JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

REPUBLIC OF ZAMBIA
MINISTRY OF ENERGY AND WATER DEVELOPMENT

THE STUDY

ON

THE NATIONAL WATER RESOURCES MASTER PLAN

IN

THE REPUBLIC OF ZAMBIA

FINAL REPORT
SUMMARY

OCTOBER, 1995

YACHIYO ENGINEERING CO., LTD.
(YEC)

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PREFACE

In response to a request from the Government of the Republic of Zambia, the Government of Japan decided to conduct a master plan study on the national water resources and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Zambia a study team headed by Mr. Yoshio Nakagawa, Yachiyo Engineering Co., Ltd., five times between October 1993 and October 1995.

The team held discussion with the officials concerned of the Government of Zambia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Zambia for their close cooperation extended to the team.

October, 1995

Kimio Fujita
President
Japan International Cooperation Agency

October, 1995

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Fujita,

LETTER OF TRANSMITTAL

We are pleased to submit to you the master plan report on the national water resources development project in the Republic of Zambia. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as the formation of the above mentioned project. Also included are comments made by the Ministry of Energy and Water Development of the Government of Zambia during technical discussions on the draft report which were held in Lusaka, Zambia.

The report proposes plans showing the general direction of future water resources development targeting the year 2015. Regarding water supply and agriculture sectors, many concrete projects have been formulated according to the proposed development targets. For other sectors related to water resources, development policies are presented from the viewpoint of water resources development, based on the analysis of the current situation and future projections. The plans for the water supply and agricultural sectors were prepared on the basis of three scenarios (three sets of future socio-economic conditions leading to the maximum, medium and minimum water demands) considering future population and economic growth. The report also presents an action plan to be implemented at an early stage, selecting from the plans proposed in the master plan.

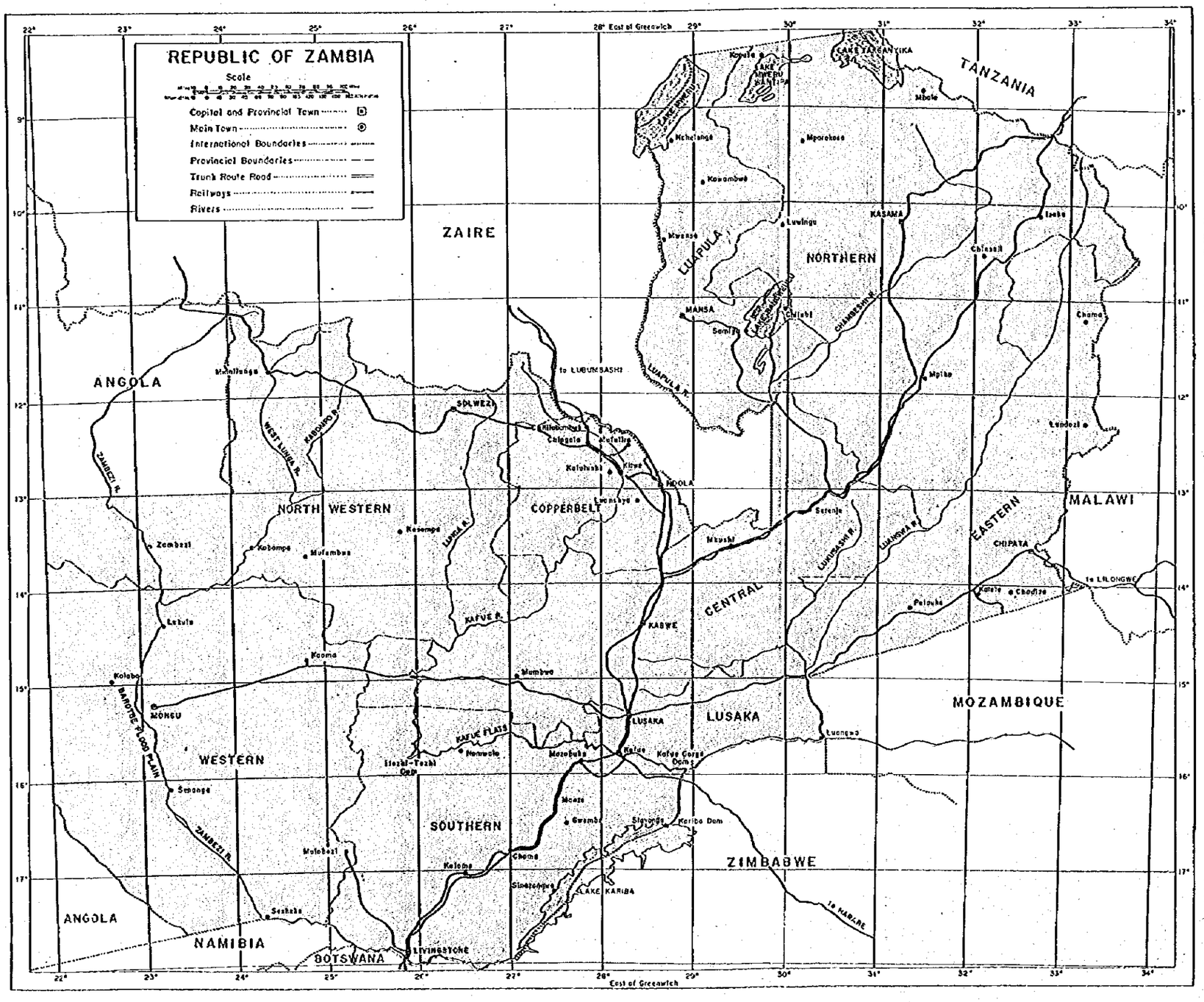
In view of the urgency of water resources development in Zambia and of the need for the socio-economic development of Zambia as a whole, we recommend that the Government of Zambia implement the projects proposed in the action plan as a top priority.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, Ministry of Construction, Ministry of Agriculture, Forestry and Fisheries. We also wish to express our deep gratitude to the Ministry of Energy and Water Development of the Government of Zambia for the close cooperation and assistance extended to us during our investigation and study.

Very truly yours,

Y. Nakagawa

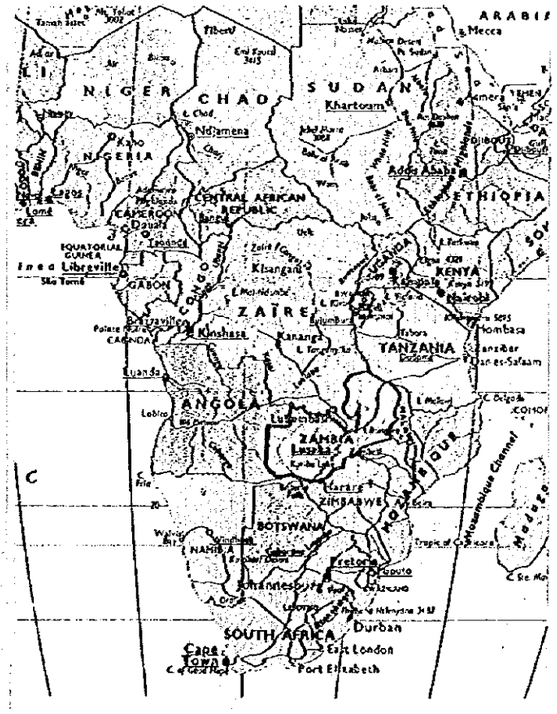
Yoshio Nakagawa
Team Leader
The Study on the National Water Resources
Master Plan in the Republic of Zambia



Location Map of Study Area

Zambia Brief Information

Long-form Name	Republic of Zambia
Independence	October 24, 1964
Former Ruler	United Kingdom
Form of Government	Republican System
President	Frederick Chiluba inaugurated on November 2, 1991
Location	Latitude 9-18 degree South Longitude 23-34 degree East
Area	753 thousand km2
Capital	Lusaka
Population	7.82 million (1990)
Official Language	English
Tribes	Tonga, Bemba, Ngoni etc. (73 Tribes)
Religion	Mainly Traditional Religions, Christianity in Cities
Education	Compulsory Education: 7-14 years old Attendance Rate: Primary School: 95 % Secondary School: 20 % University: 2 % Literacy: 73 % 1990 statistics
Time Lag	Time Lag with Japan: -7 hours



THE STUDY ON NATIONAL WATER RESOURCES MASTER PLAN
IN THE REPUBLIC OF ZAMBIA
FINAL REPORT

LIST OF REPORTS

SUMMARY

MAIN REPORT

SUPPORTING

Volume - 1	
Part - A	Socio-economy
Part - B	Meteorology
Part - C	Hydrology
Part - D	Hydrogeology
Part - E	Domestic Water Supply
Part - F	Industrial Water Supply
Part - G	Current Water Use Survey
Volume - 2	
Part - H	Agriculture, Livestock and Fishery
Part - I	Irrigation
Part - J	Forestry
Part - K	Hydroelectric Power Generation
Part - L	Navigation
Part - M	Flood Control
Part - N	Dam Geology
Part - O	Dam Development Plan Dam Geology
Part - P	Water Supply Plan
Volume - 3	
Part - Q	Water Quality and Environment
Part - R	Laws and Institutions
Part - S	Landsat Satellite Imagery Analysis
Part - T	Topographic Survey
Part - U	Groundwater Monitoring
Part - V	Well Inventory Survey
Part - W	Database

DATA

DB - 1	Meteorological Data
DB - 2	Hydrological Data
DB - 3	Well Inventory Data
DB - 4	Current Water Use Data

SYNOPSIS

The Study on the National Water Resources Master Plan in the Republic of Zambia

Study Period: October, 1993 ~ October 1995
Recipient Agency: Ministry of Energy and Water Development

1 BACKGROUND OF THE STUDY

Zambia had a population of 7.38 million in 1990. The population growth in 1980's was as high as 2.7% per annum. Rapid urbanisation has caused deterioration in public water supply services. The capital city of Lusaka has the most serious degradation. The supply capacity can meet only 60% of the demands. Rain fed agriculture prevails in Zambia for crop production, primarily maize, to meet the consumption of the nation. Rain fed agriculture has often been seriously affected by drought. Promotion of irrigation is a national target to attain stable crop production. Establishment of strengthened social and economic foundation with optimal use of the water resources is required in order to rehabilitate the economic base, which is heavily dependent on copper production at present and vulnerable to its market price, and to achieve a stable and sustainable socio-economic development of the country.

2 OBJECTIVES OF THE STUDY

The objective of the Study is to formulate a master plan for water resources development which covers the whole Zambia and whose target year is the year 2015 to remedy the current problems and to meet the future needs in the water supply sector and agricultural sector. Action plans are also formulated for immediate implementation, selecting out of the projects proposed in the Master Plan.

3 OUTLINE OF THE MASTER PLAN

Development policies are formulated for sectors, such as water supply, agriculture, hydro-electric generation, navigation, water quality, etc., after the analysis of the present status and future requirements for each sector. Projects are proposed for water supply and agricultural sectors with the target year of 2015.

3-1 Basic Policies

< Water Demand Scenario >

The following three scenarios are set, comprising population projection and economic growth forecast, for the estimation of future water demands.

1) Base Scenario-Agricultural Expansion:
   medium population projection, base economic growth - agricultural expansion
2) Base Scenario-Industrialisation:
   high population projection, base economic growth-industrialisation
3) Conservative Scenario:
   low population projection, conservative economic growth

< Development Policy for Water Supply>

Target water supply coverage in all urban areas are set as 100% by 2015. The coverage in rural areas is to be raised from current 25% to 75% by 2015. Sources from surface water

should correspond to the 10-year return period drought. Sources from groundwater should utilise rechargeable groundwater within the limit of safe yields to prevent depression of water tables for sustainable use.

< Development Policy for the Agricultural Sector >

While rain fed agriculture is to be encouraged in the northern regions favoured with adequate rainfall, irrigation is to be introduced and promoted utilising stable water sources to attain food security and improvement of balance of payment through increased production of irrigated cereal and export crops. Livestock and fishery is to be encouraged to maintain meat consumption and to increase fish consumption.

3-2 Proposed Projects

The volume of water to be developed to ensure domestic and industrial water use in large urban, small urban and rural areas is shown in Table-1. Water requirement for the development of irrigation, aqua-culture and livestock breeding is given in Table-2.

Table-1 Water Supply Projects for Domestic and Industrial Use

	Base Scenario- Agricultural Expansion		Base Scenario- Industrialisation		Conservative Scenario	
	Population Served (1000 person)	Water Developed ($1000m^3$/day)	Population Served (1000 person)	Water Developed ($1000m^3$/day)	Population Served (1000 person)	Water Developed ($1000m^3$/day)
Large Urban	4,500	723	5,223	1,095	3,433	551
Small Urban	965	156	1,948	358	870	103
Rural	7,270	169	7,165	164	6,609	148

Table-2 Agricultural Projects

	Base Scenario- Agricultural Expansion		Base Scenario- Industrialisation		Conservative Scenario	
	Area (ha) or Heads (1000)	Water Developed ($1000m^3$/day)	Area (ha) or Heads (1000)	Water Developed ($1000m^3$/day)	Area (ha) or Heads (1000)	Water Developed ($1000m^3$/day)
Irrigation	60,776	5,252	53,806	4,648	38,156	3,241
Fishery	30,950	2,130	40,500	2,793	24,050	1,648
Livestock	4,604	222	5,183	250	4,190	204

4 PROJECT COST

The project costs for water supply and agricultural sectors are estimated with unit prices in January, 1995 (1 us$ = 610 Kwacha) as shown in Table-3 and Table-4.

Table-3 Project Cost (Water Supply Sector) (Unit: US$ million)

Water Supply Sector	Base Scenario- Agricultural Expansion			Base Scenario- Industrialisation			Conservative Scenario		
	Large Urban	Small Urban	Rural	Large Urban	Small Urban	Rural	Large Urban	Small Urban	Rural
	647.86	153.03	209.52	878.09	323.04	203.77	518.34	107.47	183.85
	1,010.41			1,404.90			809.66		

Table-4 Project Cost (Agricultural Sector) (Unit: US$ million)

Agricultural Sector	Base Scenario- Agricultural Expansion			Base Scenario- Industrialisation			Conservative Scenario		
	Irrigation	Fishery	Livestock	Irrigation	Fishery	Livestock	Irrigation	Fishery	Livestock
	1,188.77	290.08	35.75	954.89	379.07	40.25	762.06	225.74	32.54
	1,514.60			1,374.21			1,021.55		

5 EVALUATION

5-1 Economic Analysis

Economic efficiencies of the projects are calculated as shown in Table-5, comparing economic benefits and cost, 5% of household income for domestic use plus 3% of value added for industrial use in the case of water supply, and net benefit of agricultural production in the case of agricultural sector, and converted costs from estimated financial cost in both cases.

Table-5 Result of the Economic Analysis

Items	Water Supply Projects				Agricultural Projects			
	Large Urban	Small Urban	Rural	Total	Irrigation	Fishery	Livestock	Total
Economic Internal Rate of Return (%)	6.3	4.0	4.2	5.3	11.4	12.7	13.1	11.7
Benefit/Cost	0.80	0.56	0.64	0.72	1.12	1.18	1.25	1.13
Net Present Value (US$ million)	-81.0	-54.3	-58.3	-193.5	65.8	32.3	3.9	102.0

5-2 Financial Evaluation

It is estimated that the government's investment for water supply will accumulate to US$ 630 million by 2015, while the proposed projects will cost 2.2~1.2 times of the estimation. The past investment by the government was too small. In case that the economic growth as set in the scenario is attained, the government budget and consequently the investment in water supply sector will be raised. The required investment will possibly be obtained. Investment of the agricultural sector relies on the private sector. Since projects of the agricultural sector have high economic efficiency, projects are feasible if finances are secured.

