CHAPTER 4 WATER RESOURCES DEVELOPMENT MASTER PLAN

4.1 Development Policy

(1) Source Development Policy

Surface Water Development

"Compensation discharge", which maintains normal function in downstream of the river, should be assured in dam development. "Compensation discharge" affords discharge for non-consumptive use of water (maintenance discharge) in downstream, such as navigation and fishery, and discharge for consumptive use (water-use discharge). In this Master Plan Study, however, ten year average "drought discharge", the discharge which exceeds the river flow for more than 355 days in a year, is estimated and applied as compensation discharge for proposed dam development projects.

Groundwater Development

Required number of boreholes to meet the demands by region is estimated for formulation of groundwater development plan. Boreholes provide more stable source of water with better quantity and quality. Besides, shallow wells are affected by droughts and provide less quality of water, thus, are not reliable source for sustainable development. The following criteria is applied for the development plan.

- Urban Water Supply : Water supply in urban areas requires large volume of water. Pumped water from one borehole is determined based on the assessment of safe yield according to the hydrogeological characteristics of the area. Standard size of boreholes is 20 - 30cm in diameter and 60 - 100m in depth.
- Rural Water Supply : Standard pumped water is assumed to be 7.5 m^3/day for rural water supply. Hand pumps are to be used and the design safe yield is to be the standard pumping capacity of the hand pump. Standard size of boreholes is 10 - 15cm in diameter and 60m in depth.

(2) Development Policy for Water Supply for Domestic and Industrial Use

In the "Social Sector Rehabilitation and Development Programme", the Government addresses the water supply goal to fulfil the supply of sustainable safe drinking water to the people. The immediate target extends the coverage of safe water supplies to 70% of urban people and 35% of rural population by the year 1996. No targets after 1996 have been addressed so far officially. In this Study, the goal is set to fulfil the safe water supply to urban and rural people as follows:

1) Complete coverage (100%) in urban areas, including twelve large urban areas (cities and municipalities) and 80 other smaller townships by 2015
2) For rural areas, to cover 55% by the year 2005 and 75% in 2015

Water resources development plans for respective areas are prepared on the basis of the following criteria in consideration of the present water use situation.

1) Both domestic and industrial water is served by public water supply systems. Since water for mining activity is generally supplied by mining companies themselves in Zambia, the public water supply system does not cover mining use. Thus, the

water demand for public system is determine to cover domestic and industrial requirement.

2) Water supply system should utilise stable source and employ sustainable development measures. Source of supply is determined as surface or groundwater, taking economic validity and developed volume into account. For surface water development, average "drought discharge" in ten years is applied to secure stable supply. For groundwater development, developed amount for a borehole is planned based on safe yields to avoid excessive abstraction.
3) Water supply system is divided into the following three categories according to the population and the demand volume.
   - Large urban areas (12 large urban areas); including Lusaka, Ndola, Kitwe, Chililabombwe, Chingola, Mufulira, Kalulushi, Luanshya, Kabwe, Livingstone, Kasama and Chipata
   - Small urban areas (80 townships); having population of more than 1,000 persons in the 1990 census
   - Rural areas; other areas than the above urban areas
4) Required water amount is obtained by adding water allowance for losses and leakage to each water demand. The allowance covers losses and leakage which occur at intake, conveyance, treatment, distribution etc. Thus, the design amount of required water by the above category is set as follows.
   - Large Urban Areas : 125 % of the water demand
   - Small Urban Areas : 115 % of the water demand
   - Rural Areas : 110 % of the water demand

(3) Development Policy for the Agricultural Sector

Policies of water resources development for agricultural sector is set based on ASIP, whose target year is 2000. Since the Master Plan covers the period towards 2015, agricultural development plan up to 2015 is formulated as described in Section 1.4 of this Report, and is outlined as follows:

1) Domestic consumption of crops, livestock and fish is to be met, in principle, from domestic production.
2) To assure stable production resistant to drought, production of irrigated wheat is to be promoted.
3) Contribution to the national economy is to be enlarged through an increase of products suitable for export.

Policies of water resources development for agricultural sector are as follows:

1) Water sources for irrigation and aqua-culture are to be mainly surface water. Although ground water is abstracted for some irrigation projects, the scale of abstraction is quite small. On the other hand, the sources for livestock breeding are mainly to be groundwater, because regional distribution of demand is scattered and volume of individual demand is small.
2) Low flow security in the case of diversion weir or direct intake has been set to ensure the abstraction and compensation discharge even in the occurrence of the worst drought in five years. In the case of dam development, both for single purpose for irrigation and multi-purpose dams, low flow security is set against the worst drought in ten years as determined for water supply projects for domestic and industrial use.

3) Irrigation projects are classified as follows:
< Project Type >
- ASIP Rehabilitation Projects: Rehabilitation of existing irrigation for smallholders by the Government
- Expansion Projects: Expansion of existing irrigation by commercial farmers
- New Projects: Newly developed projects in potential areas for irrigation

< Scale of Projects >
- Small Scale Projects: Projects targeted for an area of less than 100 ha
- Middle Scale Projects: Projects for an area of between 100 ha and 1,000 ha
- Large Scale Projects: Projects for an area of over 1000 ha

< Source Type >
- Dam Development Project: Projects using developed water from either single or multi-purpose dam development
- Run-of-River Development Project: Projects using river water abstraction, either with or without a weir

4) Majority of proposed projects are furrow irrigation schemes. Irrigation efficiency is assumed as follows:
- Conveyance Efficiency: 80%
- Application Efficiency: 60%
- Overall Efficiency: 50%
- Efficiency in aqua-culture: 100% of application efficiency, then 80% of overall efficiency

(4) Water Resources Development for Other Sectors

<u>Hydroelectric Power Generation</u>

Most of Zambia's electricity, 99.8%, is supplied from hydroelectric power generation. Current generation has already harnessed 28% of the potential available. Construction of two major hydro-power generation plants, namely Kafue Gorge Lower Power Station with capacity of 450MW and Batoka Gorge Power Station with Zambian share of capacity of 400MW, are planned and have been evaluated as feasible. Hydroelectricity is the most advanced sector in the development and utilisation of water resources in Zambia. The objectives of these projects are promotion of export of electric power and contribution to stable economic development. Negotiations and agreements should be encouraged with the electricity importing countries and the countries which need to jointly invest in these two projects.

In addition, projects which utilise the water of the Kafue River, such as water supply to Lusaka City and irrigation for sugarcane production, are proposed in the Master Plan. Those projects will also contribute to social and economic development of the country and are necessary in the future. Co-ordination and re-adjustment of water rights and review of electricity generation plans for the existing and new Kafue Gorge Power Stations will be necessary.

<u>Navigation</u>

Inland navigation development plan should be studied in accordance with the national transportation policy. Existing navigation on slow flowing rivers and lakes will decrease

with the development of alternative road networks. Demands for navigation will, however, remain until alternative roads or bridges are completed. The continuation of dredging of waterways which are affected by low flows and sedimentation, is necessary.

Flood Control

No major flood control projects are necessary because flooding is not a major issue in Zambia. Flood control measures, whose objectives are encouragement of intensive land use through protection of lives and properties, are generally included in multi-purpose dam development because of the cost involved. Some of the dams proposed in the Master Plan will result in higher safety against floods and encourage agricultural flood plain land use.

Forestry

Forests have an important role from the viewpoint of water resources development by protecting watersheds against soil erosion and by maintaining stable water flow. Forest accounts for 14% of the territory of Zambia, and has been decreasing by 1.3%/year caused by forest fires, shifting cultivation, and demand increase in building timber and firewood. Although Zambia Forestry and Forest Industries Corporation (ZAFFICO) conducted major forest plantations, afforestation planned taking account of the future increase in demand of forestry products such as building materials, should be further promoted. Encouragement of permanent cultivation rather than shifting cultivation will also benefit forest preservation.

Water Quality

The abundant resources, combined with the low level of consumptive use (3% of the resources) 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. Even though consumptive use will grow to almost 7% of the resources by 2015, the increased use will not cause major problems in general. Degradation of water quality in rivers and contamination of groundwater caused by domestic or industrial effluent will occur in certain urban areas, imposing additional constraints for water use in the area. Construction and expansion of sewer system and treatment facilities will be required in the future. The following are necessary for water quality management.

1) adoption of aquatic ecosystem guidelines for instream river water quality
2) regular water quality monitoring at designated points
3) periodical effluent monitoring from factories and sewage treatment works

4.2 Projects for Domestic and Industrial Water Supply

(1) Water Demand and Present Balance between the Demand and Supply

Water demand and the water required to be developed for the three scenarios are shown in Table 4-1. Total demand throughout the country is estimated to reach to 2 million m^3/day in the Base Scenario-Agricultural Expansion (medium population projection), and a deficit of 1 million m^3/day in supply capacity will occur. Urban demand will account for 70% of the total demand.

Table 4-1 Water Demand for Domestic and Industrial Use

(Unit: 1000 m^3/day)

	Base Scenario Agricultural Expansion (medium population projection)				Base Scenario Industrialisation (high population projection)				Conservative Scenario (low population projection)			
	Large Urban Areas	Small Urban Areas	Rural Areas	Total	Large Urban Areas	Small Urban Areas	Rural Areas	Total	Large Urban Areas	Small Urban Areas	Rural Areas	Total
Demand/ 2005												
Domestic Use	618	122	217	957	663	199	214	1,076	593	128	208	929
Industrial Use	293	76	0	369	447	129	0	576	233	69	0	302
Losses	228	29	22	279	278	49	21	348	207	30	21	258
Total	1,139	227	239	1,608	1,388	378	235	2,000	1,033	226	229	1,489
Demand/ 2015												
Domestic Use	810	145	255	1,210	940	322	251	1,513	738	144	231	1,113
Industrial Use	362	85	0	447	552	145	0	697	287	77	0	364
Losses	293	34	25	352	373	70	25	468	256	33	23	312
Total	1,465	264	280	2,009	1,865	537	276	2,678	1,282	254	254	1,790
< Balance >												
Present Capacity	809	137	43	989	809	137	43	989	809	137	43	989
Shortage in 2005	-330	-90	-196	-619	-579	-241	-192	-1,011	-224	-89	-186	-500
(%)	29	40	82	38	42	64	82	51	22	39	81	34
Shortage in 2015	-655	-127	-237	-1,020	-1,056	-400	-233	-1,689	-473	-117	-211	-801
(%)	45	48	85	51	57	74	84	63	34	46	83	45

(2) Multi-purpose Dam Development Plans

Three multi-purpose dams are proposed, as outlined in Table 4-2. The purpose of the Chongwe Dam development is to provide water to Lusaka urban area and to irrigation schemes in the surrounding area. The volume of water developed by Chongwe Dam project is estimated as 172 thousand m^3/day. Kafubu Dam is planned to provide water for municipal water supply to Ndola and Luanshya and irrigation projects along the river with 430 thousand m^3/day of water developed. Mutundu Dam is planned with 170 thousand m^3/day of water developed for water supply to Kitwe, Kalulushi and Mufulira, and irrigation around Kitwe.

