth. Other sectors except manufacturing are assumed to grow at the average growth rate. The rest of VA to attain the expected growth of GDP is assumed to be covered by manufacturing sector. Thus, the manufacturing sector is expected to grow at considerably higher rate. Then, this case is named as "Industrialisation Case". In this case, the high population projection is applied from the point of view of domestic and industrial water demand as mentioned in Section 3.1.2.

2) Conservative Growth Case

VA of the agricultural sector grows at 10% higher than the rate of population growth. Other sectors except manufacturing are assumed to grow at the average growth rate. The rest of VA to attain the expected growth of GDP is assumed to be covered by manufacturing sector.

(2) Projected GDP

On the basis of the aforesaid assumptions, GDP in the years 2005 and 2015 are projected for the three cases of Base Growth Case - Agricultural Expansion, Base Growth Case -

Industrialisation and Low Growth Case, to aggregate K2.34 trillion, K2.46 trillion and K1.85 trillion in 2005 and K3.23 trillion, K3.63 trillion and K2.17 trillion in 2015 at 1993 constant prices, respectively. Figure 3-5 illustrated the GDP growth trend of the three scenarios up to the year 2015.

Table 3-10 shows VA of major economic sectors for the three cases. In Base Growth Case - Agricultural Expansion, manufacturing sector is expected to grow annually at 4.0 % in 1995 and 3.5% till 2000. Figure 3-5 shows the contribution of major economic sectors of this case. In Base Growth Case - Industrialisation, on the other hand, its rates are expected to be much higher of 7.8% in 1995 and 7.4% till 2000. These rates, however, are still lower than the highest records of 18.2% in 1988 and 8.8% in 1987. This projection would be thought to portray a feasible scenario with a realistic levels of investment and effective improvement, although it seems to be difficult to keep such high growth rate from the point of view of unsteady sector performance.

In the Base Growth Cases, per capita GDP was estimated at K224,000 (approximately US$515) in 2005 and K254,000 (US$583) in 2015. Per capita GDP in 2015 was expected to be about 40% more than that in 1993. In the Low Growth Case, on the other hand, per capita GDP was estimated at K184,000 (approximately US$423) in 2005 and K187,000 (US$430) in 2015. Per capita GDP in 2015 was expected to be only 5% more than that in 1993.

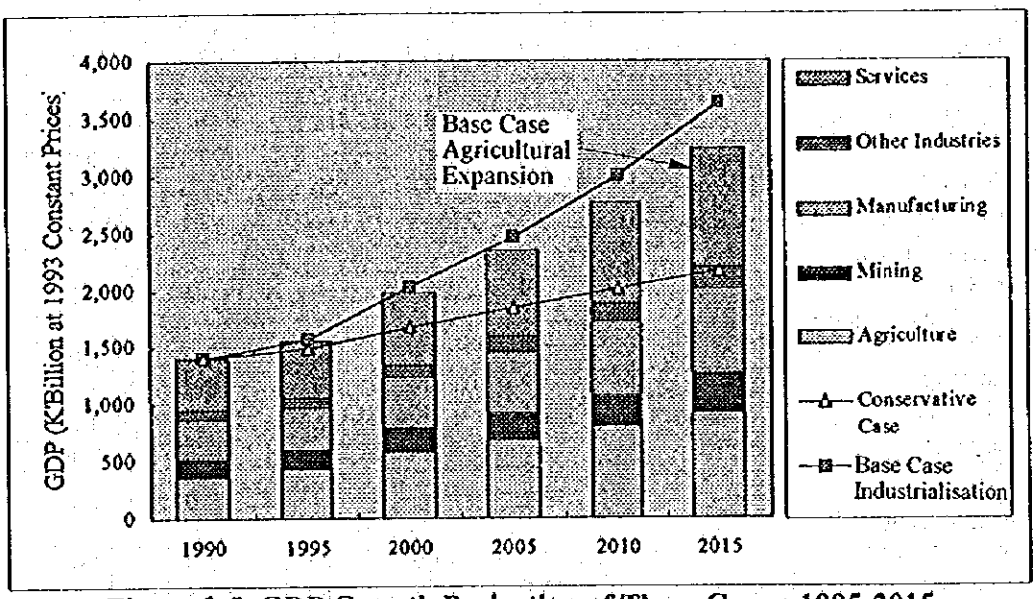

Figure 3-5 GDP Growth Projection of Three Cases: 1995-2015

Table 3-10 Projected GDP by Industrial Origin at 1993 Constant Prices:

Item	1993	1994	1995	2000	2005	2010	2015
Projected GDP and GVA (Unit: K' billion)							
I. Base Growth Case - Agricultural Expansion							
GDP	1,423.2	1,479.4	1,554.5	1,975.3	2,343.0	2,759.6	3,229.0
1. Agriculture	393.9	417.6	442.6	592.3	686.7	796.0	922.8
2. Industry	570.6	585.1	611.0	746.5	901.3	1,074.3	1,265.7
a. Mining	143.0	148.6	156.1	198.4	235.4	277.2	324.4
b. Manufacturing	350.5	356.3	370.5	440.9	538.9	647.5	766.2
c. Others	77.2	80.2	84.3	107.1	127.1	149.7	175.1
3. Services	458.6	476.7	500.9	636.5	755.0	889.3	1,040.5
GDP per Capita (K'1000)	178.9	181.4	186.0	210.4	223.9	238.2	253.5
II. Base Growth Case - Industrialisation							
GDP	1,423.2	1,489.6	1,567.9	2,025.7	2,461.5	2,990.9	3,634.3
1. Agriculture	393.9	405.6	417.6	483.1	559.0	646.7	748.2
2. Industry	570.6	604.0	645.1	889.8	1,109.3	1,380.4	1,715.0
a. Mining	143.0	149.6	157.5	203.5	247.2	300.4	365.1
b. Manufacturing	350.5	373.6	402.5	576.5	728.6	917.8	1,152.8
c. Others	77.2	80.8	85.0	109.9	133.5	162.2	197.1
3. Services	458.6	480.0	505.2	652.8	793.2	963.8	1,171.1
GDP per Capita (K'1000)	178.0	181.4	186.0	210.4	223.9	238.2	253.5
III. Conservative Growth Case							
GDP	1,423.2	1,453.8	1,492.4	1,676.6	1,845.6	2,009.1	2,165.7
1. Agriculture	393.9	404.1	414.5	463.4	510.8	556.1	599.0
2. Industry	570.6	579.3	595.3	673.7	740.3	805.6	869.4
a. Mining	143.0	146.6	150.4	168.2	185.4	201.8	217.4
b. Manufacturing	350.5	353.5	363.6	414.8	454.8	494.8	534.7
c. Others	77.2	79.2	81.2	90.8	100.1	109.0	117.4
3. Services	458.6	470.5	482.6	539.5	594.6	647.4	697.3
GDP per Capita (K'1000)	179.8	179.5	180.0	182.7	184.1	185.5	186.9
Average Annual Growth (%)							
I. Base Growth Case - Agricultural Expansion	-	3.9	5.1	4.9	3.5	3.3	3.2
1. Agriculture*1	-	6.0	6.0	6.0	3.0	3.0	3.0
2. Industry	-	2.5	4.4	4.1	3.8	3.6	3.3
Manufacturing*3	-	1.6	4.0	3.5	4.1	3.7	3.4
3. Services*4	-	3.9	5.1	4.9	3.5	3.3	3.2
II. Base Growth Case - Industrialisation	-	4.7	5.3	5.3	4.0	4.0	4.0
1. Agriculture*2	-	3.0	3.0	3.0	3.0	3.0	3.0
2. Industry	-	5.8	6.8	6.6	4.5	4.5	4.4
Manufacturing*3	-	6.6	7.8	7.4	4.8	4.7	4.7
3. Services*4	-	4.7	5.3	5.3	4.0	4.0	4.0
III. Conservative Growth Case	-	2.2	2.7	2.4	1.9	1.7	1.5
1. Agriculture*2	-	2.6	2.6	2.3	2.0	1.7	1.5
2. Industry	-	1.5	2.8	2.5	1.9	1.7	1.5
Manufacturing*3	-	0.8	2.9	2.7	1.9	1.7	1.6
3. Services*4	-	2.6	2.6	2.3	2.0	1.7	1.5