5-3 Social Evaluation

Through the implementation of the water supply and agricultural projects, the following social effects will be expected:

- Incentive to regional economy and increase of employment opportunity
- Improvement of safe water coverage and public hygiene
- Inducement to participating in "women in development" activity
- Mitigation of economic disparity among regions

5-4 Environmental Impact Assessment

While the IEE's have been based on limited investigations, no serious problems have yet been discovered. The IEE's have identified the following issues as likely to be important :

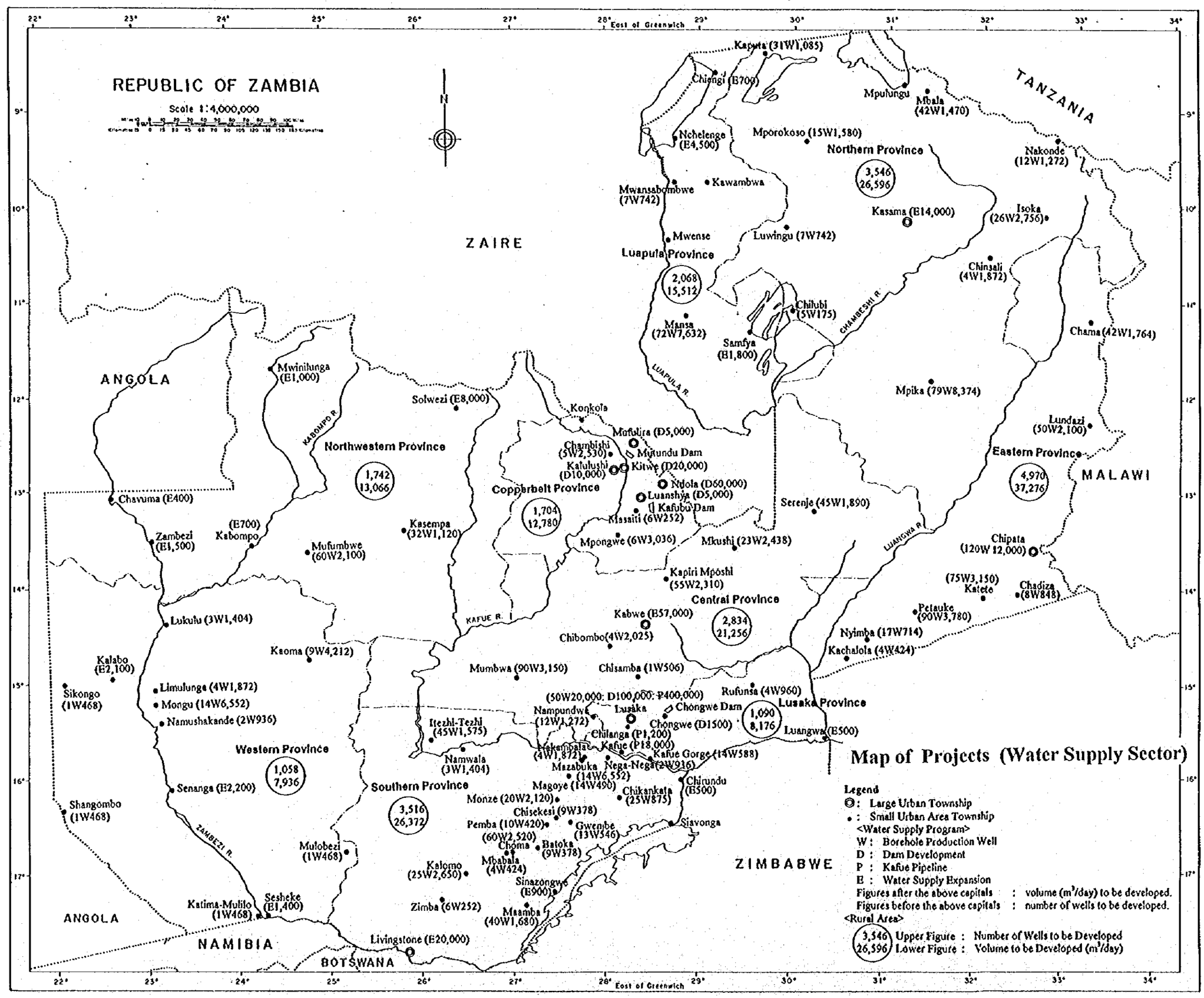
- Land tenure, acquisition, compensation and re-settlement
- Water right allocation and its impact on social equity
- New water demands and their impact on existing users
- Aquatic and terrestrial fauna in the river channel, dam reservoir, riparian strip, surrounding wetlands and along wildlife corridors
- Soil erosion due to expansion of agricultural land.

6 RECOMMENDATIONS

As well as revisions to the Master Plan evry five years, endeavours for securing finances, and encouragement of public awareness of Beneficiary-to-Pay principle and of Saving Water, immediate commencement of implementation of the Action Plan, as listed in Table-6, are recommended.

Table-6 Projects Proposed in Action Plan

Project	Outline	Implementation Schedule	Project Cost (Million US$)
(1) Northern Lusaka Production Well Project	- Location: 10km north from Lusaka - Water Developed: 20,000 m^3/day - No. of Borehole: 50 (diameter: 30 cm) (depth: 100 m)	completed by 1998	15.70
(2) Chongwe Multi-purpose Dam Project	- Location: 45km east from Lusaka - Fill Type Dam - Target: * Water Supply to Lusaka and Chongwe (103,000 m^3/day) * Irrigation (810ha, 70,000 m^3/day)	- study and design 1996-1997 - construction 1998-2000	- Water Supply: 109.87 - Irrigation: 34.74
(3) Drilling Center Project	- Location: one per province (new 6 centers) - Objective: Groundwater development by province	- construction of center by 2000 - procurement of rigs by 2005	41.64
(4) Groundwater Development Training Centre Project	- Objective: truing of engineers and technicians for groundwater development - Location: Lusaka City - Land Area: 10,000m^2 - Building Area: 3,000 m^2 - Rigs: 2 sets (DTH type) - Facilities: training rooms, reference rooms, auditorium, workshop, etc.	- Phase 1 (1996~1998) establishment of the centre and initial training by consultants - Phase 2 (1999~2003) technical transfer from foreign experts - Phase 3 (2004~) training andmanagement by Zambians	- for Phase 1 16.40
(5) ASIP Rehabilitation Projects	- Irrigated Area: 220 ha (9 sites) - Crops: vegetable (peri-urban agriculture around local townships)	completed by 1999	5.34
(6) Zambezi Left Bank Floodplain Rice Irrigation Project	- Irrigated Area: 1,500 ha - Crops: rice - Water Developed: 261,000 m^3/day	- Phase 1: 1998~2000	19.47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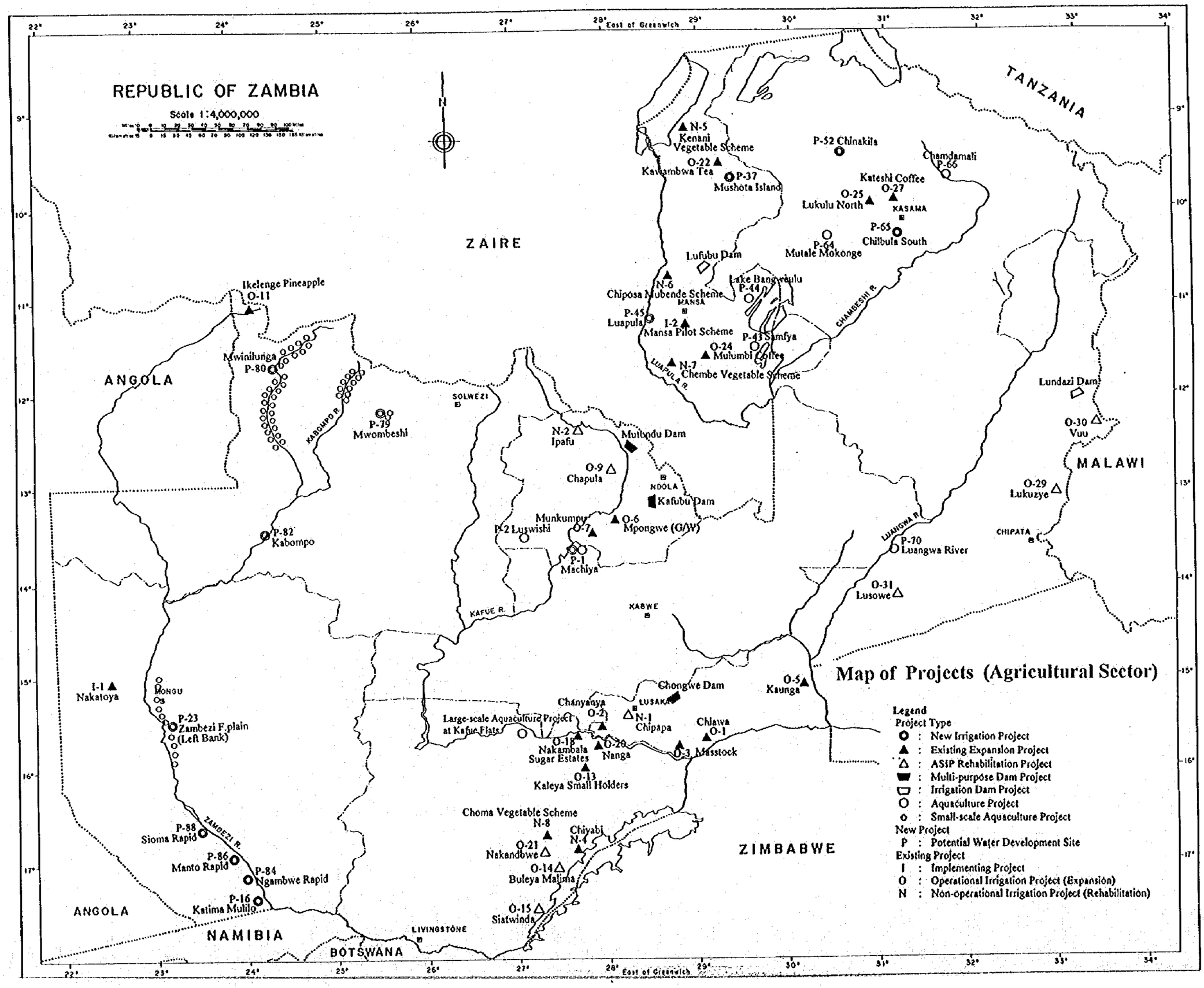
Scale 1:4,000,000
N
ZAIRE
TANZANIA
ANGOLA
MALAWI
ZIMBABWE
NAMIBIA
BOTSWANA
East of Greenwich
Kaputa (31W1,085)
Chiengi (B700)
Mpulungu
Mbala (42W1,470)
Nchelenge (E4,500)
Mporokoso (15W1,580)
Northern Province
3,546
26,596
Nakonde (12W1,272)
Mwansabombwe (7W742)
Kawambwa
Kasama (B14,000)
Isoka (26W2,756)
Mwense
Luwingu (7W742)
Luapula Province
2,068
15,512
Chinsali (4W1,872)
Chilubi (5W175)
Mansa (72W7,632)
Samfya (B1,800)
CHAMBESHI R.
Chama (42W1,764)
LUAPULA R.
Mpika (79W8,374)
Mwinilunga (E1,000)
Solwezi (E8,000)
Konkola
Mufulira (D5,000)
KABOMPO R.
Northwestern Province
1,742
13,066
Chambishi (5W2,530)
Mutundu Dam
Kalulushi (D10,000)
Kitwe (D20,000)
Ndola (D60,000)
Luanshya (D5,000)
Copperbelt Province
1,704
12,780
Kafubu Dam
Massaiti (6W252)
Lundazi (50W2,100)
Eastern Province
4,970
37,276
Serenje (45W1,890)
Chavuma (E400)
(E700)
Kabompo
Zambezi (E1,500)
Kasempa (32W1,120)
Mufumbwe (60W2,100)
Mpongwe (6W3,036)
Mkushi (23W2,438)
LUANGWA R.
Chipata (120W12,000)
Kapiri Mposhi (55W2,310)
(75W3,150)
Katete
Chadiza (8W848)
Central Province
2,834
21,256
Petauke (90W3,780)
KAFUE R.
Kabwe (B57,000)
Chibombo (4W2,025)
Nyimba (17W714)
Kachalola (4W424)
Lukulu (3W1,404)
Kaoma (9W4,212)
Kalabo (E2,100)
Mumbwa (90W3,150)
Chisamba (1W506)
Sikongo (1W468)
Limulunga (4W1,872)
Mongu (14W6,552)
Namushakande (2W936)
(50W20,000: D100,000: P400,000)
Rufunsa (4W960)
Lusaka Province
1,090
8,176
Nampundwe (12W1,272)
Lusaka
Chongwe Dam
Chongwe (D1500)
Luangwa (E500)
Itezhi-Tezhi (45W1,575)
Chilanga (P1,200)
Western Province
1,058
7,936
Kafue (P18,000)
Kafue Gorge (14W588)
Nakambala (4W1,872)
Namwala (3W1,404)
Mazabuka (14W6,552)
Nega-Nega (2W916)
Chirundu (B500)
Magoye (14W490)
Chikankata (25W875)
Senanga (E2,200)
Southern Province
3,516
26,372
Monze (20W2,120)
Shangombo (1W468)
Chisekesi (9W378)
Pemba (10W420)
Gwembe (13W546)
Siavonga
(60W2,520)
Choma
Batoka (9W378)
Mulobezi (1W468)
Mbabala (4W424)
Kalomo (25W2,650)
Sinazongwe (E900)
Sesheke (E1,400)
Katima-Mulilo (1W468)
Zimba (6W252)
Maamba (40W1,680)
Livingstone (E20,000)
Map of Projects (Water Supply Sector)
Legend
◎ : Large Urban Township
• : Small Urban Area Township
<Water Supply Program>
W : Borehole Production Well
D : Dam Development
P : Kafue Pipeline
E : Water Supply Expansion
Figures after the above capitals : volume (m³/day) to be developed.
Figures before the above capitals : number of wells to be developed.
<Rural Area>
3,546 Upper Figure : Number of Wells to be Developed
26,596 Lower Figure : Volume to be Developed (m³/day)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Scale 1:4,000,000
N
ZAIRE
TANZANIA
ANGOLA
NAMIBIA
BOTSWANA
ZIMBABWE
MALAWI
N-5 Kenani Vegetable Scheme
O-22 Kawambwa Tea
P-37 Mushota Island
P-52 Chinakila
Chamdamali P-66
Kateshi Coffee O-27
O-25 Lukulu North
KASAMA
P-65 Chilbula South
P-64 Mutale Mokonge
Lufubu Dam
N-6 Chiposa Mubende Scheme
MANSA
P-45 Luapula
I-2 Mansa Pilot Scheme
Lake Bangweulu P-44
P-43 Samfya
O-24 Mulumbi Coffee
N-7 Chembe Vegetable Scheme
LUAPULA R.
CHAMBESHI R.
Lundazi Dam
O-30 Vuu
O-29 Lukuzye
CHIPATA
LUANGWA R.
P-70 Luangwa River
O-31 Lusowe
Ikelenge Pineapple O-11
Mwiniluinga P-80
KABOMPO R.
P-79 Mwombeshi
SOLWEZI
N-2 Ipafu
Mutondu Dam
O-9 Chapula
NDOLA
Kafubu Dam
Munkumpu P-2 Luswishi
O-7
O-6 Mpongwe (G/W)
P-1 Machiya
P-82 Kabompo
KAFUE R.
KABWE
I-1 Nakatoya
MONGU
P-23 Zambezi F.plain (Left Bank)
Chongwe Dam
LUSAKA
Chanyanya
O-2
N-1 Chipapa
Large-scale Aquaculture Project at Kafue Flats
O-18 Nakambala Sugar Estates
O-20 Nanga
O-3 Masstock
Chiawa O-1
O-5 Kaunga
O-13 Kaleya Small Holders
Choma Vegetable Scheme N-8
Chiyabi N-4
O-21 Nakandowe
O-14 Buleya Malima
O-15 Siatwinda
P-88 Sioma Rapid
P-86 Manto Rapid
P-84 Ngambwe Rapid
P-16 Katima Mulilo
ZAMBEZI R.
LIVINGSTONE
Map of Projects (Agricultural Sector)
Legend
Project Type
O : New Irrigation Project
▲ : Existing Expansion Project
△ : ASIP Rehabilitation Project
▬ : Multi-purpose Dam Project
▭ : Irrigation Dam Project
O : Aquaculture Project
o : Small-scale Aquaculture Project
New Project
P : Potential Water Development Site
Existing Project
I : Implementing Project
O : Operational Irrigation Project (Expansion)
N : Non-operational Irrigation Project (Rehabilitation)