Table 4-2 Outline of Multi-purpose Dams

	Chongwe Dam	Kafubu Dam	Mutundu Dam
(1) Dam Site	- 45 km east of Lusaka, - 1 km east of Chongwe	- 30km south-west of Ndola, - 15km south-east of Luanshya	- 15km north of Kitwe, - 15km south of Mufulira
(2) Dam Type	Fill Type	Fill Type	Fill Type
(3) Dam Height	37.0 m	27.0 m	30.0 m
(4) Dam Volume	1,315,000 m^3	795,000 m^3	981,000 m^3
(5) Total Volume of Developed Water	173,000 m^3/day (2.002 m^3/sec)	430,000 m^3/day (4.977 m^3/sec)	170,000 m^3/day (1.968 m^3/sec)
(6) Purpose	- Water Supply:103,000m^3/day (Lusaka, Chongwe) - Irrigation: 70,000 m^3/day (810ha near to Chongwe)	- Water Supply: 65,000m^3/day (Ndola, Luanshya) - Irrigation: 365,000m^3/day (4,220ha along Kafubu River)	- Water Supply: 35,000m^3/day (Kitwe, Kalulushi, Mufulira) - Irrigation: 135,000m^3/day (1,560ha near to Kitwe)

(3) Water Supply Projects

Water Supply to Large Urban Areas Refer to Table 4-3 and 4-4 and Figure 4-1.

Source of water supply to the Capital City of Lusaka relies on groundwater in the Lusaka Dolomite Aquifer (90,000 m^3/day abstracted) and on the Kafue River (100,000 m^3/day conveyed). For the future source of supply, large volume of abstraction cannot be expected from the Lusaka Dolomite Aquifer. An alternative aquifer for additional source will be the Cheta Limestone Aquifer located 10km north of Lusaka. The most promising source near Lusaka City will be obtained from the Chongwe River with dam and reservoir development.

The Kafue River will remain important as a source of water supply. However, all water in the Kafue River is occupied in respect to water rights. Re-allocation of the existing water rights held by the hydro-electric entity will be necessary. In case that 400,000 m^3/day (4.63 m^3/second) of water is conveyed for water supply to Lusaka (in Base Scenario-Agricultural Expansion), reduced revenue from electric tariff collection caused by decrease in generation at Kafue Gorge Power Station lost for the water supply could be estimated as US$ 1.4 million according to the recent operation records of ZESCO. The reduced revenue corresponds to around 10% of the operating cost of water supply facilities with the capacity of 400,000 m^3/day.

Table 4-3 Development Policy of Water Supply Projects for Lusaka Urban Area by Source

Items	Source of Water Supply in Lusaka Urban Area		
	Groundwater	Chongwe River	Kafue River
Site of Source	10 km north from Lusaka	45 km east of Lusaka	50 km south of Lusaka
Type of Source	50 Boreholes Diameter: 30 cm Depth: 100m Amount of Developed Water: 400m^3/day/bore	Chongwe Dam Fill Type Dam Height: 37m Reservoir Storage: 92 million m^3	Direct Intake
Potential	Maximum Amount of Development 38,000 m^3/day (0.440 m^3/sec)	Maximum Amount of Development 173,000 m^3/day (2.002 m^3/sec)	Mean Discharge: (295.6 m^3/sec) Drought Discharge: (123.3 m^3/sec)
Feasible Scale of Development	20,000~30,000 m^3/day (0.231~0.347 m^3/sec) < Small Scale >	100,000~150,000 m^3/day (1.157~1.736 m^3/sec) < Medium Scale >	300,000~600,000 m^3/day (3.427~6.944 m^3/sec) < Large Scale >
Unit Price of Developed Water	US$ 788 m^3/day	US$ 1,099 m^3/day	US$ 805 m^3/day
Characteristics of Source	- Cheta Limestone Aquifer - No current abstraction because of the location (10km north from Lusaka)	- Current source of water supply for Chongwe Township - New source for Lusaka - Developed by storage of flood water	- Abundant water at intake point, - 180m^3/s of water rights attached to hydro-electric generation - No surplus water
Priority and Reasons	<First Priority> - No conflicts with the existing water rights - Small capital investment - Short term implementation - Highest priority	<Second Priority> - New source providing an alternative for stable supply - Joint venture project with agricultural sector - To be implemented after the groundwater project	<Third Priority> - Possible conflicts with existing water rights granted for hydro-electric generation - Large capital investment - Longest term required for preparation

As shown in Table 4-3, water supply projects of Lusaka consist of Northern Lusaka Production Well Project, Chongwe Dam Project and Kafue Pipeline Project. Northern Lusaka Production Well Projects includes construction of 50 boreholes with diameter of 30cm and depth of 100m in a groundwater basin of Cheta formation limestone with a potential of 20 to 30 thousand m^3/day, located 10km north of Lusaka City. In Chongwe Dam project, 100 thousand m^3/day of water developed from Chongwe Dam will be conveyed a distance of 45km to Lusaka. Largest project of the three is Kafue Pipeline Project for conveyance of 400 thousand m^3/day water (for the Base Scenario - Agricultural Expansion) from the Kafue River to Lusaka a distance of 50km, to be implemented in three phases.

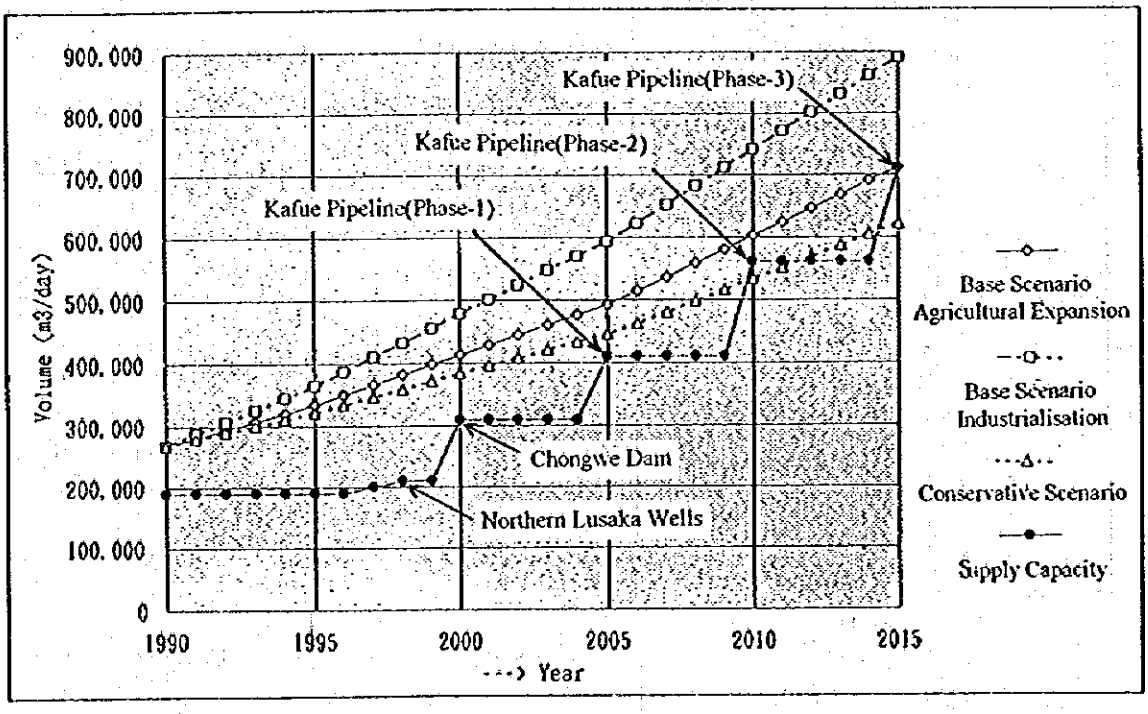

Figure 4-1 Water Demand and Supply Plan for Lusaka City

Sources of urban water supply in the five large urban areas in Copperbelt Province are to be obtained from two multi-purpose dams, namely Kafubu and Mutundu Dams. In the Base Scenario-Agricultural Expansion, a volume of 60 thousand m^3/day of water to Ndola and 5 thousand m^3/day to Luanshya will be conveyed from Kafubu Dam. In the same scenario, 20 thousand m^3/day to Kitwe, 10 thousand m^3/day to Kalulushi, and 5 thousand m^3/day to Mufulira will be conveyed from Mutundu Dam.

Water to Kabwe urban area will be supplied by an expansion of conveyance, implemented in two phases, of 57 thousand m^3/day in the Base Scenario-Agricultural Expansion from Kabwe Dam completed in 1990. Water supply to Livingstone and Kasama will be attained with water conveyance projects without dam development. Volumes of developed water will be 20 thousand m^3/day for Livingstone and 14 thousand m^3/day for Kasama in the Base Scenario-Agricultural Expansion. Water to Chipata is to be supplied with construction of 120 boreholes, with diameter of 30cm and depth of 60m, for a volume of 12 thousand m^3/day of developed water in the same scenario.

Table 4-4 Water Supply Projects for Large Urban Areas

City	Base Scenario Agricultural Expansion (medium population projection)	Base Scenario Industrialisation (high population projection)	Conservative Scenario (low population projection)
Lusaka	Northern Lusaka Production Well Project Q = 20,000 m³/day N = 50 wells L = 10 km	Same as Base Scenario-Agricultural Expansion	Same as Base Scenario-Agricultural Expansion
	Lusaka Water Supply Project (Chongwe Dam Project) Q = 100,000 m³/day L = 45 km	Same as Base Scenario-Agricultural Expansion	Same as Base Scenario-Agricultural Expansion
	Lusaka Water Supply Project (Kafue Pipeline Project) Q = 400,000 m³/day L = 45 km Phase-1 : 100,000 m³/day Phase-2 : 150,000 m³/day Phase-3 : 150,000 m³/day	Q = 600,000 m3/day Phase-1 : 150,000 m3/day Phase-2 : 150,000 m3/day Phase-3 : 200,000 m3/day	Q = 300,000 m3/day Phase-1 : 100,000 m3/day Phase-2 : 100,000 m3/day Phase-3 : 100,000 m3/day
Sub Total	Q = 520,000 m³/day	Q = 720,000 m³/day	Q = 420,000 m³/day
Ndola	Ndola Water Supply Project (Kafubu Dam) Q = 60,000 m³/day L = 40 km	Q = 110,000 m³/day	Q = 45,000 m³/day
Luanshya	Luanshya Water Supply Project (Kafubu Dam) Q = 5,000 m³/day L = 15 km	Q = 20,000 m³/day	No New Demand
Kitwe	Kitwe Water Supply Project (Mutundu Dam) Q = 20,000 m³/day L = 20 km	Q = 50,000 m³/day	No New Demand
Kalulushi	Kalulushi Water Supply Project (Mutundu Dam) Q = 10,000 m³/day L = 30km	Q = 15,000 m³/day	Q = 6,000 m³/day
Mufulira	Mufulira Water Supply Project (Mutundu Dam) Q = 5,000 m³/day L = 15 km	Q = 15,000 m³/day	No New Demand
Kabwe	Kabwe Water Supply Expansion Project Q = 57,000 m³/day L = 15 km Phase-1 : 19,500 m³/day Phase-2 : 37,500 m³/day	Q = 80,000 m3/day Phase-1 : 27,000 m³/day Phase-2 : 53,000 m³/day	Q = 45,000 m3/day Phase-1 : 15,000 m³/day Phase-2 : 30,000 m³/day
Livingstone	Livingstone Water Supply Expansion Project Q = 20,000 m³/day L = 10 km Phase-1 : 10,000 m³/day Phase-2 : 10,000 m³/day	Q = 30,000 m³/day Phase-1 : 15,000 m³/day Phase-2 : 15,000 m³/day	Q = 16,000 m³/day Phase-1 : 8,000 m³/day Phase-2 : 8,000 m³/day
Kasama	Kasama Water Supply Expansion Project Q = 14,000 m³/day L = 5 km	Q = 35,000 m³/day	Q = 10,000 m³/day
Chipata	Chipata Production Well Project Q = 12,000 m³/day N = 120 wells	Q = 20,000 m³/day N = 200 wells	Q = 9,000 m³/day N = 90 wells
<Total>	No. of Cities : 10 cities Q = 723,000 m³/day N = 170 wells	No. of Cities : 10 cities Q = 1,095,000 m³/day N = 250 wells	No. of Cities : 7 cities Q = 551,000 m³/day N = 140 wells

[Note] (1) Of the twelve large urban areas, Chililabombwe and Chingola are excluded, where new development is not necessary because the current supply capacity is sufficient to meet the future demands

(2) Of the boreholes included in Northern Lusaka Production well projects, 8 boreholes (5,200 m³/day) will be drilled through a grant aid project of the Government of Japan

(3) Q : Water Volume Developed N : Number of Well L : Distance of Water Conveyance

Adjustments of water supply projects to demand increase, in the Base Scenario - Industrialisation or decrease in the Conservative Scenario are to be made as follows:

- In Lusaka urban area, Northern Lusaka Production Well Project and Chongwe Dam Project are to be implemented as planned in any case. Water supply is adjusted in Kafue Pipeline Project.
- In Kafubu and Mutundu Multi-purpose Dams Projects, for five urban areas in Copperbelt Province, the priority in allocation of developed water is given to municipal water supply and remaining water is used for irrigation.
- In projects for expansion of conveyance or borehole construction projects, volume of conveyed water or number of boreholes to be constructed is to be adjusted in accordance with the volume of water demand.