Remark: *1 Agricultural sector is assumed to grow at the rate of 6% as projected in ASIP until 2000.
*2 Agricultural sector is assumed to grow at the rate of population growth rate plus its 10%
*3 Manufacturing sector is assumed to grow at the rate to attain the target GDP growth.
*4 Other sectors is assumed to grow at the same rate of GDP growth.

3.1.4 Public Expenditure for Development

(1) Assumptions and Given Conditions

Inadequate public finance is said as one to the most serious constraints for project implementation in developing countries. In formulation of projects in the current study, this is also considered to play a serious role. Investment ceiling of public finance for projects is laid out by the government policy. In this context, the policy is the most important decisive factor for project formulation, which declared in the development plans and is usually piled on top of the accumulation of the past capital formation.

A principle case of public expenditure for development by the central government is estimated in the following assumptions and procedure:

1) The total expenditure by the central government is estimated in proportion to GDP. Its rate is expected to be 27.5%, referring to the past records between 1989 and 1993.
2) Capital expenditure is assumed to be 19.4% of the development expenditure, referring to the past share of the central government financial statement and budget between 1989 and 1994.
3) 10.7% of the capital expenditure will be spent for projects related to water development, referring to the past records.
4) Expenditure for water development is distributed in accordance with the past trend of sector distribution, which rates were shown in Table 3-11. Expenditure for irrigation projects and main hydropower works was not included in the table, because investment for the projects was relied on the private sector in the past.

(2) Projected Public Expenditure for Development

Table 3-11 shows the trend projection of public expenditure estimated based on the above assumptions and given conditions. The public expenditure for development projects is expected to amount to K119 billion in the year 2005 and K164 billion in 2015 at 1993 constant prices. Furthermore, the public expenditure for water schemes is expected to amount to K13 billion in the year 2005 and K18 billion in 2015 at 1993 constant prices. Its total amount accumulated from 1995 will be K123 billion to 2005 and K283 billion to 2015, equivalent to US$282 million and US$651 million.

The table shows the budgetary distribution by ministry or department as well. As mentioned above, the accumulated amount of K123 billion by the year 2005 will be broken down as follows: K42 billion through DWA, K73 billion through MLGH and K8 billion through other agencies concerned. In the same manner, the amount of K283 billion will be disbursed: K96 billion through DWA, K167 billion through MLGH and K20 billion through other agencies concerned. For the recent years, the government has not invested for irrigation projects. Investment for the projects has been expected to private sector's activities. Under ASIP, this policy could be kept at least for the planning period.

Table 3-11 Projected Public Investment by Central Government for Base Growth Case - Agricultural Expansion: 1995-2015

(Unit: K' Billion)

Item	1993/94 Average*1	1995	2000	2005	2010	2015
1. GDP at 1993 Constant Prices (Base Growth Case - Agricultural Expansion) *2	-	1,554.5	1,975.3	2,343.0	2,759.6	3,229.0
2. Total Expenditure by Central Government *3	-	428.1	544.0	645.3	760.0	889.3
1) Recurrent Expenditure	-	344.9	438.3	519.9	612.4	716.5
2) Capital Expenditure *4	100.0%	83.2	105.7	125.4	147.7	172.8
01 Movable Assets	4.8%	4.0	5.1	6.1	7.1	8.4
02 Projects	95.2%	79.2	100.6	119.3	140.5	164.4
13 Ministry of Energy & Water Development	4.3%	3.5	4.5	5.3	6.3	7.3
02 Energy Department	0.5%	0.4	0.5	0.6	0.7	0.9
032 Hydrological Assistance *	0.0%	0.0	0.0	0.0	0.0	0.0
03 Department of Water Affairs *	3.6%	3.0	3.8	4.6	5.4	6.3
- Others	0.0%	0.0	0.0	0.0	0.1	0.1
46 Ministry of Health	6.3%	5.3	6.7	7.9	9.3	10.9
034 Community Water Supply & Sanitation *	0.4%	0.4	0.5	0.5	0.6	0.7
64 Ministry of Works & Supply	11.1%	9.2	11.7	13.9	16.4	19.2
02 Building Department	0.5%	0.4	0.5	0.6	0.7	0.8
002 Urban Water & Sewerage Scheme *	0.0%	0.0	0.0	0.0	0.0	0.0
- Others	10.6%	8.9	11.3	13.3	15.7	18.4
89 Ministry of Agriculture, Food & Fisheries	9.4%	7.8	9.9	11.8	13.9	16.2
09 Fishery Department *	0.2%	0.2	0.3	0.3	0.4	0.4
Loans & Investments						
20 Ministry of Local Government & Housing	7.1%	5.9	7.5	8.9	10.5	12.2
91 Loans to District Councils	7.1%	5.9	7.5	8.9	10.5	12.2
- Water Schemes *	6.3%	5.2	6.7	7.9	9.3	10.9
21 Ministry of Finance	34.1%	28.4	36.0	42.7	50.3	58.9
13 Ministry of Energy & Water Development	0.0%	0.0	0.0	0.1	0.1	0.2
37 Ministry of Agriculture, Food & Fisheries	26.1%	21.7	27.6	32.7	38.6	45.1
- Other Ministries	7.9%	6.6	8.3	9.9	11.7	13.6
- Others	22.9%	19.1	24.2	28.8	33.9	39.6
03 Expenditure for Projects Related to Water ("*" marked Agencies or Schemes)	10.7%	8.9	11.3	13.4	15.7	18.4
3. Accumulation of Expenditure for Projects Related to Water						
1) Expenditure by Agencies						
13 Ministry of Energy & Water Development	-	3.1	20.7	42.3	67.7	97.5
02 Energy Department	-	0.0	0.2	0.5	0.8	1.1
03 Department of Water Affairs	-	3.0	20.5	41.8	66.9	96.4
46 Ministry of Health	-	0.4	2.4	4.9	7.9	11.3
64 Ministry of Works & Supply	-	0.0	0.0	0.1	0.2	0.2
02 Building Department	-	0.0	0.0	0.1	0.2	0.2
89 Ministry of Agriculture, Food & Fisheries	-	0.2	1.4	2.8	4.6	6.6
09 Fishery Department	-	0.2	1.4	2.8	4.6	6.6
20 Ministry of Local Government & Housing	-	5.2	35.6	72.5	116.2	167.4
Total of Accumulated Expenditure	-	8.9	60.2	122.7	196.5	283.1
2) Expenditure by Sectors						
Water Supply & Sanitation	-	8.6	58.6	119.4	191.2	275.4
Fishery	-	0.2	1.4	2.8	4.6	6.6
Electric Hydrological Assistance	-	0.0	0.2	0.5	0.8	1.1
Total of Accumulated Expenditure	-	8.9	60.2	122.7	196.5	283.1

Remark: *1 Average of 1993 approved estimate and 1994 estimate. Refer to Table 2-31 and Appendix 3 in Part-A of Supporting Report.
*2 Refer to Table 3-10.
*3 Rate of the total expenditure to GDP was assumed at 27.5%.
*4 Rate of the capital expenditure to the total expenditure was assumed at 19.4%.