Table of Contents

Page

List of Tables and Figures

CHAPTER 1

CHAPTER 2

CHAPTER 3

CHAPTER 4

CHAPTER 5

List of Abbreviations

CSD	:	Central Statistical Office
CWSC	:	Cipata Water and Sewerage Company Limited
DGS	:	Department of Geological Survey
DISS	:	Department of Infrastructure and Supporting Services
DMIW	:	Department of Maritime and Inland Waters
DNR	:	Department of Natural Resources
DOA	:	Department of Agriculture
DOE	:	Department of Energy
DOF	:	Department of Fisheries
DOFOR	:	Department of Forest
DOI	:	Department of Industry
DOL	:	Department of Land
DOM	:	Department of Meteorology
DTCP	:	Department of Town and Country Planning
DWA	:	Department of Water Affairs
ECZ	:	Environmental Council of Zambia
GRZ	:	Government of Republic of Zambia
LWSC	:	Lusaka Water and Sewerage Company Limited
MAFF	:	Ministry of Agriculture, Food, and Fisheries
MCDSS	:	Ministry of Community Development and Social Services
MENR	:	Ministry of Environment and Natural Resources
MEWD	:	Ministry of Energy and Water Development
MLGH	:	Ministry of Local Government and Housing
MOCI	:	Ministry of Commerce Trade and Industry
MOH	:	Ministry of Health
MOL	:	Ministry of Land
MOM	:	Ministry of Mining
MOT	:	Ministry of Tourism
MOTC	:	Ministry of Transport and Communication
NCDP	:	National Commission for Development Planning
NCSR	:	National Council for Scientific Research
NENC	:	National Energy Council
NWASCO	:	National Water and Sanitation Council
PCU	:	Programme Coordination Unit
SADC	:	South African Development Community
SD	:	Survey Department
WDB	:	Water Development Board
WSDG	:	Water Sector Development Group
ZAFFICO	:	Zambia Forestry and Forest Industries Corporation
ZCCM	:	Zambia Consolidated Copper Mines Limited
ZESCO	:	Zambia Electricity Supply Corporation
ZIMCO	:	Zambia Industrial and Mining Corporation
ZNTB	:	Zambia National Tourist Board
ZRA	:	Zambezi River Authority

CHAPTER 1 CURRENT SITUATION AND FUTURE DEMAND FOR WATER RESOURCES DEVELOPMENT

1.1 Socio-Economy

(1) Social Conditions

Administration

Zambia administratively consisted of nine Provinces and 57 Districts at the 1990 census year. The central government comprises 22 Ministries and Offices of the President and the Vice President. The Ministries and the Offices have branches for respective Provinces. Under the central government, there are three levels of autonomous local government. They are distributed as follows: three city councils, i.e., Lusaka, Ndola and Kitwe; seven municipal councils, i.e., Chingola, Kabwe, Mufulira, Luanshya, Livingstone, Chililabombwe and Kalulushi; and 47 district councils which were located in District capital towns. Subsequently, Kasama and Chipata district councils were promoted to municipal council from district council. Thus, there are 12 large urban areas at present. Besides, four district councils increased after the 1990 census year, so in 1994 the total local authority is enumerated as follows: three city councils, nine municipal councils and 49 district councils. In this current study, however, the number of Districts is considered as 57 as of the 1990 census year, because of data availability.

The 1990 census showed that there were 92 urban settlements. Of these 92 settlements, the above ten cities are called as ten large urban areas, which have a population of 50,000 and above. There are 48 settlements with a population size of 5,000 and above, which are officially classified as small urban area and in which most of District capitals are located. The remaining 34 settlements are called rural townships and have a population size of more than 1,000.

Population Growth

According to the 1990 census, the national population was 7.38 million. The population growth rate between the latest two censuses dropped down to 2.7% per annum on average from 3.1% of the previous censuses. In the former decade between the two censuses of 1969 and 1980, the population migration showed the urbanisation to large urban areas, such as Lusaka or mining areas in Copperbelt Province. In the latter decade between 1980 and 1990, however, it showed the modest urbanisation with a sharp decrease of population growth in large urban areas along Copperbelt. The centralisation into Lusaka city has continued even for the latter decade, but its pace slowed down. Since the regional economy in urban areas did not grow at an expected pace and it could not absorb surplus labour force, an increasing rate of immigration into urban areas dropped down as compared with that in the former decade. Nevertheless, the economic disparity between urban and rural is still large, so an influx into urban areas will increase again in conformity with economic recovery in urban areas.

Future population was projected under the following procedure: 1) projection of the national total population; 2) distribution of district populations of which the total was arranged to be equal to the nation population; 3) projection of total urban population; 4)

distribution of township population of which the total was arranged to be equal to the total urban population; and 5) projection of rural population. The total national population up to 2015 was projected under the following three scenarios, referring to CSO's and related agencies' past projection reports and trend of population growth between the censuses.

1) High Projection:
   The future population is assumed to increase at the constant growth rate of 2.7% derived from the 1980 and 1990 census data (2.7 % => 2.7 %).
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 (2.7 % => 1.9 %).
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 in medium projection. These projected figures are similar to the figures estimated in the report of WHO which projected the future population taking influence of HIV/AIDS into account (2.7 % => 1.4 %).

The total urban population was projected on the basis of the idea, i.e., "people move from economically depressed rural areas to economically developed urban areas". The population migration to urban areas causes mitigation of the disparity between the urban and the rural areas. The urban population of respective townships was projected as follows: 1) to classify the 92 townships into three groups considering their urban characteristics; 2) to assume the growth rates of the respective groups; 3) to estimate the future population; and finally 4) to arrange the total population of respective townships to become equal to the total figure. Applying the aforesaid procedure, the future population was projected in Table 1-1.

Table 1-1 Projected Population: 2005 and 2015

(Unit: 1,000 persons)

Item	1990	2005			2015		
	Census	High	Medium	Low	High	Medium	Low
National Population	7,383	10,994	10,465	10,025	14,336	12,738	11,589
- Urban Population	2,782 (38%)	4,886 (44%)	4,253 (41%)	4,074 (41%)	7,169 (50%)	5,465 (43%)	4,982 (43%)
- Rural Population	4,601 (62%)	6,108 (56%)	6,212 (59%)	5,951 (59%)	7,167 (50%)	7,273 (57%)	6,607 (57%)
12 Large Urban Areas	2,196	3,682	3,441	3,297	5,223	3,442	4,102
Lusaka City	769	1,556	1,483	1,421	2,456	2,181	1,985

(2) National Accounts

Industrial Profile

Major industrial sectors in Zambia are agriculture, manufacturing and mining. In 1993 Gross Domestic Product (GDP) was K1,420 billion (approximately US$3.3 billion) at current prices, comprising as follows:

1) Agriculture sector, one of the key industries of the country, accounted for K394 billion or 28% of GDP.
2) Manufacturing sector accounted for K351 billion or 25%, which used to account for more than 30% before 1992.
3) Mining sector accounted for K143 billion or 10%, which contributed 90% of foreign currency earnings through export.

Agricultural sector absorbs about 50% of labour force in Zambia. The production of the sector dropped down by 33% because of serious drought in 1992, but that in 1993 recovered swiftly owing to good weather. Large portion of crop production of Zambia relies on large scale commercial firms and it cultivates mainly cash crops such as maize, ground nuts, tobacco, etc. Manufacturing sector attained a rapid growth just after independence owing to favourable international conditions of copper markets and expansion of demand for consumer goods in the domestic market. For ten years since 1985 the sector has maintained an average growth rate of about 4% per annum. Major products are agricultural processing products such as food and tobacco, whose production increased at a rate of 7.7% per annum in the recent decade. Other products are paper products, metal products and wooden products. Mining sector extracts metal ore such as copper, being proud of fourth position in the world production, zinc, cobalt, etc.

Tourism is expected to be one of the major sources of foreign exchange earnings. The tourism industry is centred in the game parks and Victoria Falls only at present. Agencies concerned are trying to develop new tourist spots in areas such as Lakes Kariba and Tanganyika. However, the tourism industry has not yet grown as expected because of lack of infrastructure for tourism. Annual foreign tourist remains less than 150,000 persons.

Gross Domestic Product (GDP)

In 1992, Zambia had serious drought. Although the worst effects of the drought on Zambia's populace were averted, it had significant negative effects on economic growth, fiscal and monetary operations, and domestic inflation. In 1993, on the other hand, the national economy grew at 5.2%, and recovered to almost the same level as the 1991 economic level. Real annual growth of GDP was 1.24% on average for the recent nine years. This growth has been one of the lowest in Africa. According to "Economic Report 1993", the 4% growth is expected as the target for GDP in 1994. The new programme for 1994-1996 aims 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. Taking into account past trends, government papers and World Bank reports, the following three scenarios were provided for economic growth projection for the target year.

Base Growth Case-Agricultural Expansion: The annual growth in GDP is assumed to grow around 5% (per capita GDP at a rate of 2.5%/year) up to 2000. Afterwards, the growth rate of GDP will reduce to 3.2%/year by 2015 (per capita GDP at 1.25%/year). As assumed in ASIP, the agricultural sector will grow at 6%/year up to 2000. Afterwards, the agricultural sector will grow at a rate of 3%/year. The growth rate of the agricultural sector is the largest of the three cases. Other sectors except manufacturing are assumed to grow at the average growth rate. The rest of Value Added (VA) to attain the expected growth of GDP is assumed to be covered by manufacturing sector.

Base Growth Case-Industrialisation: The annual growth in GDP is assumed to grow around 5% (per capita GDP at a rate of 2.5%/year) up to 2000. Afterwards, the growth rate of GDP will decrease to 4.0%/year by 2015 (per capita GDP at 1.25%/year). The agricultural sector will grow at a rate of 3%/year. The growth rate of GDP is the highest of the three cases. Other sectors and 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. Hence, this case is named as "Base Growth Case-Industrialisation".

Conservative Growth Case: GDP is assumed to grow at annual rate around 2.5% before 2000, and around 1.5% afterwards. Annual growth rate of 0.3% is applied for per capita GDP up to 2000, reflecting "World Development Report" of the World Bank. For years beyond 2000, half of the grow in GDP per capita is assumed. The growth rate of the agricultural sector will decrease from 2.6%/year to 1.5%/year in 2015. The economic growth rate is the lowest of the three cases. The growth rates of the manufacturing and other sectors are estimated with the same assumption as the other cases.

(3) Financial Conditions

Central Government

The central government has recorded a deficit balance in the fiscal accounts till the year 1994. The ratio of the government expenditure to GDP was 27.5% on average for the recent six years and ranged from 39% in 1991 to 21% in 1993. The capital expenditure accounted for around 19% of the total expenditure on average and the ratio ranged from 8.8% in 1991 to 32.1% in 1994. The capital expenditure of DWA accounted for only 0.5% of the total capital expenditure on average and ranged from K9 million or 0.2% in 1991 to K13,021 million or 1.4% in 1994.

Besides the DWA, other agencies concerned with water, such as those for agriculture, energy and public hygiene, are also investing for projects related to water. The ratio of the total investment for water projects to the total capital expenditure of the central government was 5.3% on average for the six years and ranged from 1.1% in 1992 to 15.4% in 1994. The total investment by the DWA accounted for 20% of the total investment, mainly for rural water projects, and ranged from 8% in 1991 to 38% in 1994. On the other hand, the total investment for water supply schemes through MLGH accounted for 62% of the total investment and ranged from 37% in 1992 to 81% in 1989, although that amount was disbursed not for direct investment by the central government but for loans to local governments.

Local Government

According to financial statements of local governments in 1990, there were 55 local governments because Siavonga and Sinazongwe districts were included in Gwembe district at that time. The total revenue estimate of 55 districts was K1,468 million, which accounted for only 4.7% of that of the central government. Moreover, the total revenue included K297 million (or 20% of the total amount) of the grants from the central government. Of the 55 districts, 33 district councils were managing water supply works for the people in the districts. Of the 33 district councils, only nine councils achieved a surplus from the water undertaking. The other 24 councils managed the water undertaking in deficit. The capital investment for water projects by local governments themselves was K14 million, which did not include the investment of the central government. The amount accounted for only 12% of the total amount (K115.3 million) of the central government.

Capital Investment for Water Resources Development

Assuming that the present policy trends of the central government continue, public expenditure for water resources development projects is expected to increase from K5.8 billion in 1993 to K13.4 billion in the 2005 and K18.4 billion in 2015 at 1993 constant prices. Cumulative investment will reach K123 billion by 2005 and K284 billion (or 650 million us$) by 2015. The cumulated amount by 2015 is estimated to be broken down into K275 billion for water supply and sewerage, K7 billion for fishery, and K 1 billion for hydro-electric generation. As for investment for irrigation projects, the government recently has not invested public funds, expecting the private sector's investment. During the target period of ASIP (up to 2000), this tendency can be assumed to continue.

(4) Scenarios for Water Demand Projection

Even though nine scenarios can be set corresponding to the three projections of population and three GDP Growth Cases, three typical scenarios are selected for water demand projection of the Study as shown in Table 1-2. Characteristics, projected population, and estimated GDP for each scenario are given in Table 1-3.

Table 1-2 Water Demand Projection Scenarios

GDP Growth Case Population Projection	Base Growth Case- Industrialisation	Base Growth Case- Agricultural Expansion	Conservative Growth Case
High Projection	**Base Scenario Industrialisation**	---	---
Medium Projection	---	**Base Scenario Agricultural Expansion**	---
Low Projection	---	---	**Conservative Scenario**

Table 1-3 Composition of Scenarios

Items	Base Scenario- Industrialisation	Base Scenario- Agricultural Expansion	Conservative Scenario
Characteris -tics	<Water Supply> high population projection: large water demands, urbanisation: large water demands in urban areas <Agricultural Sector> medium growth in agricultural production: self-supply of foods for high population	<Water Supply> medium population projection: medium water demands <Agricultural Sector> high growth in agricultural production: large expansion in rain fed agriculture and export of the products	<Water Supply> low population projection: low water demands, <Agricultural Sector> conservative growth in agricultural production; self-supply of foods for low population projection
Population in 2015	National: 14.336 million Urban: 7.169 million (50 %) Rural: 7.167 million (50 %) Ratio (1990=100): 194	National: 12.738 million Urban: 5.465 million (43 %) Rural: 7.273 million (57 %) Ratio (1990=100): 173	National: 11.589 million Urban: 4.982 million (43 %) Rural: 6.607 million (57 %) Ratio (1990=100): 159
GDP in 2015	GDP: K. 3,634 billion (US$ 8.36 billion) GDP per capita: K. 254 thousand (US$ 583)	GDP: K. 3,229 billion (US$ 7.43 billion) GDP per capita: K. 254 thousand (US$ 583)	GDP: K. 2,166 billion (US$ 4.98 billion) GDP per capita: K. 187 thousand (US$ 480)

1.2 Domestic Water

(1) Current Domestic Water Supply

Current Capacity of Water Supply

From the result of surveys on the current water demand and water supply capacity by the JICA study team, the coverage in rural areas was only 24% on the average of the country. The regional disparity was large as the coverage in Southern Province reached to 67%, while that in Northern Province was only 8% . With the exception of Lusaka, Livingstone and Kasama, supply capacities exceed the demands in 12 large urban cities Lusaka, Livingstone and Kasama are suffering with coverage of 57%, 70% and 67%, respectively. The coverage in small urban areas was still 80% on the average. In small townships, those in Copperbelt and North-western Provinces were in favourable conditions, while the coverage in Eastern Province was only 26%, more serious disparity than that of large urban townships.

Managing Bodies

In principal, most urban water supplies are undertaken by local authorities and most rural water supplies are managed by the DWA. In addition, 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 (33 councils)
c) Parastatals: ZESCO, ZCCM, Zambia Railways, etc.
d) Missionaries and Non-Government Organisations (NGOs)
e) Private Sector: Lusaka Water and Sewerage Company Ltd. (LWSC), Chipata Water and Sewerage Company Ltd., Mining Companies, etc.

Public Investment for Water Supply Schemes

In relation to the managing bodies, the various public agencies invest public funds to implement water supply schemes. The DWA usually disburses its capital expenditure for water projects. In 1994, 26 projects were implemented directly by the central government. The total amount reached K13.7 billion. The MLGH also invested public capital in water projects not directly but through local authorities. In other words, the MLGH loans capital funds to local governments. Eight projects were implemented by local governments and financed by the MLGH. The total amounts were K19.7 billion. Thus, the total amount was K33.2 billion in 1994, of which around three-quarters or K25.3 billion relied on foreign aid.