Water Supply to Small Urban Areas Refer to Table 4-5.

In the Base Scenario-Agricultural Expansion, sources of water supply to 80 small urban areas are divided between surface water in 17 towns and groundwater in 63 towns. Volume of surface water to be developed in the same scenario, amounts to 49.3 thousand m^3/day, and the average for each town is 2.9 thousand m^3/day. Since demand for each town is small compared to a large urban area, intakes from natural flows, not from reservoirs developed by dam construction, are planned for small towns. Total volume of groundwater developed in small towns in the scenario, will reach 106.6 thousand m^3/day with 1,281 boreholes, and the average for each town is 1.7 thousand m^3/day, equivalent to 20 boreholes.

Water Supply in Rural Areas Refer to Table 4-6.

Rural water supply projects are planned using boreholes, 15cm in diameter and 60m in depth, fitted with hand pumps. In order to cover 75% of the demands in rural areas by 2015, rural water supply projects will require construction of 22,528 boreholes with developed water of 169 thousand m^3/day in the Base Scenario-Agricultural Expansion.

Promotion Projects for Groundwater Develoment Refer to Table 4-7 and 4-8.

In the water supply plan for the Base Scenario-Agricultural Expansion, about 24,000 boreholes are planned to be constructed during 20 years to 2015. There are eight DTH type drilling rigs at present in Zambia, but more than twenty DTH type rigs are needed to complete 1,200 boreholes per year. More than 20 drilling teams are needed, with more than 200 personnel, including hydrogeologists, drilling engineers and mechanical engineers. In addition, strengthening of maintenance and management system for completed boreholes is needed and an educational institute to train personnel related to groundwater development is recommended. For the purpose of attaining these aims above, "Drilling Centre Project" and "Groundwater Development Training Centre Project" are proposed as projects for the promotion of groundwater development. Drilling centres should be constructed in each province and the existing equipment and staff of DWA should be utilised in the drilling centres. Before constructing the provincial drilling centres, a Groundwater Development Training Centre and the Lusaka Province drilling centre should be constructed at the same time in Lusaka, where the engineers related to groundwater development and personnel in charge of well maintenance and management will be trained.

Table 4-5 Water Supply Projects for Small Urban Areas

Province	Base Scenario Agricultural Expansion			Base Scenario Industrialisation			Conservative Scenario		
	No. of Towns	Volume (m^3/day)	Facility	No. of Towns	Volume (m^3/day)	Facility	No. of Towns	Volume (m^3/day)	Facility
Lusaka	5			5			5		
-Surface	4	23,600	L=40km	4	62,300	L=40km	4	13,700	L=40km
-Groundwater	1	960	W=5	1	1,728	W=9	1	576	W=3
Copperbelt	4			4			4		
-Surface	-	-		-	-		-	-	
-Groundwater	4	5,818	W=17	4	15,512	W=60	4	3,542	W=7
Central	7			7			7		
-Surface	-			-			-		
-Groundwater	7	13,590	W=230	7	31,390	W=594	7	9,390	W=156
Northwestern	7			7			7		
-Surface	5	11,600	L=12km	5	38,200	L=12km	4	7,700	L=10km
-Groundwater	2	3,220	W=92	2	6,020	W=172	3	2,520	W=72
Western	12			12			12		
-Surface	3	5,700	L=6km	2	9,400	L=6km	3	4,100	L=6km
-Groundwater	9	16,878	W=36	9	31,356	W=67	9	10,764	W=23
Southern	21			21			21		
-Surface	2	1,400	L=6km	2	2,500	L=6km	2	1,100	L=6km
-Groundwater	19	25,660	W=315	19	59,573	W=764	19	13,070	W=144
Luapula	7			7			7		
-Surface	3	7,000	L=6km	3	13,600	L=6km	3	5,900	L=6km
-Groundwater	4	8,374	W=79	4	20,760	W=185	4	5,936	W=56
Northern	10			10			10		
-Surface	-			-			-		
-Groundwater	10	19,326	W=221	10	36,988	W=445	10	14,850	W=162
Eastern	7			7			7		
-Surface	-	-		-	-		-	-	
-Groundwater	7	12,782	W=286	7	24,030	W=531	7	9,878	W=223
TOTAL	80	155,906		80	353,267		80	103,026	
-Surface	17	49,300	L=70km	17	126,000	L=70km	16	32,500	L=68km
-Groundwater	63	106,606	W=1,281	63	227,267	W=2,837	64	70,526	W=846

[Note] : L = length of conveyance (km), W = number of wells

Table 4-6 Water Supply Projects for Rural Areas

Province	Base Scenario Agricultural Expansion		Base Scenario Industrialisation		Conservative Scenario	
	Volume (m^3/day)	Number of Wells	Volume (m^3/day)	Number of Wells	Volume (m^3/day)	Number of Wells
Lusaka	8,176	1,090	3,892	519	7,275	970
Copperbelt	12,780	1,704	13,470	1,796	11,100	1,480
Central	21,256	2,834	21,923	2,923	18,975	2,530
Northwestern	13,066	1,742	11,460	1,528	11,693	1,559
Western	7,936	1,058	7,298	973	4,958	661
Southern	26,372	3,516	25,935	3,458	23,130	3,084
Luapula	15,512	2,068	15,188	2,025	13,860	1,848
Northern	26,596	3,546	26,603	3,547	23,888	3,185
Eastern	37,276	4,970	38,565	5,142	33,390	4,452
TOTAL	168,970	22,528	164,334	21,911	148,269	19,769

(Note) Of the above wells to be developed, 65 boreholes, 150 boreholes and 105 boreholes are being drilled in Lusaka, Copperbelt and Central Provinces, respectively, through grant aid projects of the Government of Japan.

Table 4-7 Drilling Centre Projects

Province	Number of Rigs	Number of New Boreholes Base Scenario Agricultural Expansion				Project Cost (mil.us$)	Note
		Large Urban	Small Urban	Rural Areas	Total		
Lusaka	(2)*	50	5	1,090	1,145	13.40	Facilities have function of both training centre and drilling centre. 2 drilling teams.
Copperbelt	2		17	1,704	1,721	6.46	Drilling centre to be newly constructed in Ndola. 3 drilling teams.
Central	(3)*		230	2,834	3,064	-	Existing drilling centre in Kabwe to be utilised. 5 drilling teams.
Northwestern	2		92	1,742	1,834	6.46	Drilling centre to be newly constructed in Solwezi. 3 drilling teams.
Western	(1)*		36	1,058	1,094	-	Existing drilling centre in Mongu to be utilised. 2 drilling teams.
Southern	(2)*		315	3,516	3,831	-	Existing drilling centre in Monze to be utilised. 5 drilling teams.
Luapula	2		79	2,068	2,147	6.46	Drilling centre to be newly constructed in Mansa. 3 drilling teams.
Northern	3		221	3,546	3,767	.57	Drilling centre to be newly constructed in Kasama. 5 drilling teams.
Eastern	4	120	286	4,970	5,376	12.69	Drilling centre to be newly constructed in Chipata. 6 drilling teams.
<Total>	13 (8)*	170	1,281	22,528	23,979	55.04	

(Note) * : Number of existing drilling rigs

Table 4-8 Groundwater Development Training Centre Project

1. Objectives	- Training of technicians for groundwater development to implement groundwater development projects proposed in the Master Plan. - Target trainees are hydrogeologists, drilling engineers, mechanics, and staff for extension services in rural areas
2. Location	- Lusaka City - Groundwater Development Training Centre and Drilling Centre of Lusaka Province should be located in the same place
3. Size	Total Land Area: 10,000 m^2 Total Building Area: 3,000 m^2, 2 rigs
4. Main Facilities	Training Rooms, Auditorium, Conference Room, Audio-visual Room, Computer Room, Dormitory, Workshop
5. Implementation Schedule	Phase 1: construction and establishment, initial training by consultants (3 years) Phase 2: technical transfer from foreign experts (5 years) Phase 3: training by Zambian trainers (after technical transfer)
6. Project Cost for Phase 1	- Construction: US$ 13.40 million - Initial Training: US$ 3.00 million - Operation and Maintenance: US$ 100,000/year

4.3 Projects for Agriculture, Livestock and Fishery

(1) Water Requirement for Agricultural Sector

Of the three scenarios, the largest amount of agricultural water requirement is projected in the Base Scenario-Industrialisation, resulting in newly developed water demand of 7.45 million m^3/day. This is caused by the largest increase in water requirement for fishery to meet the demand of fish products for the largest population increase projected in this scenario. Irrigation water shares the largest proportion of 71 % of the total agricultural water requirement. Refer to Table 4-9.

Table 4-9 Total Water Requirement of Agricultural Sector

(Unit : 1,000 m^3/day)

Items	Base Scenario Agricultural Expansion				Base Scenario Industrialisation				Conservative Scenario			
	Irri.	Fish.	Lvst.	Total	Irri.	Fish.	Lvst.	Total	Irri.	Fish.	Lvst.	Total
Present (1993)	4,581	117	129	4,827	4,581	117	129	4,827	4,581	117	129	4,827
Demand(2015)	9,837	2,131	224	12,192	9,235	2,793	250	12,278	7,881	1,648	202	9,731
Newly Develop	5,256	2,014	95	7,365	4,654	2,676	121	7,451	3,300	1,531	73	4,904

(2) Irrigation Projects

Irrigation projects can be divided into ASIP rehabilitation projects, expansion projects of existing irrigation and new development projects, as shown in Table 4-10. Dam development projects for the single purpose of irrigation are outlined in Table 4-11.