The table also shows the distribution by sector related water resources development. By the year 2005, the budget for water supply and sanitation sector will aggregate to K119 billion. That for other sectors is estimated as follows: K0.5 billion for hydropower and K3 billion for fishery. In the same way, the budget by 2015 are in order of amount: K275 billion for water supply and sanitation, K1 billion for hydropower and K7 billion for fishery.

3.2 Domestic Water

3.2.1 Domestic Water Supply Situation

(1) Present Conditions

According to the "Social Sector Rehabilitation and Development Programme, 1993-1996", only 43% of the urban population of Zambia has access to safe water and to sanitation structures. In rural areas, only about 30% of the population has access to safe water.

According to the 1990 census, 2.75 million people or 37% of the total population (7.38 million) were served by piped water system in the country, as shown in Figure 3-6. Of these served population, 0.97 million people or 35% were served by inside water taps within their houses. 1.37 million or 50% was served by communal taps around their houses. The rest of 0.41 million or 15% was also served by communal taps but their service points were located more than 100 metres away from their houses. In urban areas, 2.46 million people or 85% of the urban population were covered by the piped supply system. In rural areas, however, only 0.29 million people or 6.5% of the rural population were covered by the piped system. 2.32 million or 52% of the rural population was served by well or borehole water sources. Thus, 2.61 million or 58% of the total rural population was covered by the safe water sources in rural areas.

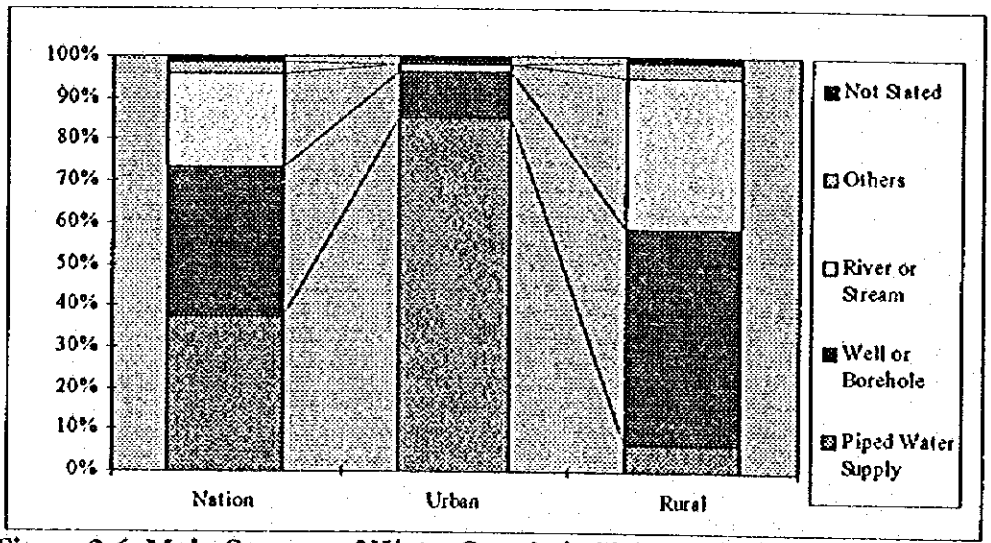

Figure 3-6 Main Sources of Water Supply in Urban and Rural Areas: 1990

From the view point of relation between water demand and water supply capacity which were estimated by the JICA study team, a safe water coverage in rural areas was only 24% in the country. The regional disparity was so large as the coverage in Southern province reached to 67% but that in Northern province was still 8% only. With the exception of Lusaka, Livingstone and Kasama, supply capacities exceed the demands in 12 large urban city. The coverage in small urban areas was still 80%. Even in the large urban areas, the disparity of the coverage was so large as townships in Copperbelt province were blessed with water resources but those of Lusaka, Livingstone and Kasama were tight as their coverage were 57%, 70% and 67%, respectively. In small townships, those in Copperbelt and North-western provinces were in favourable conditions, but the coverage in Eastern province were only 26%, more serious than that of large urban townships.

(2) Managing Bodies

In principal, most urban water supplies are implemented by local authorities and most rural water supplies are managed by DWA. In addition to it, the actual management of water supply and sanitation systems is divided among various managing bodies as follows because of historical background:

(a) Central Government: DWA under MEWD, MOH, and Department of Community Development under MCDSS
(b) Local Governments under MLGH: City Councils, Municipal Councils and District Councils
(c) Parastatals: ZESCO, ZCCM, Zambia Railways, etc.
(d) Missionaries and Non-Government Organisations (NGOs)
(e) Private Sectors: Lusaka Water and Sewerage Company Ltd., Chipata Water and Sewerage Company Ltd., Mining Companies, etc.

(3) Public Investment for Water Supply Schemes

In relation to the managing bodies, the various public agencies invest public fund to implement water supply schemes. DWA, the authority regarding water supply schemes in the central government, usually disburses its capital expenditure for water projects. Besides, MLGH also invests public capital in water projects not by itself directly but through local authorities. In other words, MLGH loans local governments its capital fund. Table 3-12 shows the summary of public investment for water supply schemes by the central government for the latest six years. In 1994, 26 projects will be implemented directly by the central government. The total amount will reach to K13.7 billion. Eight projects will be implemented by local governments and financed by MLGH. The total amounts will be K19.7 billion. Besides, the local governments will disburse their capital investment for more water projects through their own finance, but their amounts might be very small as discussed in Section 2.1.9.

Table 3-12 Public Investment for Water Supply Schemes by Central Government

Ministry	1989 Actual (K'Mil.)	1990 Actual (K'Mil.)	1991 Actual (K'Mil.)	1992 Actual (K'Mil.)	1993 Estimate (K'Mil.)	1994 No. of Projects	1994 Estimate (K'Mil.)	1994 Donor (Grant) (K' Million)
Direct Investment								
DWA	9.3	14.5	14.3	67.4	1,312.3	24	13,021.0	9,733.2
Energy Dept.	-	-	-	*	*	*	*	*
MOH	0.0	0.3	1.0	3.0	583.0	1	558.5	558.5
MWS	-	0.4	1.8	7.5	13.0	1	11.2	0.0
MAFF	*	*	*	*	*	*	*	*
Total	9.3	15.2	17.1	77.9	1908.3	26	13,590.7	10,291.7
Loan								
MLGH	64.2	75.1	127.4	89.8	3,579.2	8	19,650.8	14,993.3
Grand Total	73.5	90.3	144.5	167.7	5,487.5	34	33,241.5	25,285.0

Source: (1) Estimates of Revenue & Expenditure 1994, Volume I, II & III, MOF
(2) Financial Report for the Year Ended 31st December 1992, 1994, MOF
(3) Financial Report for the Year Ended 31st December 1991, 1993, MOF
(4) Financial Report for the Year Ended 31st December 1990, 1992, MOF
(5) Financial Report for the Year Ended 31st December 1989, 1991, MOF

Note: "-" means that the agency itself did not exist.
"*" means that the agency has water projects except water supply projects.