Financial Status of Water Supply Undertakers

Among the districts in the country, 33 district councils were managing water supply schemes for the people in the districts, of which 24 councils managed the water undertaking in deficit. Water supply services in Lusaka and Chipata townships are managed by private companies. 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, while the balances in 1991 and 1993 fell into deficit, as much as 12% and 7% of the respective operating revenue. In order to maintain a sound balance, the tariff was revised in October 1994 and in January 1995 to catch up with its expenditure. The new tariff increased noticeably for small water consumers. For example, a water user consuming 30 m³/month will be charged K5,850, around 84% higher than that under the old tariff, K,3180.

Japanese Grant Aid Projects for Water Supply

The following projects are implemented as grant aid project of the government of Japan in order to increase water supply capacity.

1) The Project for Groundwater Development in Southern Province, Phase-1 and 2: implemented in 1985-1990, 125 boreholes, supply capacity: 940m³/day
2) The Project for Rural Water Supply Development: implemented in 1991-1995, 65 boreholes in Lusaka Province, 105 boreholes in Central Province, 150 boreholes in Copperbelt Province, total supply capacity: 1,660 m³/day
3) Water Supply Project in Satellite Area of Lusaka: implemented in 1994-1996, 8 boreholes, supply capacity 5,200 m³/day

(2) Domestic Water Demand Projection

Projection Procedure

Water demand is estimated as a product of the number of consumers and unit water consumption rates of respective consumers. The domestic water demand consists of residential and non-residential water demand. The residential water demand in the future is projected on the basis of population projection. 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. The planning standard for human settlement is applied to estimate an inventory of the non-residential facilities. Applying "water consumption rates" and "planning standard for human settlement", the compound consumption rates were calculated as follows:

Table 1-4 Compound Unit Consumption Rates

Category	Definition	Unit Consumption Rate
Urban Area		
- Large Urban Area	Township with population of more than 50,000	180 lit/capita/day
- Small Urban Area	Township with population of less than 50,000	150 lit/capita/day
Rural Area	Areas other than the above	35 lit/capita/day

(Note) Unit rate in 1991 in Lusaka urban area is estimated as 130-150 lit/capita/day

Water Supply Target

In this study, the goal is set to fulfil the safe water supply to urban and rural people as follows: 1) for urban areas, to keep complete coverage in 92 large and small towns and 2) for rural areas, to cover 55% by the year 2005 and 75% by 2015.

Projected Water Demand

The summary of the projected domestic water demand for the three scenarios is given in below Table 1-5 for the years of 1995 to 2015. Under the Base Scenario-Agricultural Expansion (Medium Projection of population), projected water demand of twelve large urban areas is estimated at 618,000 m³/day in 2005 and 810,000 m³/day in 2015. In small urban townships it is estimated at 125,000 m³/day in 2005 and 151,000 m³/day in 2015. In rural areas, it is estimated at 217,000 m³/day in 2005 and 255,000 m³/day in 2015.

Table 1-5 Projected Domestic Water Demand

(Unit: 1000 m³/day)

Year	Base Scenario Industrialisation				Base Scenario Agricultural Expansion				Conservative Scenario			
	Large Urban	Small Urban	Rural	Total	Large Urban	Small Urban	Rural	Total	Large Urban	Small Urban	Rural	Total
1995	468	114	178	760	461	100	180	741	457	100	178	735
2005	663	193	214	1,070	618	125	217	961	592	120	207	919
2015	940	321	251	1,512	810	151	255	1,216	738	138	228	1,104

1.3 Industrial Water

Bulk consumers of industrial water in Zambia are the manufacturing sector and the mining sector. Water demands for the manufacturing and the mining sectors in 1990 are estimated as 222 thousand m^3 and 307 thousand m^3, respectively, and the total as 529 thousand m^3. The future demand of industrial water was studied on sector basis. The results of the forecasts are shown in Table 1-6 and 1-7.

(1) Manufacturing Sector

Industrial water demand for the manufacturing sector is forecast by major city and by province based on forecast of macro-economic indices of the country, trends in regional development, and water consumption rate by type of industry analysed from 139 samples answered by the manufacturers in the questionnaire survey. The results of the forecast are as follows:

1) Water demands in the manufacturing sector in 2005 and 2015 for the Base Scenario-Agricultural Expansion are projected as 367 thousand m^3 and 446 thousand m^3, respectively. These figures correspond to 1.7 times and 2.0 times of the demands in 1990.
2) Water demands for the manufacturing sector in the Base Scenario-Industrialisation and in the Conservative Scenario in 2015 will be 150% and 80% of that in the Base Scenario-Agricultural Expansion, respectively.
3) Major water demands for the manufacturing sector will occur in Lusaka and Copperbelt Provinces. These two provinces will share 75% of the total.
4) The towns of largest water demands for the sector will be Lusaka, Ndola and Kitwe, in descending order. These three cities will account for 60% of the total water demand for the sector.

(2) Mining Sector

Water demands for the mining sector are estimated and forecast through interview survey with Zambia Consolidated Copper Mines Limited (ZCCM), which undertakes most of the

mining production of the country. Water demand in 1990 for mining activities is estimated as 307 thousand m^3. Current water demand concentrates in Copperbelt Province by 95%. Since the ZCCM projects its future production to remain the same, future water demand for the sector is forecast as the present level for every scenario. The mining sector has developed its own water supply systems and is not provided through public services.

Table 1-6 Industrial Water Demands by Province

(Unit:1000m^3/day)

Province	1990			2005			2015		
	Mining	Manuf'g	Total	Mining	Manuf'g	Total	Mining	Manuf'g	Total
Lusaka		82.4	82.4		136.7	136.7		189.9	189.9
Copperbelt	290.6	78.5	369.1	290.6	129.8	418.4	290.6	140.7	431.3
Central	13.7	11.3	25.0	13.7	18.8	32.5	13.7	23.5	37.2
North-Western		4.6	4.6		7.7	7.7		9.1	9.1
Western		7.4	7.4		12.4	12.4		13.3	13.3
Southern	2.8	17.8	20.6	2.8	29.3	32.1	2.8	32.2	35.0
Luapula		3.2	3.2		5.3	5.3		5.7	5.7
Northern		9.5	9.5		15.9	15.9		17.1	17.1
Eastern		7.6	7.6		12.7	12.7		14.6	14.6
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 information. 2) Chingola includes ZCCM Nchanga division. 3) Kalulushi includes ZCCM Chibuluma mine. 4) Luanshya includes ZCCM Baluba mine.

Table 1-7 Water Demands for Manufacturing by Major City

(Unit:1000m^3/day)

Main City	1990	2005			2015		
	Estimated	Base Scenario -Industriali-sation	Base Scenario -Agricultural Expansion	Conservative Scenario	Base Scenario -Industriali-sation	Base Scenario -Agricultural Expansion	Conservative Scenario
- Lusaka	76.5	193.7	126.9	100.7	270.7	177.3	140.7
- Ndola	23.6	59.8	39.1	31.1	71.1	46.5	37.0
- Chilikbombwe	3.4	8.4	5.6	4.4	8.3	5.5	4.4
- Chingola	10.0	25.1	16.5	13.1	25.9	17.0	13.6
- Mufulira	8.8	21.9	14.5	11.5	21.1	13.9	11.1
- Kalulushi	2.2	5.6	3.7	2.9	6.7	4.4	3.5
- Kitwe	20.4	51.2	33.6	26.8	55.8	36.7	29.2
- Luanshya	8.3	20.8	13.7	10.9	21.0	13.8	11.0
- Kabwe	8.6	22.3	14.5	11.4	28.6	18.6	14.7
- Livingstone	6.5	16.1	10.6	8.5	17.3	11.4	9.1
- Kasama	3.9	10.0	6.5	5.1	10.9	7.1	5.6
- Chipata	4.8	12.4	8.0	6.3	14.3	9.3	7.3
Sub-total	177.0	447.3	293.2	232.7	551.7	361.5	287.2
National Total	222.4	307.1	366.7	291.8	678.4	446.1	354.8

1.4 Agriculture, Livestock and Fishery

(1) Current Conditions of Agriculture Sector

Agriculture

Agricultural land in Zambia totals 16.35 million ha, and accounts for 22% of the territory. Land area used for permanent cultivation, excluding shifting cultivation prevailing in the northern part of the country, is 8.54 million ha. Actually planted area in 1993 extended to

1.36 million ha. Maize cropping is predominant and shared 60% of the planted area. The number of agricultural households of the country was 521,000 in 1990 and more than 90% were classified as smallholding farmers. In 1990, 864,000 persons were engaged in agriculture. Cultivated area for one household and one farmer was 2.2 ha/ household and 1.34 ha/farmer.

Total production of staple crops in 1993 was 1.89 million tons and maize production accounts for 1.74 million tons. Consumption of staple crops is estimated as 160 kg/capita, taking account of production, imports and consumption for livestock breeding. Balance between demand and supply of staple crops varies by province. Surplus in supply occurs in the granary, such as Central, Southern and Eastern Provinces, while those surplus are provided to other provinces, such as Copperbelt. Copperbelt Province imports the largest amount of the staple crops, 150 thousand ton/year, followed by the Lusaka Province, 70 thousand ton/year. Imports from foreign countries are made constantly, although the amount of imports vary year by year. 160 thousand ton/year of maize is imported on average.

Irrigation development in Zambia has been implemented since early 1960's as governmental or commercial projects. Irrigated area reached 53 thousand ha by 1993, and accounts for 3.2% of the total planted area. Annual increase in irrigated area is 3,100 ha and corresponds to 5.5% of annual increase in planted area.

Livestock

It is estimated that 2.67 million head of cattle, 592 thousand sheep and goats, 303 thousand pigs, and 7.92 million poultry were bred in the country in 1990. Currently livestock production has been kept at the level which almost meets the meat consumption of the nation (14.2 kg/capita/year). Although the production level should be kept up with the consumption level and increase in population, production growth cannot be expected in some parts of the country. The number of cattle had decreased by 5.5% during the period from 1989 to 1991. The decrease was mainly caused by decrease in Southern Province. Cattle grazing requires 2 ha of land on flood plain areas and 5 ha area on plateau per head of cattle in the dry season, which means the cattle population has exceeded the capacity of the land area in Southern Province.

Fishery

Zambia has large bodies of water such as lakes, rivers and swamps covering about 2.5 million ha of the country. Fisheries production from these water bodies in 1993 was 68.6 thousand ton/year or 8.61 kg/capita/year. Annual growth in fishery production is 1.4%. Most of the production, 95% of the total, is achieved by capture fishery. Aqua-culture accounts for 3,400 ton/year (1,700 ha), and the productivity of aqua-cultural ponds is 2 ton/ha. Even though the government policy has raised the target of fishery production to meet the demand of 12 kg/capita/year, large increase in production of capture fishery cannot be expected, so that promotion of aqua-culture is necessary to increase fishery production.

(2) Agricultural Policy of the Ministry of Agriculture, Food and Fishery

Agricultural policy of the Ministry is published in "Statement of Agricultural Policy" reviewed in 1993 and "Agricultural Sector Investment Programme (ASIP)" formulated in

1994. ASIP shows concrete implementation programmes for the execution of the policy contained in the Statement during the first stage, from 1995 to 1999, of the period covered in the Statement. Investment programmes for the next stage will be formulated in the future. The Statement and ASIP raise the following objectives:

< Major Objectives in "Statement of Agricultural Policy" >

- to ensure national and regional food security
- to generate income and employment through full utilisation of local conditions
- to insure that existing agricultural resources (land, water, air) are maintained and improved upon
- to contribute to sustainable industrial development
- to expand the contribution to the national balance of payments by expansion of exports

< Major Short Term Objectives of the Agriculture Sector Investment Programme (ASIP)>

1) Agricultural Policy and Food Security
- Donor aid will decrease gradually and terminate after five years, and self-financing and management will be required afterwards. ASIP must be sustainable using only GRZ resources after this period.
- A growth rate of 6% of the agricultural sector must be achieved at the same time as reducing the government expenditure for the sector to not more than 1.5% of total GDP.
- Food Security Agency will be created for storage of 2.5 million bags of cereals

2) Irrigation Policy
- to strengthen the institutional capacity of the Irrigation Engineering Section (IES) to provide effective services and training to farmers.
- to proceed with the rehabilitation or completion of the existing nine Smallholder Irrigation Schemes

3) Mechanisation Policy
Mechanisation will be planned based on the exploitation of oxen power, aiming at expansion of ox draught system and mechanised agriculture with the establishment of mechanisation centres. Improvement of ox draught system in the southern region will be a main target in short term, while long term target will focus on introduction of ox draught system in the northern region, where hoe cultivation is still predominant.

4) Fishery Promotion
Fishery will be promoted to encourage fish consumption, which has decreased to 8.61 kg/capita/year, to increase to 12 kg/capita/year.

(3) Proposal of Long Term Agricultural Development Plan

Agricultural development plan is proposed, corresponding to the three scenarios set in the socio-economic framework, based on the present conditions and programmes expressed in ASIP. Water resources development plan for the agricultural sector is formulated according to the proposed agricultural development plan, as shown in Table 1-8.

<u>Production of Crops</u>

Rain fed agriculture will remain predominant even in the future, and most of maize and oil crop production will obtained through rain fed cultivation. Wheat and rice cropping through irrigated farming will be complementary for stable production of cereals.

Table 1-8 Agricultural Development Scenarios

Items	Present Status	Base Scenario - Agricultural Expansion	Base Scenario - Industrialisation	Conservative Scenario
Population (1000 persons)	7,969 (1993) (=100)	12,738 (160)	14,336 (180)	11,589 (145)
Annual Growth in Value Added of Agricultural Sector	Average 2.3% (1985-1993)	1994-2000: 6.0% afterwards: 3.0%	3.0% (constant)	1995-: 2.6% 2000-: 2.3% 2005-: 2.0% 2010-: 1.5%
Value Added of Agricultural Sector - 2005 - 2015	299.3 billion K. (=100)	494.9 billion K. (165) 699.8 billion K. (234)	439.6 billion K. (147) 616.4 billion K. (206)	382,7 billion K. (128) 491.2 billion K. (164)

Table 1-9 Crop Production and Water Demand for Irrigation by Scenario

Items	Current Status (1993)	Base Scenario - Agricultural Expansion	Base Scenario - Industrialisation	Conservative Scenario
< Crop Production >				
(1) Staple Crops	1,894,000 ton	3,664,000 ton	3,383,000 ton	2,728,000 ton
- domestic consumption	1,894,000 ton	3,154,000 ton	3,383,000 ton	2,728,000 ton
- export	-	510,000 ton	-	-
(wheat)	71,000 ton	166,000 ton	186,000 ton	151,000 ton
- domestic production	50 %	100 %	100 %	100 %
- import	50 %	0 %	0 %	0 %
(2) Oil Crops	154,000 ton (=100)	462,000 ton (300)	385,000 ton (250)	323,000 ton (210)
(3) Vegetables	520,000 ton (65 kg/capita/year)	855,000 ton (65 kg/capita/year)	958,000 ton (65 kg/capita/year)	775,000 ton (65 kg/capita/year)
(4) Fruits	129,000 ton (16 kg/capita/year)	348,000 ton (27 kg/capita/year)	250,000 ton (17 kg/capita/year)	202,000 ton (17 kg/capita/year)
(5) Coffee & Tea	6,300 ha (=100)	18,240 ha (290)	12,000 ha (190)	9,600 ha (152)
(6) Sugarcane	13,000 ha (=100)	21,000 ha (162)	21,000 ha (162)	21,000 ha (162)
(7) New Crops (flowers)	250 ha (=100)	2,500 ha (1000)	500 ha (200)	380 ha (152)
< Total Planted Area >	1,363,000 ha (=100)	2,633,000 ha (193)	2,343,000 ha (172)	1,916,000 ha (141)
< Total Irrigated Area >	53,000 ha (=100)	114,000 ha (215)	107,000 ha (202)	91,000 ha (172)
<Newly Irrigated Area>	-	61,000 ha	54,000 ha	38,000 ha
< Additional Irrigation Water Demand >	-	5,282,000m^3/day	4,666,000m^3/day	3,283,000m^3/day

In addition, irrigation will support the production of cash crops, such as vegetable and fruit, and of exported goods, such as coffee, sugar and flowers, in order to contribute to the improved balance of payments of the country and high growth in the Value Added of the sector. Expansion and enhancement of rain fed agriculture in the northern region, where rainfall is comparatively constant, will be necessary to achieve the stable agricultural production of the country. Of the three scenarios, the largest expansion of rain fed agriculture will be required to attain the target in the Base Scenario-Agricultural Expansion.