Table 4-10 Outline of Irrigation Projects

ASIP Rehabilitation Projects	Expansion Projects of Existing Irrigation	New Development Projects
- Contents: rehabilitation of existing irrigation scheme for smallholding farmers proposed in ASIP, simple rehabilitation, such as that of damaged pumps or pipelines, through which the whole function of disordered irrigation schemes will be recovered at low cost - No. of Projects: 9 (267 ha) - Project Scale: all small - Target Crop: vegetable	- Contents: expansion of existing irrigation mainly managed by commercial farmers. - No. of Projects: 21 (16,484 ha) - Project Scale: 5 large projects (13,340 ha) 5 medium projects (2,869 ha) 11 small projects (275 ha) - Target Crops: sugarcane, coffee and wheat, etc., large scale plantation of each crop	- Contents: projects in selected areas from potential areas, vegetable cultivation in suburbs using water from dam reservoir, or cropping of wheat, ground nuts, and fruits with direct water intake. - No. of Projects: 18 (44,070ha) Run-off-river; 13 (29,000 ha) multi-purpose dam; 3 (6,590 ha) (Chongwe, Kafubu, Mutundu) irrigation dam; 2 (8,480 ha) (Refer to Table 4-11)

Table 4-11 Outline of Irrigation Dams

Items	Lufubu Dam	Lundazi Dam
(1) Dam Site	50 km north-north-east of Mansa, 60 km south-east of Mwense	30 km north-west of Lundazi, 100 km south-south-east of Chipata
(2) Dam Type	Fill type	Fill type
(3) Dam Height	28.4 m	35.0 m
(4) Dam Volume	410,000 m^3	428,000 m^3
(5) Irrigation Plan - Area Developed - Irrigation Method - Irrigation Water	 7,000 ha (Luapula Province) Gravitational Irrigation 605,000 m3/day (7.00 m^3/s)	 1,480 ha (Eastern Province) Gravitational Irrigation 128,000 m3/day (1.48 m^3/s)

Area distribution of irrigation projects by province is given in Table 4-12. The largest irrigated area of 60,821 ha requiring 5.25 million m^3/day of developed water is planned in the Base Scenario-Agricultural Expansion.

Table 4-12 Irrigation Development Plan

Project	Base Scenario Agricultural Expansion		Base Scenario Industrialisation		Conservative Scenario	
	Irrigation Area (ha)		Irrigation Area (ha)		Irrigation Area (ha)	
	(2005)	(2015)	(2005)	(2015)	(2005)	(2015)
Lusaka Prov.	2,720	2,720	2,720	2,720	2,720	2,720
Chongwe Dam	810	810	810	810	810	810
ASIP Rehabilitation	10	10	10	10	10	10
Expansion Project	1,900	1,900	1,900	1,900	1,900	1,900
Copperbelt Prov.	4,340	10,120	4,340	8,850	4,340	10,700
Kafubu Dam	-	4,220	-	3,470	-	4460
Mutundu Dam	-	1,560	-	1,040	-	1900
ASIP Rehabilitation	140	140	140	140	140	140
Expansion Project	4,200	4,200	4,200	4,200	4,200	4,200
Central Prov.	5,000	5,000	5,000	5,000	0	0
New Project : P-1	5,000	5,000	5,000	5,000	0	0
Northwest Prov.	2,590	6,590	2,590	3,590	290	2,590
Expansion Project	290	290	290	290	290	290
New Project : P-79	-	1,000	-	1,000	0	0
New Project : P-80	2,300	2,300	2,300	2,300	0	2,300
New Project : P-82	-	3,000	-	0	0	0
Western Prov.	2,510	7,010	2,510	6,010	10	3,510
Expansion Project	10	10	10	10	10	10
New Project : P-16	1,000	1,000	1,000	1,000	0	1,000
New Project : P-23	1,500	3,000	1,500	3,000	0	2,500
New Project : P-84	-	1,000	-	1,000	0	0
New Project : P-86	-	1,000	-	0	0	0
New Project : P-88	-	1,000	-	1,000	0	0
Southern Prov.	8,539	8,539	8,539	8,539	8,539	8,539
ASIP Rehabilitation	89	89	89	89	89	89
Expansion Project	8,450	8,450	8,450	8,450	8,450	8,450
Luapula Prov.	3,144	12,144	3,144	12,144	0	3,144
Lufubu Dam		7,000		7,000	0	0
Expansion Project	1,144	1,144	1,144	1,144	0	1,144
New Project : P-37	2,000	2,000	2,000	2,000	0	2,000
New Project : P-45		2,000		2,000	0	0
Northern Prov.	2,190	7,190	490	5,490	490	5,490
Expansion Project	490	490	490	490	490	490
New Project : P-52	1,700	1,700	0	0	0	0
New Project : P-65	-	5,000	-	5,000	0	5,000
Eastern Prov.	28	1,508	28	1,508	28	1,508
Lundazi Dam	-	1,480	-	1,480	-	1,480
ASIP Rehabilitation	28	28	28	28	28	28
Total	32,061	60,821	29,361	53,851	16,417	38,201

(3) Aqua-cultural Projects

Since aqua-cultural development is planned to attain the production to meet the target per capita fish consumption of 12 kg/capita/year in all of the three scenarios, the largest amount of developed water will be required in Base Scenario-Industrialisation. In that scenario, 38,760 ha of fish ponds are planned to be constructed by 2015. In the Base Scenario-Agricultural Expansion, fish pond development will amount to 29,210 ha. Large scale fish ponds are planned to be developed in the Kafue Flood Plain in Southern Province and along

the Luangwa River in Eastern Province. Required areas in the Base Scenario-Industrialisation case are 15,875 ha and 8,000 ha, respectively, as shown in Table 4-13. These large scale projects will enable effective and efficient use of water which uselessly evaporates from Kafue Flood Plains, and of lands with heavy clayey soil unsuitable for cultivation along the Luangwa River.

Table 4-13 Projects for Fish Pond Development

Project	Base Scenario Agricultural Expansion	Base Scenario Industrialisation	Conservative Scenario
Lusaka Prov.	no project	no project	no project
Copperbelt Prov. P-2 : Luswishi	-Area developed : 1,200 ha -Source : Luswishi R. -Inlet : head works, pump -Water developed: 80,000 m^3/day	same as Base Scenario-Agricultural Expansion	same as Base Scenario-Agricultural Expansion
Central Prov. P-1 Machiya	-Area developed : 1,400 ha -Source : Kafue R. -Inlet : head works, pump -Water developed: 98,000 m^3/day	same as Base Scenario-Agricultural Expansion	same as Base Scenario-Agricultural Expansion
North-western Prov. Dispersed Small Scale Development	-Area developed : 3,690 ha -Source : tributary of Kabompo R. -Inlet : small diversion weir, small pump -Water developed: 245,000 m^3/day (36 locations)	-Area developed : 4,140 ha -Source : tributary of Kabompo R. -Inlet : small diversion weir, small pump -Water developed: 275,000 m^3/day (42 locations)	-Area developed : 3,340 ha -Source : tributary of Kabompo R -Inlet : small diversion weir, small pump -Water developed: 222,000 m^3/day (34 locations)
Western Prov. Dispersed Small Scale Development (Sushanjo : the plateau along the Barotse Flood Plain)	-Area developed : 1,140 ha -Source : seepage water from Plateau -Water developed: 79,000 m^3/day (114 locations)	-Area developed : 1,790 ha -Source : seepage water from Plateau -Water developed: 124,000 m^3/day (179 locations)	-Area developed : 690 ha -Source : seepage water from Plateau -Water developed: 48,000 m^3/day (69 locations)
Southern Prov. Large Scale Project at Kafue Flood Plain	-Area developed : 8,425 ha -Source : evaporation from Kafue Flood Plain -Inlet : Gravity -Water developed: 582,000 m^3/day	-Area developed : 15,875 ha -Source : evaporation from Kafue Flood Plain -Inlet : Gravity -Water developed: 1,097,000 m^3/day	-Area developed : 4,325 ha -Source : evaporation from Kafue Flood Plain -Inlet : Gravity -Water developed: 299,000 m^3/day
Luapula Prov. P-43 Samfya P-44 Lake Bangweulu	-Area developed : 4,105 ha -Source : evaporation from Lake Bangweulu -Inlet : Gravity -Water developed: 273,000 m^3/day	same as Base Scenario-Agricultural Expansion	same as Base Scenario-Agricultural Expansion
Northern Prov. P-64 Mutale Mokonge P-66 Chamdamali	-Area developed : 225 ha 2,000 ha -Source : Lubansenshi R., upstream of Chambeshi R. -Inlet : head works , pump -Water developed: 150,000 m^3/day	same as Base Scenario-Agricultural Expansion	same as Base Scenario-Agricultural Expansion
Eastern Prov. P-70 Luangwa River	-Area developed : 7,000 ha -Source : Luangwa R. -Inlet : head works , pump -Water developed: 508,000 m^3/day	-Area developed : 8,000 ha -Source : Luangwa R. -Inlet : head works , pump -Water developed: 581,000 m^3/day	-Area developed : 5,000 ha -Source : Luangwa R. -Inlet : head works , pump -Water developed: 363,000 m^3/day
Area developed Water developed	29,210 ha 2,014,000 m^3/day (23.3 m^3/s)	38,760 ha 2,677,000 m^3/day (30.0 m^3/s)	22,310 ha 1,532,000 m^3/day (17.7 m^3/s)

(4) Livestock Breeding

Livestock projects in all the scenarios are planned to maintain the present consumption level of livestock products, such as 14.2 kg/capita/year of meat. While Southern Province has already resulted in over-grazing, the northern region such as Chambeshi Flood Plain still remains suitable for grazing and is not fully used. Thus the target of livestock breeding is set as the expansion in the northern region in order to attain stable and sustainable development. Each project is proposed based on the cattle distribution plan, according to the potential of available lands, as shown in Table 4-14

Table 4-14 Water to be Developed for Livestock in 2015

Province	Present (1990)		Base Scenario Agricultural Expansion		Base Scenario Industrialisation		Conservative Scenario	
	Cattle (1000 heads)	Water Developed (1000m³/day)	Cattle (1000 heads)	Water Developed (1000m³/day)	Cattle (1000 heads)	Water Developed (1000m³/day)	Cattle (1000 heads)	Water Developed (1000m³/day)
Lusaka	88	4.5	168	8.4	179	9.0	155	7.7
Copperbelt	74	4.3	163	8.8	182	9.9	146	7.9
Central	504	22.3	683	31.0	683	31.4	683	30.7
N/Western	59	2.8	359	15.2	491	20.6	280	11.9
Western	547	22.6	1,090	44.9	1,179	48.7	998	41.1
Southern	1,053	50.2	916	50.0	916	51.6	916	48.9
Luapula	12	1.2	133	6.7	190	9.1	100	5.2
Northern	108	5.4	592	25.8	800	34.5	465	20.5
Eastern	224	15.7	499	31.6	562	35.6	446	28.5
Total	2,669	129.0	4,603	222.4	5,182	250.4	4,189	202.4

4.4 Estimation of Construction Costs

Construction costs of proposed projects are estimated using January 1995 prices. Foreign exchange rate at that time was 610 Kwacha for one US Dollar. Estimated costs show the approximate scale of projects, including direct construction and engineering services costs, but excluding land acquisition and contingency costs.

(1) Water Supply Projects

Direct construction cost comprises source development cost (dam or borehole cost), conveyance facility cost, treatment facility cost, and cost for distribution facilities. Total construction cost in the Base Scenario - Agricultural Expansion (middle population projection) amounts to US$ 1,010 million for 1.048 million m^3/day of developed water, equivalent to unit cost for 1,000 m^3/day of US$ 964 thousand or US$ 89.3 million /m^3/sec. Large urban areas account for US$ 648 million, or 64% of the total construction cost, while small urban areas account US$ 153 million, or 15%, and rural areas account for US$ 209 million, or 21%. Water supply projects in Lusaka are estimated to cost US$ 447.6 million. Refer to Tables 4-15 and 4-16.