(4) Financial Status of Water Supply Undertakers

According to financial statement of local governments issued by MLGH in 1990, 33 district councils among 55 districts were managing water supply schemes for the people in the districts. Of the 33 district councils, only nine councils got surplus from water undertaking. Other 24 councils managed the water undertaking in deficit. Mufulira council recorded the largest deficit of K2.35 million in 1990.

Water supply services in Lusaka and Chipata townships are managed by private companies, i.e., "Lusaka Water and Sewerage Company Limited (LWSC)" and "Chipata Water and Sewerage Company Limited (CWSC)". They were originally established as municipal undertakers of the respective councils. They were reorganised as private firms under the privatisation policy of the central government.

LWSC is a leading managing company in the country in terms of water supply and sanitation services. It is responsible for water supply and sewage services covering all over the national capital areas. Thus, it is the largest establishment in the field of water supply and sanitation among Zambia. According to a balance between revenue and expenditure of LWSC during four years from 1990 to 1993, the overall balance of the company recorded surplus in 1990 and 1992, and deficit in 1991 and 1993. In 1993, LWSC had the total assets of K5.25 billion, of which K2.39 billion was fixed assets. Of the total amount, K3.66 billion or 70% was covered by fixed liability and K1.23 billion or 25% was covered by current liability. Their capital fund and grants (K0.31 billion) covered only 5% of the total amount. Thus, a ratio of net worth to total capital was too small to manage the infrastructure service business steadily.

LWSC presents a tariff of public water services for consumers within the servicing territory of the company. The tariff was revised in October 1994 and again in January 1995. Figure 3-7 illustrated unit rate of potable water for the proposed tariff in 1995.

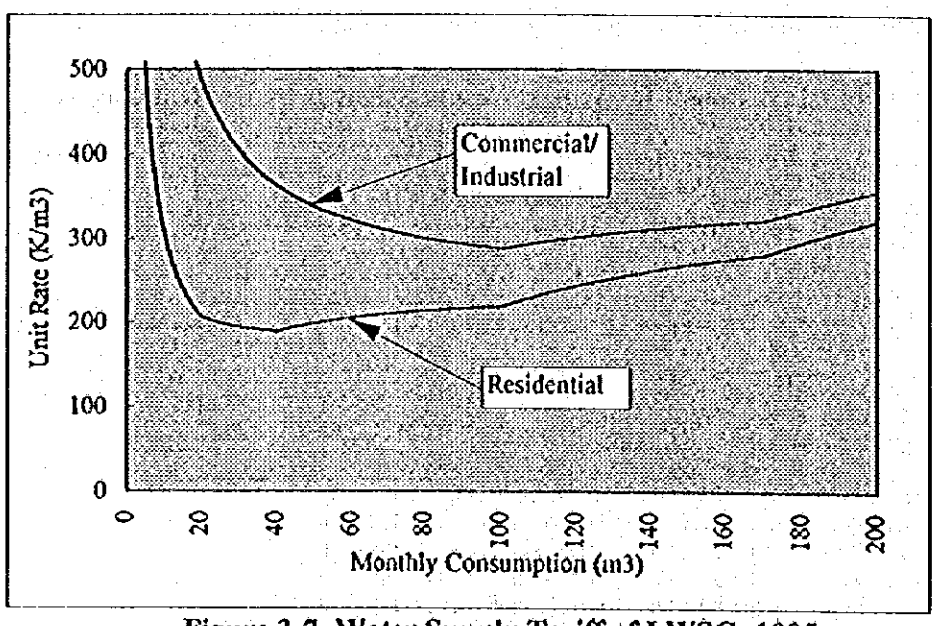

Figure 3-7 Water Supply Tariff of LWSC: 1995

3.2.2 Domestic Water Consumers

In urban areas, various supra- and infra-structures as well as residences are settled in accordance with urban agglomeration. These facilities in actual towns are not always composed in conformity with a certain rule systematically, although they should be settled to avert urban and environmental problems and to keep amenity of life. From the point of view of human settlement, Department of Town and Country Planning proposes the Planning Standard for new settlement. This Standard seems to be useful to estimate water demand as a reference for standardisation of water consumers. It was announced for human settlement standard in the "Second National Development Plan, 1972-1976".

It is important to get precise water demand information to establish a water supply system economically. The information of actual distribution of practical water consumers is prerequisite to estimated water demands in the supply areas. Nevertheless, the actual distribution of these facilities is not known even in major townships. In this study, thus, the above planning standard of human settlement is applied instead of the actual distribution of water consumers.

3.2.3 Water Consumption Rates

The average unit rates of water consumption are one of the most fundamental information for water demand estimation. In Zambia, the Standardisation Committee was established to provide the standard figures of average water consumption rates in early 80's and to revise them in August 1986. The figures were gazetted in Circulation No.1, "Consumption Figures and Population Projects for Design of Water Supply Systems".

Applying these water consumption rates and the aforesaid planning standard of human settlement, water consumption rates in urban and rural areas is calculated as compound rates. The rate in urban area is calculated for large urban area having a population of more than 50,000 and for small urban area having a population between 1,000 and 50,000, separately. These rates are summarised as follows.

Table 3-13 Unit Consumption Rates in Urban/Rural Areas

Category	Unit Compound Consumption Rate
Urban Area	
Large Urban Area	180 lit/capita/day
Small Urban Area	150 lit/capita/day
Rural Area	35 lit/capita/day

The water consumption rate of residential use will increase in proportion to improvement of people's standard living. Besides the household uses, non-residential use will also increase as the economic condition goes up. However, the above consumption rates look large enough to meet to future demand as compared to present consumption condition which was appeared in the water consumption survey. The planning standard also seems to have some allowance as compared to the actual distribution. Thus, these rates might be overestimation for projection of present water demand. In this study, however, that estimate is considered to be allowance for present water demand and to be enough for future water demand.

3.2.4 Domestic Water Demand Projection

(1) Projection Procedure

The gazette of Circulation No.1 "Consumption Figures and Population Projections for Design of Water Supply Systems" stipulates standards and criteria for water demand projection. In this master plan, the figures of water consumption unit rates in the gazette are applied to estimate water demand as basic information.

The domestic water demand consists of residential and non-residential water demand. The non-residential demand is further broken down to educational, medical, administrative and commercial water demand. It is assumed that these demands are all linearly related to the population concerned. As discussed in the above section, the planning standard for human settlement is applied to estimate an inventory of the non-residential facilities. Needless to say, water demand of residential water use is estimated on the basis of future population projected in the previous Section 3.1.

(2) Domestic Water Demand

The summary of the projected domestic water demand for the three projections is illustrated in below Figure 3-8 for the years of 1990 to 2015.