In this scenario, prompt introduction of ox draught system in the northern region should be extensively encouraged.

Staple Crops: Self supply is assumed in all scenarios. Rain fed maize and irrigated wheat will be main crops. Consumption of staple crops is presumed to be 160 kg/capita/year, and wheat consumption is supposed to remain at 13 kg/capita/year, 8% of the total consumption. Even in the future, main part of the production should rely on rain fed agriculture. In Base Scenario-Agricultural Expansion, increased production will allow to ensure the targeted cereal reserve for three months (510 thousand tons), which will upgrade the food security against drought events, and for Zambia to become a cereal exporting country. In the other two scenarios, all of the products will be consumed domestically.

Oil Crops: Oil crops, such as groundnuts and seed cotton, are ranked third of the agricultural products for export and are produced by rain fed agriculture. The market for these crops continues to look promising in the future. ASIP also emphasises the development of processing technology for vegetable oil production, assuming that demands increase. Production increase to two or three times the current volume can be projected by 2015.

Vegetables: Vegetable crops are the most suitable for cash earning. Current production has reached to the level to meet the supply of 65 kg/capita/year, and rapid consumption increase will not occur. Further, large scale export will be difficult. Current level of production is assumed to continue.

Fruit: Current consumption of fruit is 16 kg/capita/year, which corresponds to 30% of the consumption in developed countries (50 kg/capita/year). In the Base Scenario-Agricultural Expansion, where the largest increase of agricultural production is projected, production of fruit is planned to increase to meet a consumption level of 27 kg/capita/year.

Coffee and Tea: Coffee and tea plantation is expanding by 530 ha/year. Much endeavour is being made by entrepreneurs to marketing and exports of coffee and tea. Current expansion is assumed to continue in the Base Scenario-Agricultural Expansion. In the other scenarios, however, the production will grow at the same rate as that set for growth of total value added of agricultural sector in each scenario, considering possible risks in the future.

Sugarcane: Sugar is ranked second of the exported agricultural products. The complete process from plantation to exporting has been established by the sugar company. The plantation will be expanded from the current area of 13,000 ha to 21,000 ha by 2005, in accordance with projection of the production expansion planned by the company.

New Products: Flower growing and exports have been started recently mainly by commercial farmers. ASIP highlights expansion in the future. The markets for flowers are European countries, where stable and expanded supply with lower price in winter can be achieved from Zambia which enjoys summer at the same time. Therefore, production will increase to 10 times the present level in the Base Scenario-Agricultural Expansion. In the other scenarios, the production will grow at the same rate as that of total value added of the sector of each scenario, considering possible risks.

Livestock

The target of livestock development plan is set to maintain current consumption level of

livestock products, such as 14.2 kg/capita/year for meat, 1.8 kg/capita/year for eggs, and 13.7 litre/capita/year for milk. Therefore, livestock breeding should grow with population increase. Livestock production has increased with population growth so far, and will possibly keep up with population increase in the future. In Southern Province, however, the production has reached to the potential limit, and is projected to reach it in Central Province in ten years. Therefore, required increased number of livestock should be bred in Northern, North Western, and Western Provinces. Number of livestock and water demands for livestock breeding by each scenario are shown in Table 1-10.

Table 1-10 Number of Livestock and Water Demands by Scenario

Items	Current Status	Base Scenario Agricultural Expansion		Base Scenario Industrialisation		Conservative Scenario	
Year	(1990)	2005	2015	2005	2015	2005	2015
Population (1000 persons)	7,383 (=100)	10,465 (142)	12,738 (173)	10,994 (149)	14,336 (194)	10,025 (136)	14,336 (157)
No. of Livestock (1000 heads)							
- Cattle	2,669	3,779	4,603	3,974	5,182	3,625	4,189
- Sheep/Goat	592	838	1,021	882	1,149	803	931
- Pig	303	431	523	451	590	411	475
- Poultry	7,921	11,225	13,664	11,795	15,381	10,756	12,437
Water Demand (m^3/day)	128,937	188,000	222,000	192,000	250,000	175,000	202,000

Fishery

It is almost impossible to increase the supply from 8.61 kg/capita/year in 1993 to 12 kg/capita/year to meet the raised target of consumption by capture fishery alone. Thus, rapid expansion of aqua-culture as well as encouragement of capture fishery, will be necessary. Because of intensive endeavour for promotion and expansion of aqua-culture by the Department of Fishery (DOF) with support of foreign donors, Zambian aqua-culture will expand, even though the industry is only in the initial stage so far.

Aqua-culture utilising manure of poultry or pigs is recommended by the DOF for small scale farmers. Productivity in this case is 2 ton/ha/year. In the future, commercial farmers or enterprises will enter into aqua-cultural business. In that case, direct feeding will be the manner of breeding. Even in the latter case, productivity is estimated as 4 ton/ha/year because of low temperature in winter and insufficient oxygen dissolution at high altitude. In the present plan, productivity of aqua-culture is assumed as 2 ton/ha/year as a conservative projection. Major assumptions and results for each scenario are listed below and shown in Table 1-11.

1) Domestic fish demand is supposed to be fulfilled with domestic production. Target supply is achieved with capture fishery and aqua-culture. Growth in capture fishery is projected as the current rate.
2) Fish consumption is targeted as 10 kg/capita/year in 2005 and 12 kg/capita/year in 2015.
3) Area of fish pond and required water for aqua-culture is estimated as 30,950 ha and 2,131 thousand m^3/day, respectively, in the Base Scenario-Agricultural Expansion. The figures for the Base Scenario-Industrialisation are 40,500 ha and 2,793 thousand m^3/day, while for the Conservative Scenario they are 24,050 ha, and 1,648 thousand m^3/day.

Table 1-11 Projection of Aqua-culture

Items	Current Status	Base Scenario Agricultural Expansion		Base Scenario Industrialisation		Conservative Scenario	
Year	(1993)	2005	2015	2005	2015	2005	2015
Population (1000 persons)	7,969	10,465	12,738	10,994	14,336	10,025	14,336
Consumption (kg/person/year)	8.61	10.00	12.00	10.00	12.00	10.00	12.00
Required Production (ton/year)	68,625	104,700	152,900	109,000	172,000	100,300	139,100
- Caputure Fishery (ton/year)	65,151	81,200	91,000	81,200	91,000	81,200	91,000
- Aqua-culture (ton/year)	3,474	23,500	61,900	28,700	81,000	19,100	48,100
Required Ponds Area (ha)	1,737	11,750	30,950	14,350	40,500	9,550	24,050
Water Demand for Ponds (1000m3/day)	117	813	2,131	996	2,793	656	1,648

1.5 Hydroelectric Power Generation

(1) Present Situation of Electric Power Supply and Demand

In 1993, the available capacity was 1,608 MW and the available generation was 10,500 GWH. Actual output of the year was 1,433 MW and the actual generated energy was 6,400 GWH, which was divided into 70% for domestic use in Zambia and 30% for exports to Zimbabwe. Domestic use in Zambia was divided as 60% to ZCCM power division, 30% to ZESCO South and 10% to ZESCO North.

(2) Future Electricity Demand and Power Station Development

Electricity demands towards 2015 are forecast in Table 1-12. Electricity demands in 2015 for the Base Scenario-Agricultural Expansion will be 1.7 times the output and 2.7 times the generation of the actual 1993 figures. Domestic demands in 2015 are forecast as 1,540 MW output, 1.6 times that in 1993, and 9,619 GWH generated electricity, 1.7 times that in 1993. According to the ZESCO programme for power export, the export power will increase to 840 MW, almost double the present volume.

Table 1-12 Electricity Demand Forecast

Items	Domestic Demands			Demands for Export	Total Demands		
	Base Scenario Agricultural Expansion	Base Scenario industriali-sation	Conservative Scenario		Base Scenario Agricultural Expansion	Base Scenario ndustriali-sation	Conservative Scenario
Output (MW)							
- 1993	993	993	993	440	1,433	1,433	1,433
- 2005	1,272	1,310	1,122	840	2,112	2,112	1,962
- 2015	1,540	1,670	1,218	840	2,380	2,380	2,058
Generation (GWH)							
- 1993	5,600	5,600	5,600	-200	5,400	5,400	5,400
- 2005	8,141	8,353	7,310	5,040	13,181	13,181	12,350
- 2015	9,619	10,338	7,842	5,040	14,659	14,659	12,882

(Note) Domestic demands are forecast based on the average GDP Growth

To meet the future demands, ZESCO proposed the construction of two projects, namely the Kafue Gorge Lower Project and Batoka Gorge Project, to be completed as shown below during the coming two decades. The feasibility of both of these projects has been confirmed through several studies. After agreement between Zambia and the countries which import power from Zambia, the final decision of project commencement will be made.

< Kafue Gorge Lower P.S. >
- Installed Capacity : 450 MW
- Firm Energy : 2,500 GWH
- Project Cost : 486 Million US$

< Batoka Gorge P.S. >
- Installed Capacity : 800 MW (No. 1 & No. 2, Zambia Share: 400 MW)
- Firm Energy : 4,600 GWH (No.1 & No.2, Zambia Share: 2,300 GWH)
- Project Cost : 1,648 Million US$ (Final Stage)

1.6 Navigation

(1) Potential Inland Navigation Areas

There is no nation-wide long-distance water borne transportation system in Zambia. Railway and trucking transportation provide the majority of the existing transportation network. This is due to difficulties in establishing and maintaining inland waterways because of many rapids and falls on the Zambian rivers, in addition to large seasonal fluctuation of the river flows, even though some of international rivers, such as the Zambezi and the Luapula Rivers, could be developed as long distance waterways. On the other hand, there are some parts of the rivers with gentle and stable flows as well as lakes and large scale reservoirs suitable for navigation, as listed below.

1) Barotse Flood Plain, upstream of the Zambezi River (A route from Mongu to Kalabo is in regular operation)
2) Lake Mweru (A regular service is in operation)
3) Lake Tanganyika (A regular service is in operation)
4) Lake Bangweulu (A regular service is in operation)
5) Kafue Flats, middle reaches of the Kafue river (no regular service)
6) Lake Mweru Wantipa (no regular service)
7) Lake Kariba (no regular service)
8) Lake Itezhi-Tezhi (no regular service)

(2) Improvement of Inland Navigation

The main problem hindering navigation in Zambia is shallow water depth due to siltation or decrease of discharge. There are several methods to alleviate these problems, as outlined below.

1) Damming up water by a downstream dam or weir
2) Construction of deeper water river channel and/or canal
3) Concentration of low water flow in the steady river course by groynes and/or river channel improvement
4) Dredging of waterways with shallow water depth and narrow width

Expansion of the navigation services should be planned and projected based on the national transportation development policy. There could be a possibility, however, that waterway

development can be achieved as the result of a water resources development project, which provides the width and depth of water required for navigation. Then, some waterway developments can be proposed from the viewpoint of water resources development plan. The present master plan study does not contain single purpose waterway development by means of 1), 2) or 3) of the above, because those projects would definitely not be feasible. However, continuous dredging is necessary for the maintenance of the waterways currently in operation, such as the route from Mongu to Kalabo in the Barotse Flood Plain.

1.7 Flood Control

(1) Current Situation of Flood

In Zambia land use is largely limited to comparatively higher land, and almost no lower lands are used. It can be said at least that there is no city or township located within the flood plains in Zambia. Agriculture is also limited within the flood plains. According to the current situation of land use in Zambia, safety against floods can be considered to be sufficiently high although the occurrence of floods in small streams causing some damage have been recorded in Maamba (Southern Province) and in Kitwe (Copperbelt Province).

Because of the large catchment area of the basins, a series of big flood runoffs will extend over a long period of time, without causing a concentrated runoff. Thus, serious floods do not occur over the entire river. The specific discharge of floods falls within the range from 0.02 to 0.4 $m^3/s/km^2$. These figures are classified as the flat land floods according to the classification of world rivers, suggesting that the flood discharge is small. On the basis of recorded discharge data, probable flood discharges at main points are shown in Table 1-13.

Table 1-13 Probable Discharge

No.	Station	River System	Catchment Area (km^2)	Flood Discharge (m^3/s)		Specific Discharge ($m^3/s/100km^2$)	
				Qmax	Q200	Qmax	Q200
2-400	Senanga	Zanbez i River (Main)	284,531	3,982	5,500	1.40	1.93
4-130	Smith's-Bridge	Kafue River	8,914	541	552	6.07	6.19
4-669	Kafue Hook Bridge	Kafue River	96,239	2,889	4,288	3.00	4.46
5-940	Luangwa Road Bridge	Luangwa River	140,922	10,213	13,004	7.25	9.23
6-289	Chambeshi Old Pontoon	Chambeshi River	34,745	1,446	1,992	4.16	5.73
6-785	Kashiba	Luapula River	161,275	4,821	7,693	2.99	4.77
7-750	Keso Falls	Lake Tanganyika	9,027	725	1,193	8.04	13.22

[Note] Qmax: Maximum Discharge in the past Q200: Probable Discharge (200 year return period)

(2) Future Flood Control Strategy

Flood control measures are not a priority need in Zambia due to little flood damage on large rivers. Flood control measure has a function of damage mitigation and can also work effectively to control inundation in order to make good use of fertile land along the river. Although the above-mentioned measures may not be easily undertaken because of large-scale construction and associated cost, it is necessary to include suitable measures as part of developments such as electric power generation plans, industrial and drinking water development, agricultural development.

1.8 Forestry

(1) Current Status of Forest

Zambian forests cover an area of 105,700 km^2, equivalent to about 14% of the national land area of 751,851 km^2. Out of total, Reserve Forests account 72,000 km^2, 9% of the territory and 68% of the forest area. Miombo woodlands account for 80% of the forested area. It is reported that deforestation is proceeding as rapidly as 1,390 km^2/year (Average from 1975 to 1990). Main causes of deforestation are 1) forest fires during August to October, the driest period, 2) over grazing and shifting (Chitemene) cultivation and 3) high demand for fuel and building timber.

(2) Afforestation

Afforestation is carried out predominantly by the Zambia Forestry and Forest Industries Corporation (ZAFFICO), mainly for sustainable exploitation of forest product. Major forest plantations have been conducted in Copperbelt Province, where demand for timber is high for mining activities. A plantation project of 50 thousand ha is being implemented with the support of the World Bank, introducing exotic trees, such as pine and eucalyptus. Although forest plantations, such as those for timber production by private sectors and non-productive afforestation for public purposes, are carried out, the scale of these plantations is quite small compared to those by ZAFFICO. Total capacity of sawmilling of the country is estimated as 366,500 m^3/year, and sawmills based on natural forest and those based on planted forest account for 57% and 43%, respectively. Operation rate of sawmilling is assumed to be 30% in the country.

(3) Forest Conservation

Forests have an important role in protecting watersheds of the rivers from soil erosion and in maintaining continuous and stable flow in rivers. Catchment areas of the Zambezi and the Kafue Rivers are comparatively better maintained. The following measures could be recommendable: 1) Expansion of agro-forestry, preferably managed by the communities, for supply of fuel woods, fruit production and soil improvement. 2) Securing stable and permanent cultivation by enlarging farming scale and promotion of sustainable resettlement programmes

1.9 Water Quality and Environment

Water quality issues can often impose additional constraints on the development of water resources. The abundant resources, combined with the low level of consumptive use and the beneficial effect of large hydro releases, mean that water quality is not a major issue when considering the development of water resources in Zambia.

(1) River Water Quality

Zambian river water qualities are generally good to excellent. The most comprehensive results have been gathered by the JICA study teams over the period 1990 to 1994 when over 100 samples, gathered from 26 regional stations have produced more than 1000 quality observations. Further support comes from a review of a long term quality record for the

lower Kafue, maintained by the Lusaka Water and Sewerage Company, whose results (an average of 10 parameters from more than 220 samples) show no noticeable deterioration over the last twenty three years.