Table 4-15 Construction Cost of Water Supply Projects

Province	Lusaka	Copperbelt	Central	NWestern	Western	Southern	Luapula	Northern	Eastern	<Total>
Base Scenario- Agricultural Expansion										
Large Urban Area										
Water Dvlp.	520,000	100,000	57,000	-	-	20,000	-	14,000	12,000	723,000
Cost	447.58	112.55	43.46	-	-	20.58	-	12.65	11.04	647.86
Unit Price	861	1,126	762	-	-	1,029	-	904	920	896
Small Urban Area										
Water Dvlp.	24,560	5,818	13,590	14,820	22,578	27,060	15,374	19,326	12,782	155,908
Cost	27.70	3.66	13.32	18.24	18.55	25.23	15.80	16.25	14.28	153.03
Unit Price	1,128	629	980	1,231	822	932	1,028	841	1,117	982
Rural Area										
Water Dvlp.	8,176	12,780	21,256	13,066	7,936	26,372	15,512	26,596	32,276	163,970
Cost	10.14	15.85	26.36	16.20	9.84	32.70	19.23	32.98	46.22	209.52
Unit Price	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,432	1,278
Total										
Water Dvlp.	552,736	118,598	91,846	27,886	30,514	73,432	30,886	59,922	62,058	1,047,878
Cost	485.42	132.06	83.14	34.44	28.39	78.51	35.03	61.88	71.54	1010.41
Unit Price	878	1,114	905	1,235	930	1,069	1,134	1,033	1,254	969
Base Scenario- Industrialisation										
Large Urban Area										
Water Dvlp.	720,000	210,000	80,000	-	-	30,000	-	35,000	20,000	1,095,000
Cost	562.70	191.67	55.62	-	-	25.92	-	23.99	18.19	878.09
Unit Price	782	913	695	-	-	864	-	685	910	802
Small Urban Area										
Water Dvlp.	64,028	15,512	31,390	44,220	40,756	62,073	34,270	36,988	24,030	353,267
Cost	56.00	10.07	32.38	45.79	31.01	56.69	32.76	31.66	26.68	323.04
Unit Price	875	649	1,032	1,036	761	913	956	856	1,110	914
Rural Area										
Water Dvlp.	3,892	13,470	21,923	11,460	7,298	25,935	15,188	26,603	38,565	164,334
Cost	4.83	16.70	27.18	14.21	9.05	32.16	18.83	32.99	47.82	203.77
Unit Price	1,241	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240
Total										
Water Dvlp.	787,920	238,982	133,313	55,680	48,054	118,008	49,458	98,591	82,595	1,612,601
Cost	623.53	218.44	115.18	60.00	40.06	114.77	51.59	88.64	92.69	1404.90
Unit Price	991	914	864	1,078	834	973	1,043	899	1,122	871
Conservative Scenario										
Large Urban Area										
Water Dvlp.	420,000	51,000	45,000	-	-	16,000	-	10,000	9,000	551,000
Cost	387.82	55.28	37.44	-	-	18.50	-	10.47	8.83	518.34
Unit Price	923	1,084	832	-	-	1,156	-	1,047	981	941
Small Urban Area										
Water Dvlp.	14,276	3,542	9,390	10,220	14,864	14,170	11,836	14,850	9,878	103,026
Cost	20.37	2.12	9.14	13.22	12.92	13.62	12.70	12.27	11.11	107.47
Unit Price	1,427	599	973	1,294	869	961	1,073	826	1,125	1,043
Rural Area										
Water Dvlp.	7,275	11,100	18,975	11,693	4,958	23,130	13,860	23,888	33,390	148,269
Cost	9.02	13.76	23.53	14.50	6.15	28.68	17.19	29.62	41.40	183.85
Unit Price	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240
Total										
Water Dvlp.	441,551	65,642	73,365	21,913	19,822	53,300	25,696	48,738	52,268	802,295
Cost	417.21	71.16	70.11	27.72	19.07	60.80	29.89	52.36	61.34	809.66
Unit Price	945	1,084	956	1,265	962	1,141	1,163	1,078	1,174	1,009

(Note) Water Dvlp. = Amount of Water Developed in m^3/day, Cost = Construction Cost in US$ million,
Unit Price = Unit Price of Water Developed in US$/ m^3/day

Table 4-16 Construction Cost for Large Urban Water Supply

	Base Scenario Agricultural Expansion			Base Scenario Industrialisation			Conservative Scenario		
	Water Dvlp. (m^3/day)	Cost (US$million)	Unit Price (US$/$m^3$/day)	Water Dvlp. (m^3/day)	Cost (US$million)	Unit Price (US$/$m^3$/day)	Water Dvlp. (m^3/day)	Cost (US$million)	Unit Price (US$/$m^3$/day)
Lusaka Well	20,000	15.75	788	Same as Agricultural Expansion			Same as Agricultural Expansion		
Chongwe Dam	100,000	109.87	1,099	Same as Agricultural Expansion			Same as Agricultural Expansion		
Kafue Pipe Line	400,000	321.96	805	600,000	437.08	728	300,000	262.20	874
- Phase-1	100,000	87.40	874	150,000	117.28	782	100,000	87.40	874
- Phase-2	150,000	117.28	782	150,000	117.28	782	100,000	87.40	874
- Phase-3	150,000	117.28	782	300,000	202.52	675	100,000	87.40	874
<Lusaka Total>	520,000	447.58	861	720,000	562.27	782	420,000	387.82	923
Ndola	60,000	53.50	892	110,000	86.85	790	45,000	41.54	923
Luanshya	5,000	8.80	1,760	20,000	18.51	926	no project		
Kitwe	20,000	22.99	1,150	50,000	46.64	933	no project		
Kalulushi	10,000	17.63	1,763	15,000	21.75	1,450	6,000	13.74	2,290
Mufulira	5,000	9.63	1,926	15,000	17.92	1,195	no project		
Kabwe	57,000	43.46	762	80,000	55.62	695	45,000	37.44	832
- Phase-1	19,500	16.82	863	27,000	21.26	787	15,000	14.43	962
- Phase-2	37,500	26.64	710	53,000	34.36	648	30,000	23.01	767
Livingstone	20,000	20.58	1,029	30,000	25.92	864	16,000	18.50	1,156
- Phase-1	10,000	10.29	1,029	15,000	12.96	864	8,000	9.25	1,156
- Phase-2	10,000	10.29	1,029	15,000	12.96	864	8,000	9.25	1,156
Kasama	14,000	12.65	904	35,000	3.99	114	10,000	10.47	1,047
Chipata	12,000	11.04	920	20,000	18.19	909	9,000	8.83	981
< Total >	723,000	647.86	896	1,095,000	878.09	784	551,000	518.34	941

(2) Agricultural Projects

Total construction cost of agricultural projects amounts to US$ 1,516 million in the Base Scenario-Agricultural Expansion, comprising US$ 1,190 million (79%) for irrigation, US$ 290 million (19%) for aqua-culture and US$ 36 million (2%) for livestock breeding. Total construction cost in the Base Scenario-Industrialisation and in the Conservative Scenario are US$ 1,375 million and US$ 1,022 million, respectively, or 91% and 68%, compared to that in the Base Scenario-Agricultural Expansion.

Direct construction cost of irrigation projects includes those for source development (dam or diversion weir), conveyance facility (pump, pipeline), land consolidation (new reclamation or improvement of existing farm) and terminal irrigation facility (furrow or sprinkler). That for aqua-culture comprises costs for source development (diversion weir), conveyance facility (pump), and fish pond construction.

Unit costs of irrigation projects for land area and water are US$ 19,600 /ha and US$ 226 /m^3/day in the Base Scenario-Agricultural Expansion. Those for aqua-cultural projects in the same case are US$ 9,930 /ha and US$ 119 /m^3/day, respectively.

Livestock breeding requires stable good quality water supply in the dry season. Dispersed water demand occurs because herds of cattle are widely distributed. For this reason, groundwater is the most suitable source. Water supply for cattle breeding is planned using borehole construction, and the unit cost amounts to US$ 161 /m^3/day.

Table 4-17 Construction Cost of Agricultural Projects

(Unit: US$ million)

Province	Base Scenario Agricultural Expansion			Base Scenario Industrialisation			Conservative Scenario		
	Irrigation	Aqua-culture	Livestock	Irrigation	Aqua-culture	Livestock	Irrigation	Aqua-culture	Livestock
Lusaka	73.47	0.00	1.35	73.47	0.00	1.45	73.47	0.00	1.24
Copperbelt	230.67	14.04	1.42	190.42	14.04	1.59	247.00	14.04	1.28
Central	103.40	16.38	4.98	103.40	16.38	5.04	0.00	16.38	4.93
N/Western	203.36	43.17	2.44	50.57	48.44	3.32	35.99	39.08	1.92
Western	103.39	10.49	7.22	87.33	16.47	7.82	48.72	6.35	6.61
Southern	177.54	77.51	8.04	177.54	146.05	8.30	177.54	39.79	7.86
Luapula	132.77	37.77	1.07	132.77	37.77	1.47	39.95	37.77	0.84
Northern	138.49	26.32	4.15	113.71	26.32	5.54	113.71	26.33	3.29
Eastern	26.90	64.40	5.09	26.90	73.60	5.73	26.90	46.00	4.58
Total	1,189.98	290.08	35.75	956.10	379.07	40.25	763.27	225.74	32.54
	1,515.81			1,375.42			1,021.55		

Table 4-18 Unit Construction and Water Cost of Agricultural Projects

	Base Scenario Agricultural Expansion	Base Scenario Industrialisation	Conservative Scenario
(1) Irrigation Projects			
- Irrigated Area (ha)	60,821	53,851	38,201
- Irrigated Water (1000m^3/day)	5,256	4,654	3,300
- Const. Cost (US$ million)	1,189.98	956.10	763.27
- Unit Const. Cost (US$/ha)	19,600	17,700	20,000
- Unit Water Cost (US$/m3/day)	226	205	231
(2) Aqua-cultural Projects			
- Fish Pond Development (ha)	29,210	38,760	22,310
- Water Developed (1000m3/day)	2,014	2,677	1,532
- Const. Cost (US$ million)	290.08	390.07	225.74
- Unit Const. Cost (US$/ha)	9,930	10,060	10,120
- Unit Water Cost (US$/m3/day)	144	146	147
(3) Livestock Projects			
- Water Developed (1000m3/day)	222	250	202
- Const. Cost (US$ million)	35.75	40.25	32.54
- Unit Water Cost (US$/m3/day)	161	161	161