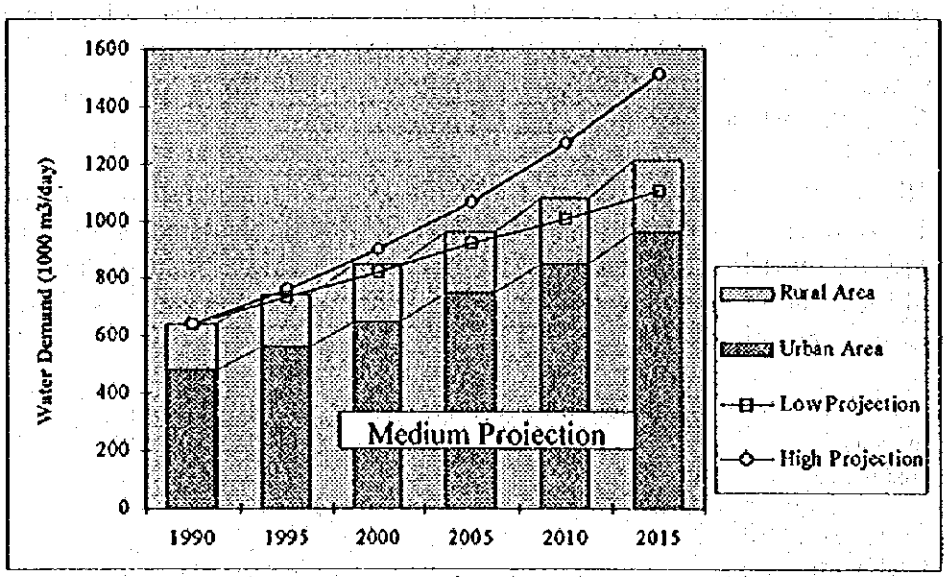

Figure 3-8 Future Domestic Water Demand: 1990-2015

Urban potential water demand is tabulated for respective townships for the years 1995, 2005 and 2015 in Appendix 1 in Part E of Supporting Report. District-wise water demand is enumerated for respective districts classified into urban and rural areas in Appendix 2 in Part E of Supporting Report.

3.3 Industrial Water

3.3.1 Manufacturing Sector Situation

(1) Past Development Trend

Industrial production index over the past 10 years since 1980 is shown in Table 3-14. The table shows that all industrial production (total index) decreased slightly from the level of 1980. The present activity (1992) of the mining sector stands at almost 20% less than that in 1980; in particular, coal production decreased by almost 25%. In spite of this, the manufacturing sector increased by almost 34% from 1980. Within manufacturing, "Food & Beverages" increased sharply by almost 70%, "Chemicals, Rubber & Plastics" also increased by 40% and "Textiles and Clothing" increased by 27% which is almost the same as the rate of increase of the total manufacturing sector. On the contrary, "Basic metal industries" stand at almost 60% of the 1980 level and "Metal products" have remained at almost the same level since 1980.

Table 3-14 Index of Industrial Production

Year	Weight	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992 (**)
TOTAL INDEX	1000	100	98.3	98.9	100.3	98	99.1	96.7	95.3	96.2	96.1	96.6	92.4	101.4
- Coal	13	100	87.6	104.3	73.2	88.2	88.2	96.2	80.1	82.9	68.2	65.3	65.4	74.2
- Non-Ferrous Ore (*)	535	100	91.3	94.2	93	89.5	36.8	85.3	83.7	80.6	82.8	79.2	72	80.6
- Stone Quarrying	1	100	77.5	83.6	81.4	87.5	80.5	84.3	69.6	78.5	162.4	126.4	142.1	114.7
TOTAL Mining	549	100	91.2	94.4	92.7	89.5	86.8	85.6	83.6	80.6	82.6	79	72	80.5
- Food, Beverage &Tobacco	106	100	106.6	104.8	117.3	112	117.9	108.3	109.6	113.2	107.9	124.8	128.1	172.7
- Textiles and Clothing	78	100	119.6	117.5	126.7	134.6	166.9	145.7	120.4	147.1	155.5	161.1	145.2	127.7
- Wood , Wood Products	19	100	99.3	94.1	77.7	65.3	73.3	66.1	69.8	74.9	83.6	102.2	103.2	102.9
- Paper & Paper Products	23	100	118.1	125.2	137.3	133.4	122.7	125.9	197	191.9	146.3	138	134.9	132.2
- Chemicals, Rubber, Plastic	66	100	100.9	86.2	102.1	96.6	90.1	100.8	103.3	108	108	110.4	111.1	141.5
- Non-Metallic Mineral Products	19	100	101.1	100.2	96.3	79.5	90.9	100.2	126.3	119.7	124.4	119.2	115	110.3
- Basic Metal Industries	9	100	90.7	79.8	80.5	81.5	96.6	90.3	91.9	91.9	66.9	49.5	50.3	57.3
- Metal Product and Other	72	100	102.4	98.4	94.3	101.3	93.7	98.6	99.2	97.8	108	101.1	101.5	99.3
TOTAL Manufacture	392	100	107.1	102.9	109.8	108.6	115	110.9	112.5	118.9	118.4	123	120.6	133.6
TOTAL Electricity	59	100	106.2	114.7	109.2	106.3	109.1	106.4	91.3	90.7	73.1	84.3	94.2	82.5

Notes:
* Including copper refineries
** Provisional Source: Index of Industrial Production, June 1993

(2) Manufacturing Characteristics

In order to understand the Zambian manufacturing sector, Table 3-15 shows Value Added by industry type in 1990 and a comparison of the number of establishments and employees by industry type in 1980 and 1990.

Table 3-15 Manufacturing Establishments and Employees by Industry Type

ISIC Code	Description	1980			1990			1990		
		(A) No. of Estab	(B) No. of Employee	(C) Ave. (B/A)	(A) No. of Estab	(B) No. of Employee	(C) Ave. (B/A)	Share of Employee (%)	Value Added (K'million)	Share of Value Added (%)
31	Food & Beverage	136	20,399	150	200	29,877	149	42.5	11,820	32.7
32	Textiles & Leather	127	11,192	88	125	15,195	122	21.6	2,505	6.9
33	Wood & Furniture	29	3,410	118	54	3,584	66	5.1	898	2.5
34	Paper & Printing	37	2,680	72	53	3,368	64	4.8	3,027	8.4
35	Chemicals	51	7,310	143	79	8,012	101	11.4	2,452	6.8
36	Non-metallic	25	3,539	142	28	2,606	93	3.7	3,727	10.3
37	Iron & Steel	4	1,202	301	17	926	54	1.3	241	0.7
38	Metal & Machinery	123	9,019	73	105	6,516	62	9.3	10,347	28.7
39	Other Manuf.	7	158	23	4	273	68	0.4	1,089	3.0
3	TOTAL	539	58,909	109	665	70,357	106	100.0	36,107	100.0

Notes: 1) Data in 1976 and 1980 are based on "Census of Industrial Production, 1974 and 1980".
2) Data in 1990 are based on information given by CSO.

The table shows that, from the viewpoint of Value Added, number of establishments and number of employees, "Food & Beverages" is the leading sector accounting for almost 40% share of total manufacturing sector. "Textiles & Leather" accounts for almost 22% of total employees, and almost 7% of total Value Added, whereas "Metals & Machinery" accounts for almost 30% of total Value Added. This implies that Value Added type of industry should be expanded to achieve national economic development. However, as stated above, the "Metal & Machinery" sector has not been developed over the past 10 years. "Food & Beverages" and "Textiles & Leather" make a large contribution to the national economy by not only creation of employment opportunities but also by supplying to the domestic demands. For these reasons, such industries have expanded noticeably in the past.