(2) Water Quality Guidelines

Zambia's drinking water guidelines are identical to those published by the World Health Organisation and this study recommends that they remain in place. However, for instream river water qualities, it is recommended that aquatic ecosystem guidelines, that aim to protect aquatic ecosystems by using biological testing to derive chemical water quality criteria, be adopted. These guidelines encourage a sound biological balance in rivers thereby protecting fishing and wildlife, as well as avoiding algae blooms and other problems that affect drinking water supplies for both towns and livestock.

(3) Water Quality Laboratories

In order to adopt of a set of aquatic ecosystem guidelines in the longer term, it will be necessary to upgrade the capability of Zambian water quality laboratories. A survey of Zambian laboratories revealed that most do not have on-going programs on regular testing and research and they all suffer from staff, equipment and transport shortages.

(4) Recommendations

The Final Report contains details of all the above JICA testing, as well as reviews of nutrient levels in Zambian streams, sedimentation effects in storages, weed growth in the lower Kafue and instream environmental requirements. The Final Report recommends that:

1) Testing for Total P and Total N be introduced for Zambian streams as part of the ecosystem guidelines process.
2) Sedimentation effects in storages be monitored through hydrographic branch sampling and the introduction of silt lines.
3) Extent and nutrient content of weed growth in the lower Kafue be monitored and any offers to physically remove and dispose of the weed be accepted.
4) All new reservoirs developed as part of the Master Plan adopt downstream minimum flow rules, control diversions on unregulated streams and set aside small reserves within storages to meet "environmental contingencies".

1.10 Laws and Institutions

Among legal enactment in Zambia that are related to water, the Water Act is the supreme law. The act stipulates the state ownership of water and procedures of authorisation and invalidation of water rights. Under this act, the Water Board has been established as the authorising entity.

Other important laws on water resources management are the Natural Resources Conservation Act, Environmental Protection and Pollution Control Act, the Local Government Act, and the Lands Acquisition Act. The Natural Resources Conservation Act is the law for conservation and rational use of natural resources, while the Environmental Protection and Pollution Control Act covers environmental protection and pollution control. The Lands Acquisition Act makes provisions for compulsory lands acquisition in the national interest, including those for dam and reservoir development. The roles and

responsibilities of the local governments, the City, Municipal and District Councils, are stipulated in the Local Government Act.

The African customary law provides another source of legal order. At the time of independence, all lands, including waters, were vested in the Government. The African customary law, however, still has relevance in land tenure, cultivation grazing, animal watering and fishing rights, water user's association, settlement and redistribution of land and water. This law emphasises community interest, and private ownership of water is not recognised except to the extent that the water is owned by the tribe as a whole.

There are many ministries and governmental agencies which have interests or are involved in water resources development, management or administration. Among the relevant authorities, the Water Development Board and the Department of Water Affairs in the Ministry of Energy and Water Development are prime organisations of water resources management and development, while the resource conservation is discharged mainly by the Ministry of Environment and Natural Resources, and Environmental Council of Zambia. The Study reviewed the Zambian water institutions, and has revealed a number of problems.

<Legal problems>

a) Lack of legal instruments
b) Legal status of groundwater and control of its use
c) Legislation on water use in traditional areas
d) Geographical coverage of the Water Act
e) Lack of technical standards and regulations
f) Difficulty in interpretation of Natural Resources Conservation Act
g) Weak enforcement of Environmental Conservation and Pollution Control Act

<Organisational problems>

a) Some deficiencies in assignment of responsibilities
b) Insufficient staff and equipment in Water Development Board
c) Lack of technical staff in Department of Water Affairs for the resource development and management
d) Unclear demarcation and lack of staff in Ministry of Environment and Natural Resources and Environmental Council of Zambia
e) Lack of experience in irrigation for small scale farmers
f) Serious staff shortage in National Council for Scientific Research
g) Insufficient office equipment and transportation

CHAPTER 2 WATER RESOURCES POTENTIAL

2.1 Rainfall

For a land-locked tropical country located in the south-central of Africa, Zambia has clearly separated dry and rainy season, according to south-to-north movement of the Inter Tropical Convergence Zone (ITCZ). The year is generally divided into 4 seasons, namely winter season (June to August), pre-rainy season (September and October), rainy season (November to March) and post-rainy season (April and May). Average annual rainfall of last 30 years in Zambia is 1,001 mm - approximately equal to the world average annual rainfall of 970 mm - and 90 % of the annual rainfall is concentrated in the rainy season. Focusing on regional distribution of annual rainfall, Luapula Province (1,259 mm), Copperbelt Province (1,231 mm), Northwestern and Northern Province exceeds the Zambian average annual rainfall, whereas Southern Province (737 mm), Western Province (808 mm), Lusaka, Central and Eastern Province have less than the Zambian average annual rainfall. The Zambian average annual rainfall of the last 10 years, 974 mm, is less than that of last 30 years by 27 mm.

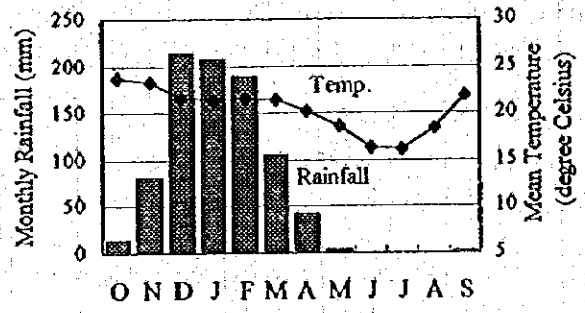

Figure 2-1 Monthly Rainfall and Temperature in Lusaka

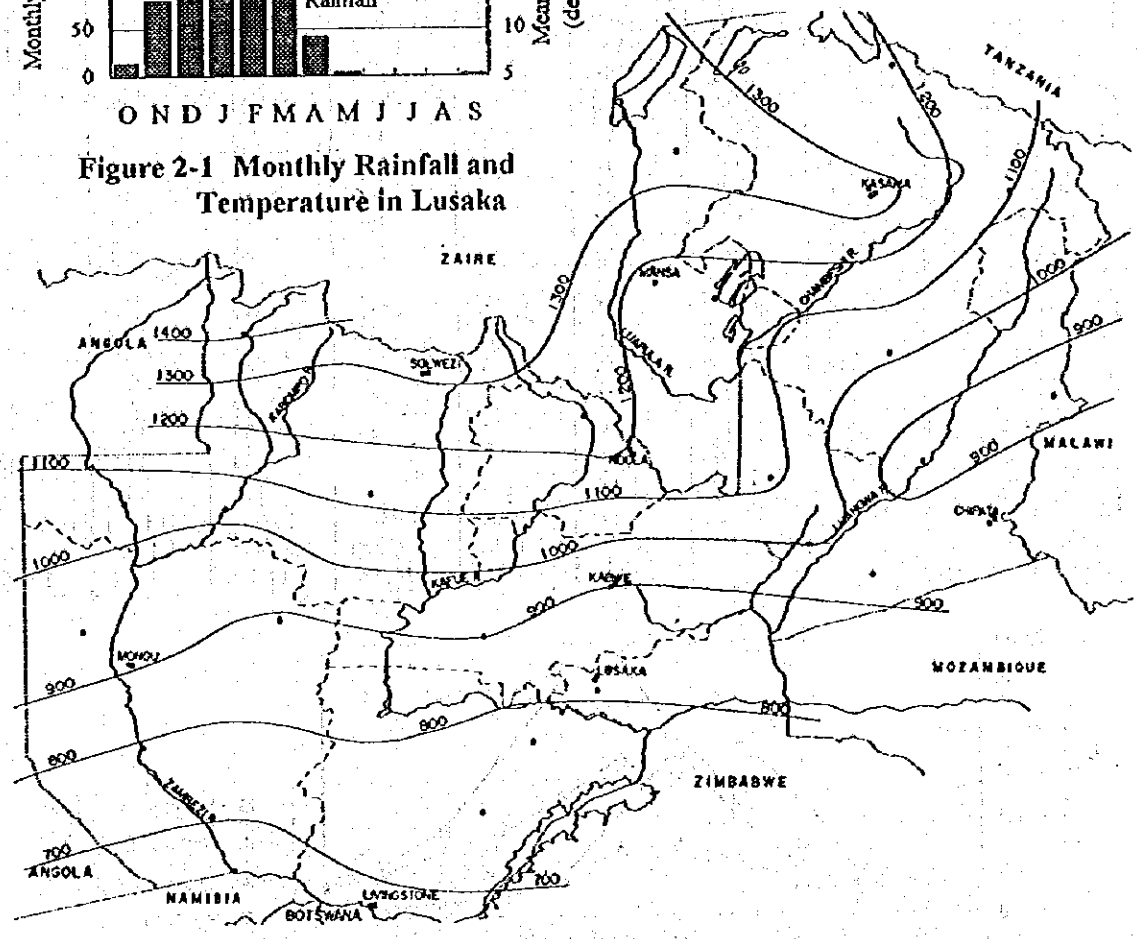

Figure 2-2 Isohyetal Map of Annual Rainfall

2.2 Surface Water

(1) River Flow Characteristics

There are two main river systems in Zambia, namely the Zambezi River and the Zaire (Congo) River systems. The Zambezi River system covers threequarters of the country and can be divided into three smaller river systems, the Zambezi (main), Kafue and Luangwa Rivers. The Zaire River system includes the rivers in the northern region, mainly the Chambeshi and Luapula Rivers. The Lake Tanganyika Basin is a closed basin on the border with Tanzania. Monthly mean discharge, flow summary, annual runoff depth and runoff percentage, etc. at main points of these rivers are shown in Table 2-1.

Table 2-1 Flow Characteristics at Main Points

River Basin	Zambezi (main)		Kafue		Luangwa	Chambeshi	Luapula	Tanga-nyika
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 (C.A. : km²)	Lukulu (206,531)	Victoria F (513,780)	Smith's B (8,914)	Kafue H/B (96,239)	Luang. R/B (140,922)	Chamb. OP (34,745)	Kashiba (161,275)	Keso F (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	1,320	170	536	77
February	1,336	1,270	157	619	1,917	307	1,068	112
March	1,726	1,972	186	774	1,865	461	1,758	161
April	1,663	2,762	156	709	1,121	471	1,741	149
May	957	2,577	89	428	420	294	1,295	77
June	569	1,770	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	2,134	3,225	251	1,113	4,258	582	2,021	301
High	1,076	1,766	116	469	849	280	1,096	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%

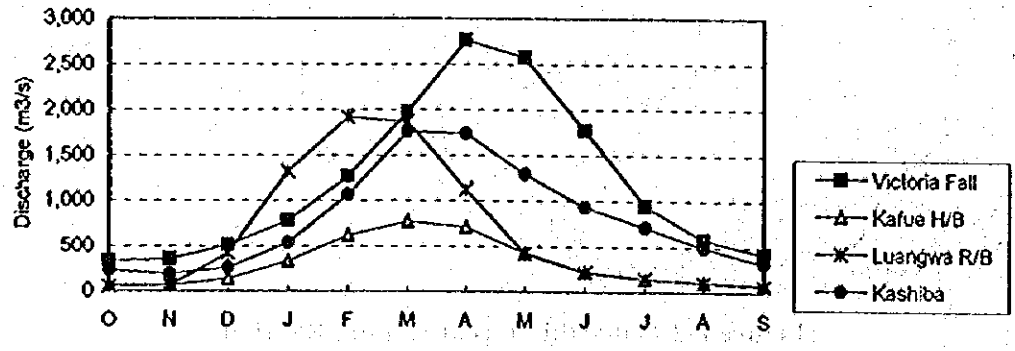

Figure 2-3 Monthly Mean Discharge at Main Points

(2) Surface Water Resources Potential

The river basins in Zambia were divided into 34 blocks as shown in Figure 2-4. Difference between average river inflow to each block and average river outflow from the block, was calculated and was regarded as surface water resources potential of that block. Surface water resources potential was estimated in terms of the last 30 years average (average year) and drought year average (10-year return period). By using these block potentials, surface water resources potential by the main river basins and the provinces were compiled and the results are shown in Table 2-2. Surface water resources potential in Zambia is about 237 million m^3 per day in an average year and 136 million m^3 per day in a drought year. The water potential in a drought year is 57 % of that of an average year. In terms of regional distribution of surface water resources potential, Northern and Northwestern Province have more potential and Southern and Lusaka Province have less potential.

Table 2-2 Surface Water Resources Potential

Basin and Province	Area (km^2)	Population (person)	Surface Water Resources Potential (Mm^3/day)	
			Average Year	Drought Year (10-year return period)
< by River Basin >				
Zambezi	268,235	1,699,062	59.9	33.2
Kafue	156,995	2,864,334	29.7	14.6
Luangwa	144,358	1,310,998	57.2	28.5
Chambeshi	44,427	375,861	23.9	14.3
Luapula	113,323	832,900	54.1	38.3
Lake Tanganyika	15,856	80,725	10.0	5.5
Other Basin	8,658	219,204	2.5	1.8
< by Province >				
Lusaka	22,094	987,106	10.9	3.7
Copperbelt	31,217	1,427,528	13.0	6.6
Central	94,684	720,628	33.6	11.0
Northwestern	125,280	387,554	38.9	21.5
Western	127,344	606,813	20.3	16.3
Southern	85,199	907,150	5.3	1.2
Luapula	49,594	525,160	26.3	17.7
Northern	147,294	855,177	67.5	44.8
Eastern	69,146	965,968	21.5	13.4
Total & Average	751,852	7,383,084	237.3	136.2

(3) Intake Rate Potential from River

The intake rate potential is defined as the discharge available for abstraction from the river, without constructing water storage facility, at the most downstream point of a block even at the time of drought with return period of 5 or 10 years. Assuming compensation discharge as the past minimum discharge (approximately equivalent to probable discharge of 30 years return period), intake rate potential was estimated by 34 basin blocks and is shown in Figure 2-4. The intake rate potential with return period of 10 years at main points are as follows: 36.9 m^3/s (3,190,000 m^3/day) at Livingstone [BZ-6], 8.6 m^3/s (740,000 m^3/day) at Kafue H.B.[BK-8], 4.1 m^3/s (350,000 m^3/day) at the most downstream of the Luangwa River [BL-5], 9.2 m^3/s (790,000 m^3/day) at Mbati [BC-2], 24.8 m^3/s (2,140,000 m^3/day) at Kashiba [BP-3].