Table 4-19 Construction Cost for Irrigation Projects

Province	Base Scenario-Agricultural Expansion			Base Scenario-Industrialisation			Conservative Scenario		
	Dvlp. Water ($1000m^3$/day)	Const. Cost (Mil.us$)	Unit Price (us$/m3/day)	Dvlp. Water ($1000m^3$/day)	Const. Cost (Mil.us$)	Unit Price (us$/m3/day)	Dvlp. Water ($1000m^3$/day)	Const. Cost (Mil.us$)	Unit Price (us$/m3/day)
Lusaka	235	73.47	312.64	235	73.47	312.64	235	73.47	312.64
Chongwe Dam	70	34.74	496.29	70	34.74	496.29	70	34.74	496.29
ASIP Rehabilitation	1	0.09	90.00	1	0.09	90.00	1	0.09	90.00
Extension Project	164	38.64	235.61	164	38.64	235.61	164	38.64	235.61
Copperbelt	874	230.67	263.92	765	190.42	248.92	924	247.00	267.32
Kafubu Dam	365	103.49	283.53	300	83.85	279.50	385	107.78	279.95
Mutundu Dam	135	60.09	445.11	90	39.48	438.67	164	72.13	439.82
ASIP Rehabilitation	12	3.27	272.50	12	3.27	272.50	12	3.27	272.50
Extension Project	363	63.82	175.81	363	63.82	175.81	363	63.82	175.81
Central	432	103.40	239.35	432	103.40	239.35	0	0.00	0.00
New Project P-1	432	103.40	239.35	432	103.40	239.35	0	0.00	0.00
Northwestern	569	203.36	357.40	310	50.57	163.13	224	35.99	160.67
Extension Project	25	2.46	98.40	25	2.46	98.40	25	2.46	98.40
New Project P-79	86	14.58	169.53	86	14.58	169.53	0	0.00	0.00
P-80	199	33.53	168.49	199	33.53	168.49	199	33.53	168.49
P-82	259	152.79	589.92	0	0.00	0.00	0	0.00	0.00
Western	606	103.39	170.61	519	87.33	168.27	303	48.72	160.79
Extension Project	1	0.21	210.00	1	0.21	210.00	1	0.21	210.00
New Project P-16	86	16.06	186.74	86	16.06	186.74	86	16.06	186.74
P-23	261	38.94	149.20	261	38.94	149.20	216	32.45	150.23
P-84	86	16.06	186.74	86	16.06	186.74	0	0.00	0.00
P-86	86	16.06	186.74	0	0.00	0.00	0	0.00	0.00
P-88	86	16.06	186.74	86	16.06	186.74	0	0.00	0.00
Southern	738	177.54	240.57	738	177.54	240.57	738	177.54	240.57
ASIP Rehabilitation	8	2.42	302.50	8	2.42	302.50	8	2.42	302.50
Extension Project	730	175.12	239.89	730	175.12	239.89	730	175.12	239.89
Luapula	1,050	132.77	126.45	1,050	132.77	126.45	272	39.95	146.88
Lufubu Dam	605	56.94	94.15	605	56.94	94.15	0	0.00	0.00
Extension Project	99	10.8	109.09	99	10.8	109.09	99	10.8	109.09
New Project P-37	173	29.15	168.50	173	29.15	168.50	173	29.15	168.50
P-45	173	35.86	207.28	173	35.86	207.28	0	0.00	0.00
Northern	621	138.49	223.01	474	113.71	239.89	474	113.71	239.89
Extension Project	42	10.305	245.36	42	10.305	245.36	42	10.31	245.48
New Project P-52	147	24.78	168.57	0	0.00	0.00	0	0.00	0.00
P-65	432	103.4	239.35	432	103.4	239.35	432	103.4	239.35
Eastern	130	26.90	206.92	130	26.90	206.92	130	26.90	206.92
Lundazi Dam	128	26.13	204.14	128	26.13	204.14	128	26.13	204.14
ASIP Rehabilitation	2	0.77	385.00	2	0.77	385.00	2	0.77	385.00
Total	5,256	1,189.98	226.40	4,564	956.10	205.44	3,300	763.28	231.30

4.5 Implementation Schedule of Projects

(1) Water Supply Projects

Implementation schedule of water supply projects for domestic and industrial use in the Base Scenario-Agricultural Expansion is shown as an example in Table 4-20. The most urgent large urban water supply projects, to be implemented during the first five years, are two projects in Lusaka (Northern Lusaka Production Well Project and Chongwe Dam Project) and phase-1 of two Extension Projects in Kabwe and Livingstone. The next most urgent projects, to be implemented in the following five years, are phase-1 of Kafue Pipeline Project, phase-2 of Livingstone Extension Project, Kasama Extension Project, and Chipata Production Well Project. Other projects are to be implemented during the latter ten years.

Many projects for small urban areas should be implemented in the ten years to 2005, because of the present low service coverage in small towns. For rural water supply projects, the preparatory works, such as procurement of boring equipment and facilities, and training of staff, mean that smaller numbers of projects are planned to be implemented in the first five years. Later, projects are to be implemented at a constant pace.

Table 4-20 Implementation Schedule of Water Supply Projects

(Base Scenario - Agricultural Expansion)

Project Name	Water Developed (m^3/day)	Const. Cost (mil. us$)	Implementation Schedule																			
			'96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
<Large Urban Area>																						
Northern Lusaka Well Project	20,000	15.70	--	--	--																	
Lusaka (Chongwe Dam)	100,000	109.87			--	--	--															
Lusaka (Kafue Pipeline Project)	400,000	321.96								--	--	--			--	--	--			--	--	--
Ndola (Kafubu Dam)	60,000	53.50													--	--	--					
Luanshya (Kafubu Dam)	5,000	8.80													--	--	--					
Kitwe (Mutundu Dam)	20,000	20.58													--	--	--					
Kalulushi (Mutundu Dam)	10,000	17.63													--	--	--					
Mufulira (Mutundu Dam)	5,000	9.63													--	--	--					
Kabwe (Expansion)	57,000	43.46			--	--	--								--	--	--					
Livingstone (Expansion)	20,000	20.58				--	--				--	--										
Kasama (Expansion)	14,000	12.65									--	--										
Chipata Well Project	12,000	11.04									--	--										
(5 year Progress Rate)	723,000	647,000	22%					23%					34%					21%				
<Small Urban Area>																						
(5 year Progress Rate)	155,908	153.03	50%					26%					17%					7%				
<Rural Area>																						
(5 year Progress Rate)	168,970	209.52	18%					26%					28%					28%				
<Promotion Project for G/W Development>																						
Dring Center		(41.64)	--	--	--	--	--	--	--	--	--	--										
G/W/D Training C		(16.40)	--	--	--																	

(2) Agricultural Projects

Implementation schedules for irrigation projects, fish pond development projects, and livestock projects are shown in Tables 4-21, 4-22, 4-23, respectively. Irrigated area is planned in accordance with the Value Added of the sector and projected demands for agricultural products. For the years up to 2000, however, implementation priority is given to the ASIP rehabilitation projects and the expansion projects. New development projects are planned to be implemented after 2000, with the exceptions of the Chongwe Dam Project and the Zambezi Left Bank Flood Plain Development Project. Dam development is planned to commence after 2005 because of the required period for training of technical staff for the design and operation.

Table 4-21 Implementation Schedule of Irrigation Development Projects

(Base Scenario-Agricultural Expansion)

Project	Irrigation Area (ha)	Const. Cost (Mil.us$)	Implementation Schedle																		
			'96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Lusaka Prov.	2,720	73.47																				
- Chongwe Dam	810	34.74			--	--	--															
- ASIP Rehabilitation	10	0.09		--																		
- Expansion Project	1,900	38.64						--	--	--	--	--										
Copperbelt Prov.	10,120	230.67																				
- Kafubu Dam	4,220	103.49													--	--	--					
- Mutundu Dam	1,560	60.09													--	--	--					
- ASIP Rehabilitation	140	3.27			--																	
- Expansion Project	4,200	63.82	--	--	--	--	--	--	--	--	--	--										
Central Prov.	5,000	103.40																				
- New Project : P-1	5,000	103.40								--	--	--										
North western Prov.	6,590	203.36																				
- Expansion Project	290	2.46			--	--	--															
- New Project : P-79	1,000	14.58											--	--	--							
- New Project : P-80	2,300	33.53						--	--	--												
- New Project : P-82	3,000	152.79																--	--	--		
Western Prov.	7,010	103.39																				
- Expansion Project	10	0.21			--																	
- New Project : P-16	1,000	16.06						--	--	--												
- New Project : P-23	3,000	38.94			--	--	--						--	--	--							
- New Project : P-84	1,000	16.06												--	--	--						
- New Project : P-86	1,000	16.06															--	--	--			
- New Project : P-88	1,000	16.06																		--	--	--
Southern Prov.	8,539	177.54																				
- ASIP Rehabilitation	89	2.42				--																
- Expansion Project	8,450	175.12	--	--	--	--	--	--	--	--	--	--										
Luapula Prov.	12,144	132.77																				
- Lufubu Dam	7,000	56.96														--	--	--				
- Expansion Project	1,144	10.80				--	--	--														
- New Project : P-37	2,000	29.15						--	--	--												
- New Project : P-45	2,000	35.86											--	--	--							
Northern Prov.	7,190	138.49																				
- Expansion Project	490	10.31						--	--	--	--	--										
- New Project : P-52	1,700	24.78						--	--	--												
- New Project : P-65	5,000	103.40														--	--	--				
Eastern Prov.	1,508	26.90																				
- Lundazi Dam	1,480	26.13											--	--	--							
- ASIP Rehabilitation	28	0.77					--															
Total	60,821	1,189.98	16%					25%					40%					19%				

Fish pond development is planned by determining the ponds required according to the balance between the demand and supply by capture fishery in each province. However, in the case of Lusaka, whose potential for aqua-culture is low and demands are quite large, supply after 2005 is planned from large scale fish pond developments in the Kafue Flood Plain. Eastern Province will achieve self-supply of fish products after the completion of the large scale fish pond development along the Luangwa River in 2011.

The number of livestock is planned to increase according to the population growth projected in each scenario. Regionally, in Southern Province, however, the number of cattle is planned to decrease because of the present over-grazing. Number of cattle in other provinces are distributed corresponding to the potential of the area.

Table 4-22 Implementation Schedule of Fish Pond Development Projects

(Base Scenario-Agricultural Expansion)

Project	Fish Pond Area (ha)	Const. Cost (Mi.us$)	Implementation Schdule																	
			'96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Lusaka Prov.	-	-																				
Copperbelt Prov.	1,200	14.04																				
- P-2 Luswishi	1,200	14.04			--	--	--															
Central Prov.	1,400	16.38																				
- New Project : P-1	1,400	16.38								--	--	--										
N/western Prov.	3,690	43.17																				
- Dispersed Small Scale Development	3,690	43.17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Western Prov.	1,140	10.49																				
- Dispersed Small Scale Development	1,140	10.49	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Southern Prov.	8,425	77.51																				
- Project at Kafue Flood Plain	8,425	77.51											--	--	--				--	--	--	
Luapula Prov.	4,105	37.77																				
- P-43 : Samfya	2,000	18.40						--	--	--												
- P-44 : Bangweulu	2,105	19.37			--	--	--															
Northern Prov.	2,250	26.32																				
- P-64 : Mutale Mokonge	250	2.92											--	--	--							
- P-66 : Chamdamali	2,000	23.40						--	--	--												
Eastern Prov.	7,000	64.40																				
- P-70 : Luangwa	7,000	64.40														--	--	--				
Total	29,210	290.08	16%					19%					40%						25%			

Table 4-23 Implementation Schedule of Livestock Projects

(Base Scenario-Agricultural Expansion)

Project	Water Dev. (1000m³/day)	Const.Cost (Mil.us$)	Implementation Schedule																	
			'96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Lusaka Province	6.92	1.35	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Copperbelt Province	7.00	1.42	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Central Province	30.39	4.98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
N/western Province	9.03	2.44	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Western Province	36.71	7.22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Southern Province	47.74	8.04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Luapula Province	3.90	1.07	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Northern Province	15.78	4.15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eastern Province	25.14	5.09	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	182.61	35.75	25%					30%					25%						20%			

4.6 Project Evaluation

(1) Economic Evaluation of Proposed Projects

The economic value of Master Plan projects is assessed by the rates of economic efficiency at which the present value of both economic costs and economic benefits equalise over the project life. For economic evaluation, Economic Internal Rates of Return (EIRR) of respective projects are calculated to verify economic viability in the national economy. In calculation of other economic indices such as Net Present Value (NPV) and Benefit-Cost Ratio (B/C), costs and benefits are discounted at the rate of 10% for the respective project lives. In estimating the economic cost and benefit, the economic values are estimated applying the following conditions and assumptions for every sector related to water.

1) Foreign exchange rate was set at K610 to US$ 1.00 in accordance with the official exchange rate at the time.
2) Economic values are estimated to be 90% of total financial values in the case of including both local and foreign portions.
3) Costs and benefits are discounted to calculate NPV at the rate of 10%.
4) The economic life of the projects is taken as 50 years for water supply facilities. However, the life of some mechanical facilities is considered as 20 years, as they would be replaced within the main economic life.