(3) Regional Industrial Characteristics

Regional industrial distribution is illustrated in Table 3-16 by the number of establishments and employees, based on CSO information. The industrial census was made in 1990; however, results and analysis have not yet been published. The table shows that almost 40% of the total number of establishments and total employees are located in Lusaka Province and another 42% of total number of establishments and 34% of total employees are located in Copperbelt Province. Of lesser importance are Southern Province, with almost 10% of total establishments and employees ,and Central Province with almost 5% of industries.

Generally, Lusaka is the most industrialised province; however, Copperbelt Province is more advanced in "Metal & Machinery" industries than Lusaka. Although most industries are located in Lusaka and Copperbelt Provinces, "Food & Beverages", "Textiles" and "Wood & Furniture" are distributed nation-wide. In other words, light industries exist in all provinces, while more technically advanced industries such as metal and machinery industries are mainly concentrated in Lusaka and Copperbelt Provinces.

Table 3-16 Regional Industrial Accumulation in 1990

Province	31 Food, Beverages	32 Textiles Leather	33 Wood & Furniture	34 Paper & Printing	35 Chemicals	36 Non-Metallic	37 Iron & Steel	38 Metal & Machinery	39 Other Manuf'g	TOTAL
<LUSAKA>										
- No.of Establishment	74	37	21	26	31	16	8	31	3	247
- No. of Employees	12,946	5,818	1,514	1,722	3,076	1,278	454	1,805	196	29,012
<COPPERBELT>										
- No.of Establishment	65	44	23	24	43	7	7	71	1	285
- No. of Employees	6,299	4,592	1,585	1,610	4,486	1,002	425	4,153	77	24,229
<CENTRAL>										
- No.of Establishment	11	7	1		2	2	1			24
- No. of Employees	454	2,634	14		112	248	27			3,489
<NORTH WESTERN>										
- No.of Establishment	5		1							6
- No. of Employees	165		38							203
<WESTERN>										
- No.of Establishment	8	1	2							11
- No. of Employees	250	65	134							723
<SOUTHERN>										
- No.of Establishment	16	28	4	1	2	2	1	2		56
- No. of Employees	6,176	1,907	254	10	102	40	20	407		8,642
<LUAPULA>										
- No.of Establishment	3	1	2		1					7
- No. of Employees	1,611	31	45		236					1,923
<NORTHERN>										
- No.of Establishment	10	4		1		1				16
- No. of Employees	1,587	96		14		38				1,735
<EASTERN>										
- No.of Establishment	8	3		1				1		13
- No. of Employees	389	52		12				151		604
(National Total)										
- No.of Establishment	200	125	54	53	79	28	17	105	4	665
- No. of Employees	29,877	15,195	3,584	3,368	8,012	2,606	926	6,516	273	70,560

Note: Prepared on the basis of industrial data in 1990 as given by CSO.

3.3.2 Industrial Water Demand Forecast

Industrial water demand for manufacturing sector is assumed at city and district level over the whole country by the following study steps.

1) Industrial development forecast is made on the basis of production amount (VA: Value Added) by industrial type which is projected by macro-economic development as described in Section 3.1.
2) Industrial development forecast by district level is also assumed by the present industrial situation such as the existing industrial accumulation and regional population growth.
3) Unit water consumption rates by industrial type are estimated on the basis of analysis of results of questionnaires answered by manufacturing enterprises in Zambia.
4) Industrial water demand in 2005 and 2015 are assumed by growth of industrial type by district and unit water consumption rate.

(1) Industrial Development Forecast

As discussed in Section 3.1, the GDP projection of manufacturing sector in the year 2015 according to Base Case(1) is given as K 766.2 billion. Value added forecast of the manufacturing sector is broken down by the above manufacturing growth rate and past growth rate of each industrial type. According to this analysis, average industrial sub-sector growth rates are obtained as shown in Table 3-17.

Table 3-17 Industrial Sub-sector Growth Rate

Industrial Sub-sector	Share in 1993	1993-2005	2005-2015
Food, Beverages, etc	41.5%	4.0%	4.0%
Textiles & Leather	5.5%	2.9%	2.8%
Wood & Furniture	2.1%	3.2%	3.1%
Paper & Printing	2.9%	3.2%	3.2%
Chemicals	18.2%	3.6%	3.6%
Non-Metallic Products	11.5%	4.1%	4.0%
Iron & Steel	0.3%	2.4%	2.3%
Metal & Machinery	5.9%	3.5%	3.4%
Other Manufacturing	2.0%	4.8%	4.7%
(Average)	100%	3.6%	3.6%

Note: Growth rate is calculated from Base Case(1) of GDP Projection

Growth rates of "Food/Beverages" and "Non-Metallic Products" are slightly higher than the average rate and other sub-sectors are below the average rate. "Food/Beverages" accounted for about 42% in 1993 and was the largest sub-sector in manufacturing sector. It can be said that the industrial development situation in Zambia is only at the early stages of industrialisation. According to data of external trade, imports of food/beverages and non-metallic products are relatively high. To reduce foreign exchange, these industries should be developed within Zambia in the future. Value added forecast by industry in 2005 and 2015 based on the above rates is shown in Table 3-18.

Manufacturing sector will increase by almost 220% in 2015 from the present level. Thus, this sector is a significantly important sector for Zambia. From this sector, "Food/Beverages" accounts for 42% of total manufacturing.

Table 3-18 Industrial Structure Forecast in Zambia

Value Added in Basic Value (K'Million)

Code	Description	1974	1980	1990	1993	2005	2015
2	Total / Mining	551	923	10,217	142,957	235,400	334,400
31	Food, Beverages etc.	55	110	11,820	145,622	225,661	322,146
32	Textiles & Leather	27	81	2,505	19,215	26,960	35,566
33	Wood & Furniture	12	19	898	7,462	10,879	14,810
34	Paper and Printing	13	25	3,027	10,234	14,969	20,431
35	Chemicals	48	85	2,452	63,724	97,795	138,833
36	Non-metallic Product	15	30	3,727	40,433	65,139	96,223
37	Iron and Steel	5	9	241	978	1,296	1,633
38	Metals & Machinery	48	96	10,347	55,887	84,041	117,339
39	Other Manufacturing	1	2	1,089	6,948	12,159	19,219
3	Total / Manufacturing	224	457	36,107	350,503	538,900	766,200

Notes: 1) Figures for 1974 , 1980 and 1993 are current prices based on the Industrial Census.
2) Figures for 2005 and 2015 are constant prices at 1993 levels as estimated by the Team.

(2) Regional Industrial Development

According to industrial statistics in 1990 given by CSO, there are 665 manufacturing enterprises with a total of 70,357 employees in the whole country. Industrial water consumption depends on industrialisation at both national and regional level. It is advantageous to estimate industrial water consumption at the regional and district level; therefore, the present industrial situation and future development frame should be drafted at the district level. The results of the present industrial accumulation and annual growth rate by Province and township are shown in Table 3-19.