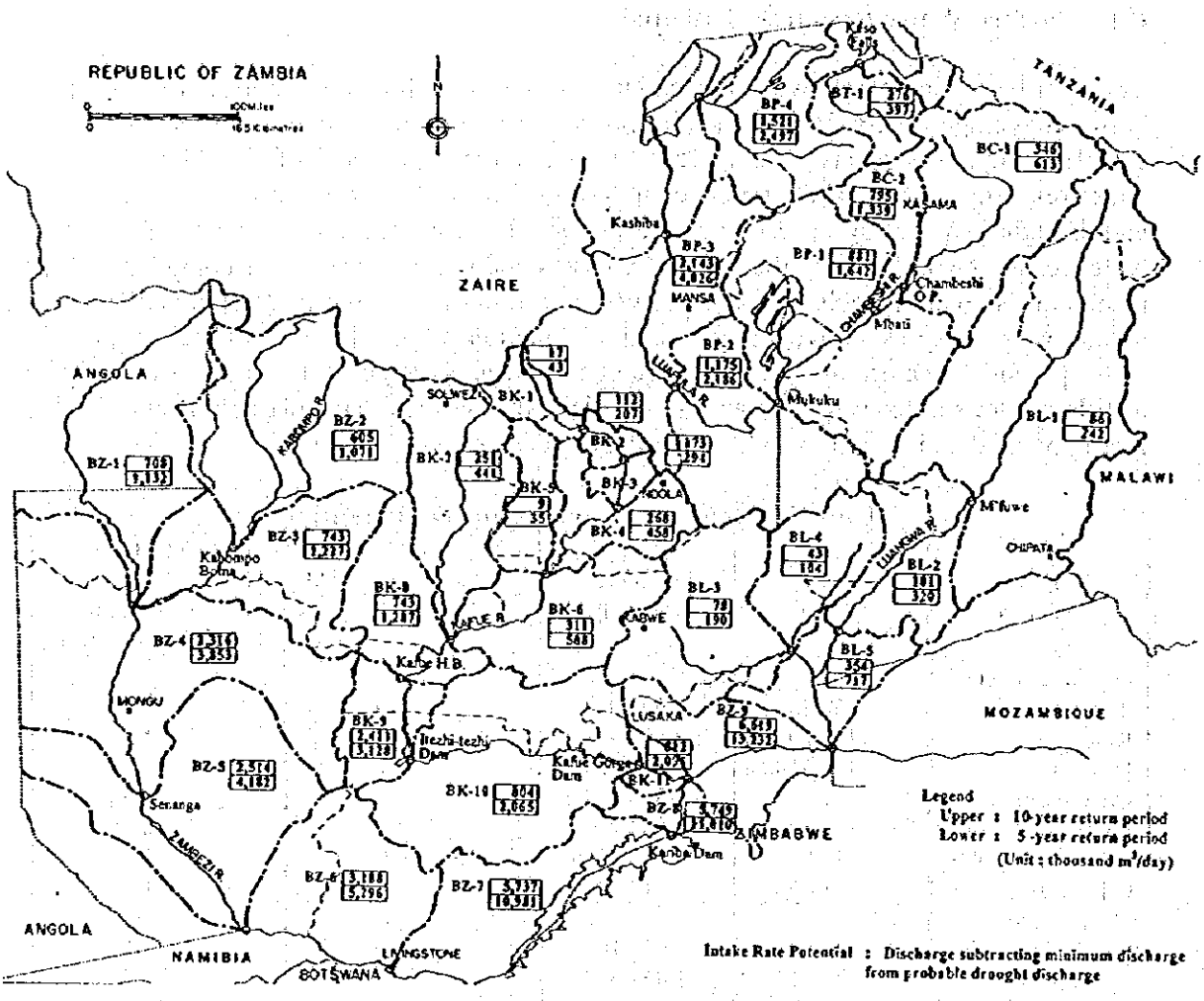

Figure 2-4 Intake Rate Potential by Basin Block

(4) Water Potential Developed by Proposed Dams

Based on the 1/50,000 - 1/100,000 scale maps, candidate dam sites were identified and their advantages were estimated taking account of topography, catchment area, distance from beneficial areas. Topographical and geological field inspections for the advantageous dam sites were carried out and possible maximum dam heights were evaluated. The location of these dam sites are shown in Figure 2-5. The discharge at proposed dam sites were estimated using the flow data at the closest hydrometric stations. The average drought discharge was adopted as compensation discharge and evaporation loss from a reservoir was also considered. The water potential developed by the proposed dams was estimated as the discharge available to be utilised even at the time of 10 year return period drought. The result is shown in Table 2-3. Among the proposed dams, five dams are adopted on the Master Plan. They are Chongwe dam, Mutundu dam, Kafubu dam, Lufubu dam and Lundazi dam

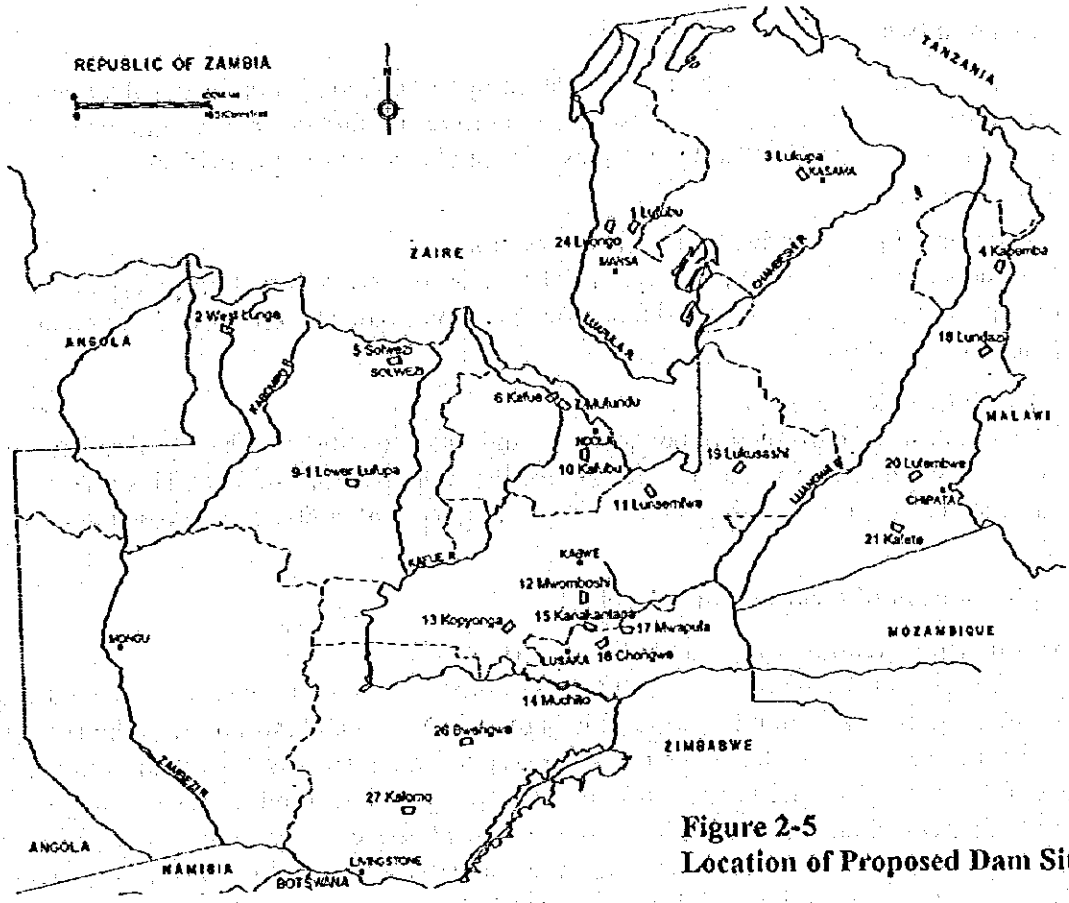

Figure 2-5
Location of Proposed Dam Sites

Table 2-3 Water Potential Developed by Proposed Dams

Province	No.	Dam site	River System	Catchment Area (km^2)	Dam Height (m)	Reservoir Area (km^2)	Effective Res.Vol. ($mil.m^3$)	Water Potential Developed (m^3/s)	Water Potential Developed (m^3/day)
Lusaka	14	Muchito	Kafue	40	20	4.0	16.4	0.06	5
	15	Kanakantapa	Zambezi	256	24	5.8	29.6	0.26	22
	16	Chongwe	Zambezi	1,917	37	13.8	87.0	2.15	186
	17	Mwapula	Zambezi	398	28	2.9	13.0	0.29	25
Copperbelt	6	Kafue	Kafue	7,549	33	31.6	247.0	14.36	1,241
	7	Mutundu	Kafue	493	36	13.7	127.0	2.28	197
	10	Kafubu	Kafue	1,047	31	32.7	293.0	5.60	484
Central	11	Lunsemfwa	Luangwa	1,473	27	15.5	111.0	4.28	370
	12	Mwomboshi	Luangwa	1,985	35	4.4	20.0	0.60	52
	13	Kopyonga	Kafue	288	30	5.4	44.0	0.67	58
	19	Lukusashi	Luangwa	961	56	15.9	293.0	5.01	433
Northwestern	2	West Lunga	Zambezi	4,651	41	146.0	2,203.0	28.49	2,462
	5	Solwezi	Kafue	354	30	2.0	17.0	0.99	86
	9-1	Lower Lufupa	Kafue	1,038	31	2.6	13.0	0.45	39
Southern	26	Bwengwa	Kafue	1,677	40	3.2	32.0	1.52	131
	27	Kalomo	Zambezi	1,925	27	4.5	7.0	0.28	24
Luapula	1	Lufubu	Luapula	1,292	33	26.5	218.0	8.52	736
	24	Luongo	Luapula	6,493	43	94.0	483.0	18.32	1,583
Northern	3	Lukupa	Chambeshi	1,256	27	11.2	79.0	2.07	179
Eastern	4	Kapemba	Luangwa	403	30	1.9	11.0	0.24	21
	18	Lundazi	Luangwa	1,580	38	14.9	90.0	1.86	161
	20	Lutembwe	Luangwa	1,517	48	11.1	127.0	2.77	239
	21	Katete	Luangwa	73	24	4.9	38.4	0.18	16
< Total >	23 Points		-	38,666	-	468.5	4,599.4	101.25	8,750

2.3 Groundwater

In addition to investigations of existing data on hydrogeology, groundwater fluctuation and characteristics of aquifers, the situation of current groundwater use and groundwater potential have been made clear by analyses of data obtained from the field surveys described below.

1) Nation-wide Groundwater Level Observation
Groundwater levels were measured at 312 wells for 169 observation points in order to obtain the annual groundwater fluctuation. The observations were carried out eight times from 1994 to 1995.

2) Well Inventory Survey
The situation of current groundwater use and characteristics of the aquifers have been investigated in order to obtain basic data for the well inventory survey. This investigation has been carried out by using a data-base established with 4,600 sets of existing borehole data.

(1) Fluctuation of Groundwater-level

< Nation-wide Groundwater Level Observation >

Figure 2-6 shows the relationship between seasonal change of rainfall and groundwater-level fluctuation. The groundwater level is highest in March and April during the latter half of the rainy season. On the other hand, the groundwater level is lowest in October and November during the latter half of the dry season. This trend of groundwater level fluctuation was almost the same over the whole of the country. Figure 2-7 shows the difference in groundwater level between the rainy season and dry season. The average difference between the rainy and dry season was 2.2m.

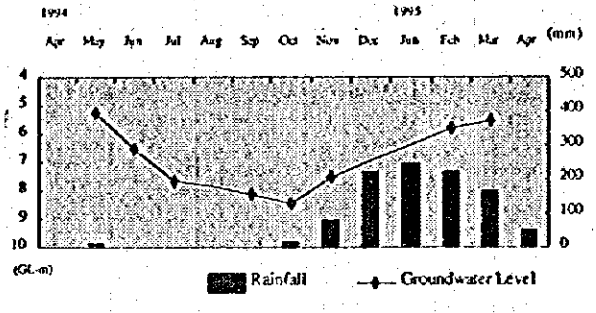

Figure 2-6 Groundwater Fluctuation and Rainfall in Eastern Province

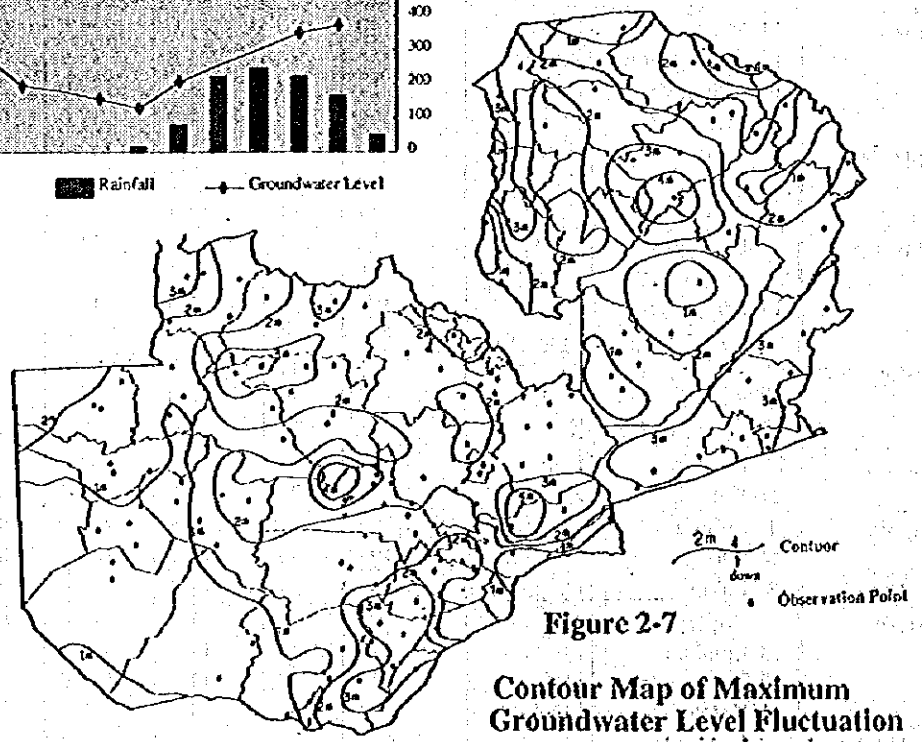

Figure 2-7

Contour Map of Maximum Groundwater Level Fluctuation

< Groundwater Level Monitoring in Large Cities >

Fluctuations in groundwater level are caused by abstraction of large quantities of groundwater, especially in Lusaka. Figure 2-8 shows the groundwater level fluctuation of large production wells in Lusaka and Kabwe. As shown in Figure 2-8, the effect of pumping on groundwater level fluctuation is more clear than that of seasonal rainfall in Lusaka. On the other hand, the effect of seasonal rainfall is more clear than that of pumping in Kabwe. Actually in Lusaka, it is said that the groundwater level is declining in recent years. Therefore, it is necessary to continue this survey to monitor any long term groundwater level decline.

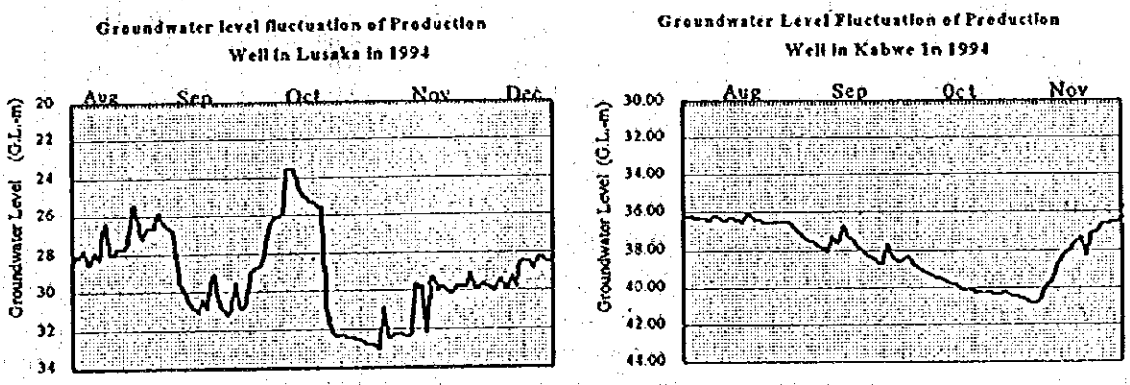

Figure 2-8 Groundwater Fluctuation in Lusaka and Kabwe

(2) Characteristics of Aquifers and Safe Yields

< Geology of Aquifer >

Wells in Zambia are classified into two types, "Shallow Well" and "Deep Well". Shallow wells are wells dug by manpower with an average depth of 15m and provide groundwater from strongly weathered zones of rocks. On the other hand, deep wells are boreholes with average length of about 60m and provide groundwater from fractured zones of rocks. The average yield of shallow wells is $2m^3$/day. On the other hand, the yields of deep wells vary greatly, however, a yield of less than $100m^3$/day is most common. Aquifers suitable for shallow wells do not depend on type of lithology, however, aquifers suitable for deep wells do depend on the type of geology. The types of lithologies suitable for deep wells are, limestone, dolomite, schist, granite, sand & gravel, sandstone, quartzite and gneiss as shown in Table 2-4.

< Aquifer Constants>

Aquifer constants have a wide range of values even within the same lithology. However, these values tend to concentrate within a certain range by lithology type. Therefore, it is possible to determine the representative values by lithology type. These representative values are shown in Table 2-4 and they are the values used for estimation of groundwater potential.

< Safe Yield >

The actual groundwater development potential depends on not only natural groundwater potential but also the method of abstracting groundwater. In order to obtain the actual groundwater development potential, sustainable yields of boreholes have been calculated by making a standard model of a deep well and aquifer. This sustainable yield is called a safe yield because it is possible to continue pumping groundwater at this yield over a long period.