(a) Water Supply Projects

The basic economic benefit from water supply schemes is based on the maximum affordable value. It is generally adopted as 3 to 5 per cent of household income. In this master plan study, the benefit for water supply system are estimated to be 5% of income for domestic water supply schemes. For municipal and industrial use, economic benefit is also based on the maximum affordable payment for water. The rate of maximum affordable value for water is assumed to be 3%. The financial construction costs of the proposed projects were converted to economic costs by making adjustments base on the conversion method. The O&M costs are required annually during the economic life of the projects from just after completion of the construction works. The O&M costs are assumed to be 5% of the total construction costs for urban water supply schemes. For rural water supply schemes, the O&M costs were estimated individually. The replacement costs are assumed to be 20% for the conveyance and treatment costs.

<u>Large Urban Areas</u>

The twelve urban systems are examined in economic efficiency through factors of NPV, B/C and EIRR. Table 4-24 shows the results of the examination. Of the 12 schemes, four schemes resulted in EIRR in excess of 10%, the opportunity cost of capital as mentioned above. They are in order of economic efficiency: Kitwe, Kasama, Luanshya and Ndola. In Lusaka City, although the economic efficiency of proposed projects is comparatively low, the implementation of the projects should be determined by also taking social factors into consideration.

Table 4-24 Economic Efficiency of Large Urban Water Supply Projects

Urban Name	Projects Name	EIRR (%)	NPV (Mil. us$)	B/C
Lusaka	Lusaka Wells	8.4	-1.9	0.90
Lusaka	Chongwe Dam	3.8	-45.9	0.61
Lusaka	Kafue Pipeline	3.7	-72.8	0.68
Ndola Township	Kafubu Dam	10.2	1.1	1.02
Mufulira	Mutondu Dam	7.4	-1.8	0.81
Kalulushi	Mutondu Dam	--	-12.1	0.37
Kitwe	Mutondu Dam	17.9	19.2	1.77
Luanshya	Kafubu Dam	12.4	1.8	1.19
Kabwe Township	Water Supply Extension	6.7	-5.3	0.82
Livingstone	Water Supply Extension	2.9	-9.3	0.57
Kasama	Water Supply Extension	14.0	4.8	1.32
Chipata	Chipata Wells	7.0	-2.8	0.77

(Note): Discounted at 10%

Small Urban Areas

For the other 80 small township schemes, the economic efficiency has also been examined. 33 townships schemes have a positive EIRR. Of the 33 townships, three townships resulted EIRR in excess of 10%, which is the border of economic feasibility. They are Choma, Monze and Zimba in Southern province. All of them are groundwater projects. It seems to be difficult to supply potable water using surface water sources because of the high water treatment costs.

Rural Areas

The economic efficiency of rural water supply was examined for each province covering all the schemes. Of the nine provinces, six provinces had a positive EIRR. They are Lusaka, Copperbelt, Central, Southern, Luapula and Eastern. Of the six provinces, two provinces of Copperbelt and Central resulted in EIRR in excess of 10%.

Consideration

Cost allocation for water supply schemes varies depending the condition of each country, ranging full cost recovery by tariff collection including capital investment to the recovery completely excluding investment cost. Although some points among the two are often chosen in fact, the full recovery should be applied in principle. This Study also applies this principle. In 1991, water tariff shared 0.57% of the household expenditure in urban areas and 0.11% in rural areas. This study applies 5% of household income of the served populace as affordable amount, as advocated by the World Bank. The gap between the principle and the fact in the country are considerably wide. This gap might have resulted from socialistic water tariff policy by the previous government, under which the tariff was kept unfairly low. Beside the benefit calculated above, water supply development will create various benefits, such as decrease in diseases or mortality caused by improved public sanitation, and raised public health standards. Further, the development will contribute to many benefits, including stabilisation of human settlements and improvement of social welfare, which are unaccountable. The implementation of water supply projects should not be discussed not only economic point of view. Implementation of important projects should be promoted, even though the projects has low economic efficiency.

(b) Agricultural Projects

The total benefit of the 48 irrigation schemes proposed in the agricultural development plan is expected to aggregate US$ 189 million per annum in economic yerms by the time all the schemes reach maturity. Project costs of the 48 irrigation schemes are estimated at US$ 1,071 million in total at economic costs. For the rehabilitation schemes, the value of existing facilities were not included in the project costs and were considered as sunk costs. All 48 irrigation scheme projects were examined for economic efficiency. Table 4-25 shows the results of the examination. Of the 48 schemes, the EIRR of 29 schemes exceeded 10%, the opportunity cost of capital. Among these 29 schemes, Chipata rehabilitation projects, EIRR: 28.7%, is the most efficient. The total EIRR of the 48 projects is 10.9%.

For fishery projects, an economic efficiency test was examined for the national total. The economic indices of EIRR, NVP and B/C were 12.7%, US$32.3 million and 1.18, respectively. Thus, the projects would be said to have high economic efficiency and to be economically viable. For livestock projects, the economic efficiency test was also examined for the national total. The indices of EIRR, NVP and Bb/C were 13.1%, US$3.9 million and 1.25 respectively.

(2) Financial Evaluation of Projects

<u>Water Supply Projects</u>

Construction cost of water supply projects are estimated for each scenario, and variation in construction cost by fluctuation of parameters, such as unit consumption rate and service coverage, is examined in Table 4-26. This Study assumes unit consumption rate for domestic use in large urban area, in small urban area and in rural areas as 180 lit./person/day, 150 lit./person/day and 35 lit./person/day respectively. However, the current unit consumption rate in Lusaka is estimated at between 130 and 150 lit/person/day. The cost variations if the unit consumption rate decreases by 10% or 20% are as shown in Table 4-24, fluctuating the industrial consumption in the same way. The result of the examination shows that 10% decrease in the amount of water developed would save 20% of the construction cost.

The coverage of the water supply services in large urban, small urban and rural areas are assumed as 100%, 100% and 75% for this Study. If the coverage rates for large urban areas, small urban areas and rural areas are changed to 100% (same), 80% and 50%, the construction cost would decrease by around 10%. The construction cost varies from US$ 1,010 million to US$ 500 million when unit consumption rate is decreased by 0% to 20% and the supply coverage changes as described above, for the Base Scenario-Agricultural Expansion (medium population projection) and the Conservative Scenario (low population projection).

The cumulative capital expenditure of the central government for water supply projects during the years up to 2015 can be estimated as US$ 630 million, assuming continuous foreign assistance and government expenditure for the sector. The ratio of estimated government capital expenditure to the construction cost is calculated as 1.6 to 0.8. The gap between the two is not so wide.

Table 4-25 Economic Efficiency of Irrigation Projects

Province	Code	Project Name	EIRR (%)	NPV (US$ Million)	B/C
Multipurpose Dam Projects					
Lusaka	D-16	Chongwe	10.5	1.75	1.05
Copperbelt	D-10	Kafubu	13.2	36.41	1.33
	D-7	Mutundu	8.8	-7.14	0.89
Irrigation Dam Project					
Luapula	D-1	Lufubu	21.3	81.84	2.44
Eastern	D-18	Lundazi	18.1	25.70	1.98
ASIP Rehabilitation					
Lusaka	N-1	Chipapa	28.7	0.25	3.64
Copperbelt	N-2	Ipafu	15.3	0.99	1.55
	O-9	Chapula	12.1	0.36	1.21
Southern	O-14	Buleya Malima	12.1	0.34	1.21
	O-15	Siatwinda	11.6	0.10	1.15
	O-21	Nakandabwe	11.3	0.04	1.13
Eastern	O-28	Makungwa	12.0	0.03	1.19
	O-30	Vuu	12.2	0.08	1.22
	O-31	Lusowe	11.3	0.04	1.13
Expansion of Existing Projects					
Lusaka	O-1	Chiawa	2.5	-0.25	0.44
	O-2	Chanyanya	2.5	-9.98	0.45
	O-3	Masstock	2.4	-12.82	0.44
	O-5	Kaunga	11.8	0.13	1.20
Copperbelt	O-6	Mpongwe (G/W)	2.4	-28.20	0.44
	O-7	Munkumpu	11.3	2.52	1.14
Northwestern	O-11	Ikelenge Pineapple	11.8	0.47	1.19
Western	I-1	Nakatoya	2.2	-0.13	0.42
Southern	N-4	Chiyabi	2.2	-0.13	0.42
	O-13	Kaleya Small Holders	--	-4.52	0.33
	O-18	Nakambala Sugar	3.2	-80.41	0.39
	O-20	Nanny	2.4	-14.62	0.44
Luapula	I-2	Mansa Pilot Scheme	2.2	-0.13	0.42
	N-5	Kenny Vegetable Scheme	10.8	0.01	1.09
	N-6	Chiposa Mubende Scheme	2.2	-0.13	0.42
	N-7	Chembe Vegetable Scheme	2.2	-0.13	0.42
	N-8	Chama Vegetable Scheme	2.2	-0.13	0.42
	O-22	Kawambwa Tea	2.4	-0.60	0.44
	O-24	Mulumbi Coffee	11.5	0.08	1.16
	O-25	Lukulu North	11.8	1.58	1.19
Northern	O-27	Kateshi Coffee	2.4	-6.30	0.44
Potential Irrigation Projects					
Central	P-1	Machiya	8.7	-13.60	0.88
Northwestern	P-79	Mwombeshi	12.7	4.31	1.28
	P-80	Mwinilunga	14.1	15.13	1.50
	P-82	Kabompo	0.6	-103.87	0.36
Western	P-16	Katima Mulilo	10.7	1.12	1.06
	P-23	Zambezi Floodplain	10.8	3.11	1.07
	P-84	Ngambwe Rapid	10.7	1.12	1.06
	P-86	Manto Rapid	10.7	1.12	1.06
	P-88	Sioma Rapid	10.7	1.12	1.06
Luapula	P-37	Mushota Island	12.7	8.64	1.28
	P-45	Luapula	10.0	0.06	1.00
Northern	P-52	Chinakila	12.7	7.34	1.28
	P-65	Chilbula South	8.7	-13.60	0.88

(Note): "--" means that EIRR marks less than zero per cent

The estimation of cumulative government capital expenditure is made based on the past record of government investment, which might be smaller than it should be. Further, if the target of economic growth is achieved as the scenarios assume, government investment will consequently grow. It would therefore be possible to secure the investment to cover the required construction cost as proposed in the Base Scenario-Agricultural Expansion and in the Conservative Scenario.

Agricultural Projects

Total construction cost for the agricultural projects will amounts to US$ 1.51 billion. Investment in agricultural projects are mainly conducted by the private sector, and public investment for the sector will be small. Past records of the private investment could not be obtained, and the estimation of cumulative investment by 2015 would be quite difficult. However, since proposed agricultural projects have high economic efficiency, the implementation of the projects would be feasible if the finances are secured.