Table 3-19 Manufacturing Distribution Ratio by Province in 1990

Province and District	Population in (1990)	31 Food, Bev.	32 Textile	33 Wood, Furn.	34 Paper, Print'g	35 Chemicals	36 Non-metal	37 Iron, Steel	38 Metal, Mach.	39 Other	Total
Lusaka P.	829,473	43.9%	38.3%	43.3%	51.1%	38.4%	49.0%	49.0%	27.7%	71.8%	41.2%
- Lusaka Urban	769,353	40.7%	35.5%	40.2%	47.4%	35.6%	45.5%	45.5%	25.7%	66.6%	38.2%
Copperbelt P.	1,112,637	21.1%	30.2%	44.2%	47.8%	56.0%	38.4%	45.9%	63.7%	28.2%	34.4%
- Ndola Urban	334,531	6.3%	9.1%	13.3%	14.4%	16.8%	11.6%	13.8%	19.2%	8.5%	10.4%
- Chililabombwe	48,055	0.9%	1.3%	1.9%	2.1%	2.4%	1.7%	2.0%	2.8%	1.2%	1.5%
- Chingola	142,379	2.7%	3.9%	5.7%	6.1%	7.2%	4.9%	5.9%	8.2%	3.6%	4.4%
- Mufulira	124,746	2.4%	3.4%	5.0%	5.4%	6.3%	4.3%	5.1%	7.1%	3.2%	3.9%
- Chambishi	9,945	0.2%	0.3%	0.4%	0.4%	0.5%	0.3%	0.4%	0.6%	0.3%	0.3%
- Kitwe	288,592	5.5%	7.8%	11.5%	12.4%	14.5%	10.0%	11.9%	16.5%	7.3%	8.9%
- Luanshya	118,143	2.2%	3.2%	4.7%	5.1%	5.9%	4.1%	4.9%	6.8%	3.0%	3.7%
Central P.	213,198	1.5%	17.3%	0.4%	0.0%	1.4%	9.5%	2.9%	0.0%	0.0%	5.0%
- Kabwe	161,456	1.2%	13.1%	0.3%	0.0%	1.1%	7.2%	2.2%	0.0%	0.0%	3.8%
N-Western P.	54,320	0.6%	0.0%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
Southern P.	211,984	20.7%	12.6%	7.1%	0.3%	1.3%	1.5%	2.2%	2.0%	0.0%	12.3%
- Livingstone	76,875	7.5%	4.6%	2.6%	0.1%	0.5%	0.6%	0.8%	0.7%	0.0%	4.5%
Luapula P.	83,126	5.4%	0.2%	1.3%	0.0%	2.9%	0.0%	0.0%	0.0%	0.0%	2.7%
Northern P.	118,301	5.3%	0.6%	0.0%	0.4%	0.0%	1.5%	0.0%	0.0%	0.0%	2.5%
- Kasama	48,045	2.2%	0.3%	0.0%	0.2%	0.0%	0.6%	0.0%	0.0%	0.0%	1.0%
Eastern P.	82,750	1.3%	0.3%	0.0%	0.4%	0.0%	0.0%	0.0%	2.3%	0.0%	0.9%
- Chipata	52,213	0.8%	0.2%	0.0%	0.2%	0.0%	0.0%	0.0%	1.5%	0.0%	0.5%
National Total	2,781,530	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

[Note] 1) Distribution ratio is based on number of employees by type of industry and by township.
2) Ratio is calculated by the Team. Source: Number of employees in 1990 is given by CSO.

Manufacturers are mainly located in Lusaka and Copperbelt Provinces which account for 75% of all manufacturing industry. In particular, Lusaka city is the most industrialised region in Zambia accounting for about 40% of total manufacturing industry. Secondly, Ndola city in Copperbelt accounts for about 10% of total manufacturing industry. Although the manufacturing share of Copperbelt is lower than Lusaka province, its share of "metal & machinery" and "chemicals" is larger than Lusaka province. This implies that Copperbelt is a more industrialised region than Lusaka Province. On the other hand, the least industrially developed province is North Western Province which accounts for only 0.3%.

Future regional industrial development is assumed based on the growth rates of industrial sub-sectors and district population combined with the present industrial accumulation by districts. The reason why population growth rate is employed for the assumption of industrial development is based on the fact that employment opportunities should be expanded to match increasing population growth rate.

(3) Unit Water Consumption Rate

Unit water consumption rates vary widely from industry to industry and from country to country. To grasp unit water consumption rate by industrial type in Zambia, the Study Team conducted a questionnaire survey supported by DWA and ZACCI (Zambia Association of Chambers of Commerce and Industry) between February and April 1994. The number of questionnaires answered by manufacturers was 139 samples which accounts for about 20% of manufacturers listed in the 1990 statistical data of CSO.

The assumed unit water consumption rates are categorised by sub-sector, as given by the two digit ISIC codes (International Standard Industrial Classification). In order to avoid discrepancies caused by differences in scale between those establishments who responded to the questionnaire survey and the national average in Zambia, the following weighting formula is employed for analysis of unit water consumption rate. The analytical results are shown in Table 3-20.

$$Ur = \sum_{1}^{i} \{AWC \times NAN / ANE\} / NME$$

Where,

- Ur : Unit water consumption rate by sub-sector (2 digit ISIC code)
- AWC : Average water consumption per sample (3 digit ISIC code)
- NAN : National average number of employees (3 digit ISIC code)
- ANE : Average number of employees per sample (3 digit ISIC code)
- *i* : Number of manufacturing establishments by industrial type (3 digit ISIC code)
- NME : Number of manufacturing establishments by sub-sector (2 digit ISIC code)

Table 3-20 Average Water Consumption Rate by Industry

ISIC Code	Industrial sub-sector	Number of Manufacturing Establishments	Number of Samples Collected	Collection Rate (%)	Weighted Average Consumption Rate (m^3/day)
31	Food, Beverage etc.	200	26	13	910.5
32	Textiles & Leather	125	10	8	84.6
33	Wood & Furniture	54	9	17	24.3
34	Paper & Printing	53	6	11	28.1
35	Chemicals	79	29	37	296.3
36	Non-metallic Products	28	12	43	57.1
37	Iron and Steel	17	3	18	10.9
38	Metals & Machinery	105	42	40	15.9
39	Other Manufacturing	4	2	50	5.1
3	Total Manufacturing	665	139	21	159.2

(4) Industrial Water Demand in 2005 and 2015

(a) Manufacturing Sector

Water demand of the manufacturing sector is estimated by using the following formula. The mining sector is dealt with separately below, because mining sector activity in Zambia is quite significant and solely operated by ZCCM.

$$MWDd = \sum_{1}^{n} (Ur \times NME) \times (1 + GR - WR)^{t}$$

Where,

MWDd	: Manufacturing water demand by district
n	: Number of manufacturing sub-sectors
Ur	: Unit water consumption rate by sub-sector (2 digit ISIC code)
NME	: Number of manufacturing establishments by sub-sector
GR	: Annual growth rate by sub-sector
WR	: Annual growth rate of water recycling
t	: Years up to the targeted year

Generally, the water recycling rate in a country normally increases in parallel with industrial advancement. In this study, water recycling growth rate is set at 0.5% per annum in consideration of Japanese past performance which recorded an increase of 6.5% over 13 years (water recycling rate in Japan increased from 68.8% in 1976 to 75.3% in 1988). From the results of the above analysis, assumed water consumption volumes in 2005 and 2015 are shown in Table 3-22.