This safe yield is used to determine the number of boreholes required in a given area without adverse effects. These yields are shown by lithology in Table 2-4.

Table 2-4 Characteristics of Main Aquifers and Safe Yield

Aquifer Lithology	Rate (%)	Permeability Coef. (m/day)	Specific Yield	Safe Yield (m^3/day)
Limestone, Dolomite	32	1.31	0.05	580 - 630
Schist	30	0.11	0.02	40 - 80
Sand, Gravel	12	0.68	0.05	310 - 470
Granite	12	0.15	0.03	70 - 110
Sandstone	4	0.27	0.04	130 - 190
Quartzite	4	0.16	0.02	70 - 110
Gneiss	2	0.06	0.02	30 - 40
Shale	2	0.05	0.02	20 - 40
Other Rocks	1	0.05	0.02	20 - 40

(3) Current Groundwater Use

< Number of Existing Wells >

The number of existing wells is about 10,000 deep wells and 9,000 shallow wells in the whole of Zambia, as shown in Table 2-5. The number of boreholes varies among Provinces. There are many boreholes in Western Province, Lusaka Province and Southern province. On the other hand, there are relatively few boreholes in Northern Province, Northwestern Province and Luapula Province. However, the number of shallow wells shows little difference among provinces. The number of shallow wells seems to be inversely proportional to the number of deep wells.

Table 2-5 Number of Existing Wells and Water Supply Rate in Rural Areas

Province	Number of Existing Wells			Water Supply Rate in Rural Area (%)		
	Deep Well	Shallow Well	Total	Deep Well	Shallow Well	Total
Lusaka	2,570	400	2,970	24	8	31
Copperbelt	870	660	1,530	21	7	27
Central	890	620	1,510	16	3	20
Northwestern	170	950	1,120	6	9	14
Western	2,970	1,060	4,030	61	6	67
Southern	1,520	840	2,360	24	4	28
Luapula	200	1,130	1,330	5	8	13
Northern	240	1,130	1,370	4	5	8
Eastern	780	2,170	2,950	10	8	17
<Total>	10,210	8,960	19,170	18	6	24

< Water Supply Ratio and Current Groundwater Use in Rural Areas>

Groundwater is the most important water resources for rural areas. Rural water supply plays the main role in groundwater use in Zambia. The average water supply ratio in rural areas is 24% throughout the whole of the country. The water supply ratio is proportional to the number of deep wells and four provinces are lower than the country average. These four provinces are Eastern, Northern, Northwestern and Luapula Provinces. The average production of wells in rural areas is $2m^3$/day for shallow wells and $6m^3$/day for deep wells which is approximately the capacity of a typical hand pump.

(4) Groundwater Potential

< Definition of Groundwater Potential>

Groundwater potential is defined as renewable groundwater. The renewable groundwater is the water that is recharged by rainfall, infiltrates into aquifers and runs off from aquifers every year. Therefore, groundwater potential is obtained by assessing the volume of recharge from rainfall. The volume of recharge is assessed by calculating the change of

groundwater storage in aquifers and groundwater runoff into rivers. Groundwater potential has been estimated based on the results of hydrogeological surveys, groundwater-level observations, numerical simulation, surface water analysis and meteorological analysis. The groundwater potential is shown in Table 2-6.

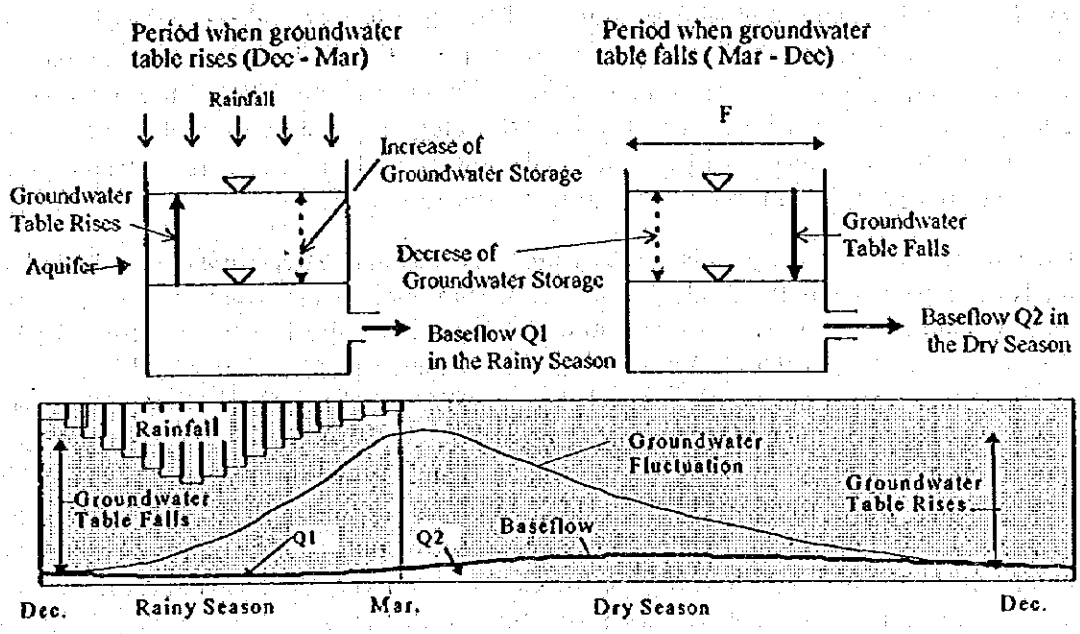

Figure 2-9 Concept of Groundwater Potential

< Result of Groundwater Potential Analysis>

Recharge from rainfall is carried out during the rainy season and groundwater storage is maximum in March and April every year. On the other hand, the groundwater stored in aquifers runs off into rivers during the dry season and groundwater storage is minimum in October and November every year. The difference in groundwater storage in rainy and dry season is the groundwater potential. 8% of annual rainfall infiltrates into aquifers and runs off into rivers over the whole of Zambia. Therefore, the groundwater potential is 8% of the annual rainfall. It follows that those provinces which have a greater total of rainfall have greater groundwater potential. The values of groundwater potential shown in Table 2-6 should be considered the maximum values that can be available for groundwater development.

Table 2-6 Groundwater Potential

Province	Annual Rainfall (mm)	Annual Change of Groundwater Level (m)	Annual Groundwater Potential	
			Annual Recharge (%)	Total Volume ($10^9 m^3$/year)
Lusaka	857	2.20	8.0	1.5
Copperbelt	1,231	2.40	6.8	2.6
Central	947	2.59	8.6	7.7
Northwestern	1,173	2.23	7.8	11.4
Western	808	0.86	6.8	7.0
Southern	737	1.93	9.4	5.7
Luapula	1,259	2.23	6.8	3.9
Northern	1,138	2.18	7.0	11.5
Eastern	961	2.90	9.2	6.1
<Total>		2.10	7.7	57.4

CHAPTER 3 BALANCE BETWEEN WATER DEMAND AND SUPPLY

3.1 Current Water Balance

Zambia's total surface water potential in an average year is 2,747 m^3/sec, or over 237 million m^3/day, and the total potential groundwater abstraction is 1,822 m^3/sec, or over 157 million m^3/day. In a drought year (1 in 10 year return period), the total surface water potential was estimated as 1,576 m^3/sec (over 136 million m^3/day) or about 57% of the potential in an average year. The provinces with the largest water resource potential are Northern and North Western provinces, with a combined total of 1,232 m^3/sec surface water (45% of national total) and 725 m^3/sec (40%) groundwater resources.

Current water demands are assessed from both existing water rights records and from analysis undertaken by the Study Team. The distribution of water rights by district/province and by main river basin is presented. Actual current water use is estimated from the Study Team's investigations. Domestic water use is calculated from census population data and assumed unit water consumption rates based on DWA and MLGH standards. Industrial use is assessed based on the CSO Industrial Census and unit consumption rates calculated from a questionnaire survey carried out by the Study Team. Agricultural water use is calculated from existing water rights records and compared to information provided by MAFF. To evaluate the proportion of water resources actually utilised, the current water use is compared to the average flow regime for each of the river sub-basins and the 'utilisation percentage' calculated. The results show that, with the exception of the Kafue river, Zambia's surface water resources are under-utilised and have significant potential for development. A provincial water balance shows that the current water demand situation can be met from available resources in all provinces, although the demands in Southern Province are significantly higher than in other parts of Zambia.

The national water balance given below shows that only a very small amount (around 74 m^3/sec or less than 3%) of water resources are currently consumed for use as domestic, industrial or agricultural water. Of this consumptive use, less than 10% is from groundwater sources. A larger proportion (42%) of surface water is utilised for hydropower generation, but most of Zambia's surface water flows to other countries un-utilised. There is obviously considerable scope for the development of both surface and groundwater resources.

Table 3-1 Current National Water Balance

Current Situation 1995

Water Resource					Water Use		
Description	Average Year		Drought Year (10-year return period)		Type of Use	Current Situation in 1995	
	million m^3/day	m^3/second	million m^3/day	m^3/second		million m^3/day	m^3/second
Surface Water	237.3	2,747	136.2	1,576	Domestic & Industrial	1.2	14
					(Groundwater)	(0.2)	(2)
(Groundwater)	(157.4)	(1,822)			Agricultural	5.2	60
					(Groundwater)	(0.3)	(4)
					Flow to other countries	230.9	2,673
					(Hydropower)	(99.4)	(1,150)
< Total >	237.3	2,747	136.2	1,576	< Total >	237.3	2,747

Note: ( ) shows included volume in the above volume.

3.2 Future Water Balance

Future water balance is shown in Table 3-2. Future domestic water demands are calculated from projected population growth and unit consumption rates. Industrial demands are also based on unit consumption rates and are linked to predicted growth in GDP. Future irrigation demands are evaluated for the proposed development projects of multi-purpose dams, irrigation only dams and run of river schemes. Livestock and fishpond water requirements are also assessed and the peak water requirement in the dry season calculated. The current and future demands are summarised by province in the table on the following page for the Base Scenario - Agricultural Expansion in accordance with Zambian government policy. From the table it can be seen that water demands will increase significantly across the country and that the provinces with the lowest potential water resources, namely Lusaka, Copperbelt and Southern Provinces, are also those with the highest demands. However, even with the increased demands outlined above, the future water balance on both national and provincial level show that Zambia's water resources are adequate to meet those demands even in a drought year. The main area of concern is Southern Province where, for the drought year condition, predicted demands exceed the available surface water resources. These demands can be met, however, from the inflow into Southern Province from Western and North-western Provinces via the Zambezi and Kafue rivers.

The increased demands are summarised in the future national water balance below as an increase in domestic and industrial use of 71% from 14 m^3/sec to 25 m^3/sec over the next twenty years. For agricultural use, including irrigation, livestock and fishpond demands, an increase of 150% from 60 m^3/sec to 150 m^3/sec is predicted. However, the total demands of around 175 m^3/sec still represent less than 7% of Zambia's total potential water resources. The major proportion of Zambia's surface water will continue to flow to other countries, although increased hydropower generation will utilise some of this potential. Development of multipurpose dams and groundwater borehole schemes will be able to satisfy the increases in domestic and industrial demands, while run of river irrigation schemes, in conjunction with the proposed multipurpose and irrigation dams, will meet the demands of increased agricultural production.

Table 3-2 Future National Water Balance

Future Situation 2015 (Base Scenario - Agricultural Expansion)

Water Resource					Water Use		
Description	Average Year		Drought Year (10-year return period)		Type of Use	Future Projection in 2015	
	million m^3/day	m^3/second	million m^3/day	m^3/second		million m^3/day	m^3/second
Surface Water	237.3	2,747	136.2	1,576	Domestic & Industrial	2.2	25
					(Groundwater)	(0.3)	(4)
(Groundwater)	(157.4)	(1,822)			Agricultural	13.0	150
					(Groundwater)	(0.7)	(8)
					Flow to other countries	222.1	2,572
					(Hydropower)	(103.7)	(1,200)
< Total >	237.3	2,747	136.2	1,576	< Total >	237.3	2,747

Note: ( ) shows included volume in the above volume.

Table 3-3 Water Balance by Province

(Base Scenario - Agricultural Expansion) (Unit: 1000 m^3/day)

Demands	Lusaka	Copperbelt	Central	N/western	Western	Southern	Luapula	Northern	Eastern	Zambia
1995 year										
Domestic Water	192	233	64	22	33	66	31	49	51	741
Industrial Water	98	93	13	6	9	22	4	12	9	266
Losses	70	79	15	4	5	14	4	9	9	209
Sub-Total (PS)	360	405	92	32	47	102	39	70	69	1,216
Irrigation	490	803	564	45	0	1,660	185	790	43	4,580
Livestock	5	4	22	3	23	50	1	5	16	129
Fishponds	4	84	1	1	1	7	3	13	4	117
Sub-Total (Ag)	499	891	587	49	24	1,717	189	808	63	4,826
TOTAL	859	1,296	679	81	71	1,819	228	878	132	6,042
2005 year										
Domestic Water	291	281	86	27	37	80	35	57	64	958
Industrial Water	137	130	19	8	12	29	5	16	13	369
Losses	103	99	21	5	6	17	5	11	11	278
Sub-Total (PS)	531	510	126	40	55	126	45	84	88	1,605
Irrigation	725	1,178	996	269	303	2,394	457	979	45	7,346
Livestock	7	7	30	9	37	48	4	16	25	183
Fishponds	4	164	97	173	24	7	3	13	329	814
Sub-Total (Ag)	736	1,349	1,123	451	364	2,449	464	1,008	399	8,343
TOTAL	1,267	1,859	1,249	491	419	2,575	509	1,092	487	9,948
2015 year										
Domestic Water	425	328	110	33	42	93	40	63	76	1,210
Industrial Water	190	141	24	9	13	32	6	17	15	447
Losses	149	113	27	5	7	20	6	12	14	353
Sub-Total (PS)	764	582	161	47	62	145	52	92	105	2,010
Irrigation	725	1,678	996	614	604	2,394	1,235	1,411	173	9,830
Livestock	8	9	31	15	45	50	7	26	32	223
Fishponds	4	164	97	246	80	589	276	162	512	2,130
Sub-Total (Ag)	737	1,851	1,124	875	729	3,033	1,518	1,599	717	12,183
TOTAL	1,501	2,433	1,285	922	791	3,178	1,570	1,691	822	14,193
Surface Water Potential										
Average year	10,800	13,000	33,600	38,900	20,300	5,300	26,300	67,500	21,500	237,200
Drought year	3,700	6,600	11,000	21,500	16,300	1,200	17,700	44,800	13,400	136,200
[Groundwater]	4,100	7,200	21,200	31,300	19,200	15,700	10,600	31,400	16,700	157,400
Balance - Average Year										
1995 year	9,941	11,704	32,921	38,819	20,229	3,481	26,072	66,622	21,368	231,158
% Not Utilised	92%	90%	98%	100%	100%	66%	99%	99%	98%	98%
2005 year	9,533	11,141	32,351	38,409	19,881	2,725	25,791	66,408	21,013	227,252
% Not Utilised	88%	86%	96%	99%	98%	51%	98%	98%	98%	96%
2015 year	9,299	10,567	32,315	37,978	19,509	2,122	24,730	65,809	20,678	223,007
% Not Utilised	86%	81%	96%	98%	96%	40%	94%	97%	96%	94%
Balance - Drought Year										
1995 year	2,841	5,304	10,321	21,419	16,229	-619	17,472	43,922	13,268	130,158
% Not Utilised	77%	80%	94%	100%	100%	-52%	99%	98%	99%	96%
2005 year	2,433	4,741	9,751	21,009	15,881	-1,375	17,191	43,708	12,913	126,252
% Not Utilised	66%	72%	89%	98%	97%	-115%	97%	98%	96%	93%
2015 year	2,199	4,167	9,715	20,578	15,509	-1,978	16,130	43,109	12,578	122,007
% Not Utilised	59%	63%	88%	96%	95%	-165%	91%	96%	94%	90%

Notes : 1. Demand sub-totals : PS - Public Supply, Ag - Agriculture
2. Groundwater potential is shown for information only - not included in the water balance.
3. Deficit in Southern Province in a drought year is supplemented with inflow from other provinces (Western, North Western and Copperbelt) Provinces.