In 1990, the water consumption volume of Lusaka province was almost the same as that for Copperbelt province. The two provinces accounted for more than three quarters of total water consumption in the manufacturing sector. From the viewpoint of city or district level, Lusaka city is the highest consumer of industrial water (76,500 m^3/day) and accounted for almost one third of total water consumption (222,400 m^3/day) in the manufacturing sector in 1990. In second place, Ndola city at about 23,600 m^3/day accounted for almost 10% of total industrial water consumption. Other major users in Copperbelt province are Kitwe city and Chingola.

By 2015, the industrial water demand of Lusaka city will have increased by about 230% from the 1990 level, and will account for 40% of total manufacturing water demand. Ndola's manufacturing water demand will also increase; however, the rate of increase is slightly lower than for Lusaka city because of differing rates of industrialisation.

(b) Mining Sector

Water consumption rates in the mining sector vary widely depending on type and capacity of processing plant. There are various mineral processing plant, such as concentrators, smelters, refineries and other mineral plants, located at the different ZCCM Divisions or mines. Therefore the present water consumption rates as given by ZCCM are applied for the mining sector and future water consumption is assumed as almost the same volume, because ZCCM expects to maintain annual copper production at the present level of 440,000 tonnes in future. It is noted that other potential development ores have been identified; however, water

consumption rates are not mentioned because detailed development plans are not known at present. Resulting from the above, assumed water consumption volumes for the mining and manufacturing sectors are summarised in Table 3-21 and the details are shown in Table 3-22.

Table 3-21 Summary of Water Demand Forecast

(Unit:1000m³/day)

Sub-sector	(1990)		(2005)		(2015)	
Mining	307.1	(58%)	307.1	(46%)	307.1	(41%)
Manufacturing	222.4	(42%)	366.7	(54%)	446.1	(59%)
< Total >	529.5	(100%)	673.8	(100%)	753.2	(100%)

Water consumption in the manufacturing sector will exceed the mining sector by the years 2005 and 2015. Water consumption in manufacturing sector will increase by almost 165% in 2005 and 200% in 2015 from the 1990 level. Water consumption of Copperbelt province, with most of Zambia's mining industry, accounts for almost 70% of the national total at present; this share will decrease to 67% by 2015. On the other hand, Lusaka Province's share will increase to 25% of the total in 2015 from 16% in 1990.

Table 3-22 Water Demand Forecast by Province and Main City

(Unit:1000m³/day)

Province & Main City	1990			2005			2015		
	Mining	Manufg	Total	Mining	Manufg	Total	Mining	Manufg	Total
Lusaka P.		82.4	82.4		136.7	136.7		189.9	189.9
- Lusaka		76.5	76.5		126.9	126.9		177.3	177.3
Copperbelt P.	290.6	78.5	369.1	290.6	129.8	418.4	290.6	140.7	431.3
- Ndola		23.6	23.6		39.1	39.1		46.5	46.5
- Chililabombwe	8.0	3.4	11.4	8.0	5.6	13.6	8.0	5.5	13.5
- Chingola	78.8	10.0	88.8	78.8	16.5	95.3	78.8	17.0	95.8
- Mufulira	53.0	8.8	61.8	53.0	14.5	67.5	53.0	13.9	66.9
- Kalulushi		2.2	2.2		3.7	3.7		4.4	4.4
- Kitwe	25.4	20.4	45.8	25.4	33.6	59.0	25.4	36.7	62.1
- Luanshya	52.0	8.3	60.3	52.0	13.7	65.7	52.0	13.8	65.8
Central P.	13.7	11.3	25.0	13.7	18.8	32.5	13.7	23.5	37.2
- Kabwe	13.7	8.6	22.3	13.7	14.5	28.2	13.7	18.6	32.3
N/Western P.		4.6	4.6		7.7	7.7		9.1	9.1
Western P.		7.4	7.4		12.4	12.4		13.3	13.3
Southern P.	2.8	17.8	20.6	2.8	29.3	32.1	2.8	32.2	35.0
- Livingstone		6.5	6.5		10.6	10.6		11.4	11.4
Luapula P.		3.2	3.2		5.3	5.3		5.7	5.7
Northern P.		9.5	9.5		15.9	15.9		17.1	17.1
- Kasama		3.9	3.9		6.5	6.5		7.1	7.1
Eastern P.		7.6	7.6		12.7	12.7		14.6	14.6
- Chipata		4.8	4.8		8.0	8.0		9.3	9.3
National Total	307.1	222.4	529.5	307.1	366.7	673.8	307.1	446.1	753.2

[Notes]

1) Figures in mining sector are based on ZCCM's information.
2) Chingola includes ZCCM's Nchanga division.
3) Kalulushi includes ZCCM's Chibaluma mine.
4) Luansha includes ZCCM's Baluba mine.

(c) Case Study

Water consumption stated above is assumed based on Base Case (1) of projected GDP in the industrial (manufacturing) sector. In addition, the following case study of water consumption for the Industrialisation and Conservative cases of GDP projection, is described below. Average annual growth rates are calculated according to GDP projections for both the Industrialisation (maximum) and the Conservative (minimum) assumptions.

Table 3-23 Projected GDP in Max. and Min. Assumption

Projection Case	Projected GDP (K Million)			Ave. Annual Rate of Increase	
	1993	2005	2015	1993-2005	2005-2015
(1) Base Growth Case - Industrialisation (Maximum Assumption)	350.5	728.6	1,152.8	6.3%	4.7%
(2) Base Growth Case - Agricultural Expansion (Medium Assumption)	350.5	538.9	766.2	3.6%	3.6%
(3) Conservative Growth Case (Minimum Assumption)	350.5	454.8	534.7	2.2%	1.6%

The same formula is employed to estimate industrial water consumption for manufacturing sector. The projection results for the national total and for 3 cities and 7 municipalities are as shown in Table 3-24.

Table 3-24 Industrial Water Demand Forecast in Max. and Min. Cases

(unit:1000m^3/day)

City and Municipality	2005			2015		
	Min.	Base	Max.	Min.	Base	Max.
- Lusaka City	100.7	126.9	193.7	140.7	177.3	270.7
- Ndola City	31.1	39.1	59.8	37.0	46.5	71.1
- Chililabombwe	4.4	5.6	8.4	4.4	5.5	8.3
- Chingola	131	16.5	25.1	13.6	17.0	25.9
- Mufulira	11.5	14.5	21.9	11.1	13.9	21.1
- Kalulushi	2.9	3.7	5.6	3.5	4.4	6.7
- Kitwe City	26.8	33.6	51.2	29.2	36.7	55.8
- Kabwe	11.4	14.5	22.3	14.7	18.6	28.6
- Livingstone	8.5	10.6	16.1	9.1	11.4	17.3
- Kasama	5.1	6.5	10.0	5.6	7.1	10.9
- Chipata	6.3	8.0	12.4	7.3	9.3	14.3
[Above Total]	211.8	279.5	426.5	276.2	347.7	530.7
[National Total]	291.8	366.7	557.5	354.8	446.1	678.4

Comparing GDP projection in 2015, Case (1) in Table 3-23 (1,152.8 billion Kwacha) stands at almost 50% higher than Case (2) (766.2 billion Kwacha) and the Case (3) (534.7 billion Kwacha) stands at almost 30% less than Case (2). In the case of industrial water consumption, however, the Case (3) (minimum assumption) gives a figure almost 20% less than Case (2) (medium assumption). Case (1) (maximum assumption) shows almost the same differential as GDP of 50% higher than Case (2).