Table 4-26 Water Demand and Construction Cost (2015)

Demand Decrease	Area	Unit Consumpt.	Service Coverage	Domestic Use	Industrial Use	Loss	Present Capacity	Water Developed	Const. Cost
		lit/per/day	%	1000m3/day	1000m3/day	1000m3/day	1000m3/day	1000m3/day	US$ million
Base Scenario - Agricultural Expansion									
0%	Large U.	180	100	810	362	293	989	1,048	1,010
	Small U.	150	100	145	85	34			(1.00)
	Rural	35	75	255	0	25			
10%	Large U.	162	100	729	326	264	989	822	792
	Small U.	135	100	131	77	31			(0.78)
	Rural	32	75	230	0	23			
10%	Large U.	162	100	729	326	264	989	706	680
	Small U.	135	80	104	77	27			(0.67)
	Rural	32	50	153	0	15			
20%	Large U.	144	100	648	290	235	989	620	598
	Small U.	120	100	116	68	28			(0.59)
	Rural	28	75	204	0	20			
20%	Large U.	144	100	648	290	235	989	519	500
	Small U.	120	80	93	68	24			(0.50)
	Rural	28	50	136	0	14			
Conservative Scenario									
0%	Large U.	180	100	738	287	256	989	802	807
	Small U.	150	100	144	77	33			(1.00)
	Rural	35	75	231	0	23			
10%	Large U.	162	100	664	258	231	989	622	626
	Small U.	135	100	130	69	30			(0.78)
	Rural	32	75	208	0	21			
10%	Large U.	162	100	664	258	231	989	514	517
	Small U.	135	80	104	69	26			(0.64)
	Rural	32	50	137	0	14			

(3) Social Evaluation

(a) Incentive to Regional Economy and Increase of Employment Opportunity

It is obvious that commencement of construction works such as water supply and irrigation projects induces regional economy to activate in the sectors related to construction works as well as construction sector itself. According to the analysis of the input-output table of Zambia in 1985, the Leontief inverse matrix showed that one unit of construction work

would induce 1.54 units of economic effects in the national economy. The regional effects could be activated by the investment in the same sense, although the regional effects could not be expected to get the same effects as the national total ones.

According to "Labour Force Survey 1986, CSO", 0.36 million or 13% of the total labour force was unemployed. Of the unemployed people, the unemployment rate for urban areas was 19.2% while that for rural areas was 10.6%. Taking into account of the economic growth of 1.2% on average during the recent eight years, it would be difficult that the present labour market was improved more than that in 1986.

The investment of the proposed projects would activate the regional economy and create a new labour market in the regions. Accordingly, it would be clear that the investment proposes new labour opportunity for the people unemployed and underemployed in the regions.

(b) Improvement of Safe Water Coverage and Public Hygiene

After the completion of the proposed projects, all urban people and 75% of rural people will be able to enjoy their living conditions with safe and sufficient potable water. Popularization of potable water decreases mobility of water-borne diseases, and accordingly provides the decrease of medical expenses and the alleviation of absence because of diseases. These effects have already intertwined into economic evaluation.

Besides, the popularization of potable water might be effective for decrease of mortality rate of water-borne diseases, infant mortality rate in particular. As a result, healthy and comfortable living conditions could be created for the people in the society, and the people could enjoy their lives under the conditions. This amenity improvement might provide them a base for social activity in the next stage.

In particular, the rural water supply projects are expected to be managed by the rural beneficiaries themselves. This activity would be useful to enlighten them regarding public hygiene and to formulate their community. The community functioning well is indispensable for better management on water facilities. Thus, the existence of good community is a key issue whether or not the water supply system is maintained and operated in good condition. In the time when the water supply system is constructed in rural areas, an organizer should arrange a water supply system with a special view to organizing a good community. In that case, the managing body could be function not only for maintenance of the system but also for better living in the community.

(c) Inducement to Participating in "Woman in Development" Activity

A cooperation of projects beneficiaries in the region where the proposed projects will be implemented, in rural areas in particular, is one of the most fundamental issues with a view to proceeding the projects effectively. It is insisted that a role of women in the region is essential for the projects to be managed favourably and to be accepted smoothly by the beneficiaries. Once that people in the beneficial areas, women in particular, participate to development activity from a planning stage, the plan could introduce an appropriate technology for the people and reflect their customs in the society. In this context, this process would cause for the people to accept the new system fully and to adopt the projects

easily. From this point of view, it is essential that a planning agency formulates an organization of the people which gives advises to the agency and that the agency reflects the advises from them. Accordingly, the projects would give incentive for the people, particularly women power, to be involved, and the people could participate to the management of the projects easily. It is a basic element that the projects are managed favourably and perpetually in the region.

(d) Mitigation of Economic Disparity among Regions

There are not a few projects which were given priority to mitigate economic disparity among the regions in the country. Some irrigation projects took priority to mitigate food imbalance among regions, in spite of their less economic efficiency. In water supply projects as well, some projects were given priority to improve living conditions because of serious water deficit in the region. Thus, the schedule was established to settle the regional balance even on the way of implementation, although the completion of the projects in the target year would nevertheless give the people sufficient living conditions in the country.

(4) Initial Environmental Examination

The approach adopted in this Master Plan study is limited to "Initial Environmental Examination" (IEE) for the proposed projects. More detailed "Environmental Impact Assessment" (EIA) studies would follow during the feasibility study stage. The issues of adopted IEE are, water quantity, water quality, water resources management plans, system operations, runoff from stream and channel, flood plain management, ecological, recreational, commercial and cultural value of the aquatic environment and licensing requirements. The possible projects for environmental impact assessment are multi-purpose dam and reservoir projects, development of irrigation storages and their associated irrigation areas, pipeline projects, aqua-culture (fish pond) projects, and groundwater borehole projects.

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

1) Land tenure, acquisition, compensation and re-settlement
2) Water right allocation and its impact on social equity
3) New water demands and their impact on existing users
4) Groundwater level changes and their impact on waterlogging and land salinisation
5) Effect of effluent discharges on the quality of receiving water
6) Aquatic and terrestrial fauna in the river channel, dam reservoir, riparian strip, surrounding wetlands and along wildlife corridors
7) Effect on downstream river due to intake and outlet of water
8) Sedimentation in reservoirs and degradation of downstream river bed caused due to construction of dams
9) Soil erosion due to expansion of agricultural land.

4.7 Laws and Institutions

(1) Target for Institutional Improvement

To improve the water resources development and management in Zambia, institutional restructuring should be attempted to deal with the following key issues:

1) Capacity enhancement of institutions for implementation of development projects and their subsequent operation and maintenance
2) Comprehensive water resource planning
3) Co-ordinated operation for water resource management and administration
4) Introduction of river basin management
5) Contingency management systems for drought and flood
6) Establishment of cost recovery system for water resource development, operation and maintenance
7) Decentralisation of water resource management
8) Establishment of appropriate water quality standards and monitoring system
9) Encouragement of residents' participation

(2) Correspondence of the Proposed Programmes to the Problems and Needs

Current problems and future institutional requirement to implement the projects as proposed in this Study can be summarised as shown in Table 4-27. The proposed programmes correspond to these problems and future needs as illustrated in the table.

(3) Legal Arrangements

Establishment of legal hierarchies and separation of fundamental stipulations from their legal instruments, are recommendable.

<u>Legislation of Water Resources Management</u>

Current revisions to the Water Act, prepared by the Water Development Board, will correct most of the present major deficiencies. Further, the following issues should be discussed.

- Period of water right
- Water resources management in traditional land
- Promotion of international agreement

Under the revised Act, the following subsidiary regulations should be established.

- Preparation of regulations and technical standards for water resources development and management
- Regulations for groundwater management
- Classification of rivers and aquifers and regulations for decentralisation

<u>Laws on Water Resources Conservation</u>

Before making arrangement for the establishments of a legal system for water resources conservation, as generally stated above, conformation of fundamental laws, especially between the Natural Resources Conservation Act and the Environmental Protection and Pollution Control Act, should be achieved. In short term, some part of the Natural Resources Conservation Act should be reviewed, whose interpretation falls difficult because of the revocation made at the time of establishment of the Environmental Protection and

Pollution Control Act. The scope of the two laws should be clearly demarcated. In long term, the Natural Resources Conservation Act should contain the national policy for rational use and conservation of natural resources, including pollution control, and framework for policy enforcement, regulations and responsible entities.

Table 4-27 Correspondence of Proposed Programmes to Problems and Needs

Recommended Programmes	Identified Problems							Future Needs		
	Insufficient Regulations and Standards	Deficiency/Duplication/Unclear Definition of Responsibilities	Insufficient Staff	Limited Finance	Insufficient Water Resources Management	Insufficient and Unstable Water Supply	Insufficient Office Equipment and Transport	Increasing Water Resource Development Projects	Necessity for Water Allocation	Increase in Pollution Loads
Regulations/Standards for Water Resources Development	◎				◎	◎		◎	◎	
Regulations for Groundwater Use	◎				◎			◎		
Regulations for Classification on Rivers/Aquifers	◎				◎			◎	◎	
Environmental Legal System										◎
Environmental Standards and Regulations	◎									◎
Separation of Regulatory/Operational Functions										
Establishment of the Kafue River Authority					◎			◎	◎	◎
Responsibility Re-allocation between DNR and ECZ	◎	◎	◎							◎
Separation of Water Resource Sector And Water Supply and Sanitation Sector										
Establishment of NWASCO (proposed by WSDG)						◎		◎		
Establishment of DISS (already established)			◎			◎		◎		
Strengthening Water Development Board										
Enhancement of Existing Sections					◎				◎	
Establishment of the Water Resources Development/Allocation Policy Committee					◎			◎		
Establishment of the Drought Relief Committee					◎					
Establishment the Fee Collection Unit				◎					◎	
Enhancement of the DWA/MEWD										
Establishment of the Technical Standards Committee	◎					◎		◎		
Establishment of the Database Section					◎				◎	
Establishment of the Design Section								◎		
Establishment of the Human Resource Development Section			◎							
Revisions of Tariff and Fee for Water Supply/Water Rights				◎				◎	◎	
Increased Government's Priority and Budget Spending				◎		◎		◎		
Encouragement of Residents' Participation						◎		◎	◎	
Investment in Office Equipment and Transport							◎			

(Note) DNR: Dept. of Natural Resources, ECZ: Environmental Council of Zambia,
NWASCO: National Water and Sanitation Council,
WSDG: Water Sector Development Group under the Programme Co-ordination Unit,
DWA: Dept. of Water Affairs,
MEWD: Ministry of Energy and Water Development

For effective and efficient conservation activities with limited resources, zoning and designation of areas for intensive water quality management would be required.

Further, the following legal instruments would be necessary after the establishment of conformation among fundamental laws, which provides a frame of the national environmental conservation policy and co-ordination of conservation activities, including the introduction of the following instruments.

- Promotion of environmental impact assessment
- Introduction of water quality atandards of water courses of Zambia by basin or sub-basin
- Establishment of regulations for effluent control

(4) Organisational Strengthening

Proposed re-organisations by the Study are aimed at achieving three principles:

- Separation of regulatory and operational functions
- Separation of water resources management from that of water supply and sanitation
- Achieving a phased programme for re-organisation

Staffing and human resources development, and allocation of responsibilities are also described, as a basis to attain the above three principles.

(5) Re-organisation of Water Resource Sector

Water Development Board should be extensively strengthened to resolve the current deficiencies and to discharge increasing responsibilities for water resources allocation, and additional regulating activities on groundwater abstraction.

Establishment of Kafue Authority, as the first step, is recommended as decentralised body for water resource management activities by river basin. After the establishment of River Authorities, DWA would be a regulatory body for the technical aspects of water resource development and management.

The recommended organisation is shown in the following figure. Each line section should carry out the duties as listed below each section in the figure. Inspection should be carried out by Registry Section for monitoring water use, including detection of non-registered water use or the conformity of water use to the granted water right, especially for groundwater.

The proposed Kafue River Authority should set up water allocation and development objectives, which could minimise the possible conflict, specific to the Kafue catchment area. The Authority would be in charge of water resource conservation as well. Operation and maintenance of multi-purpose dams and other water facilities would also be the duty of the Authority.

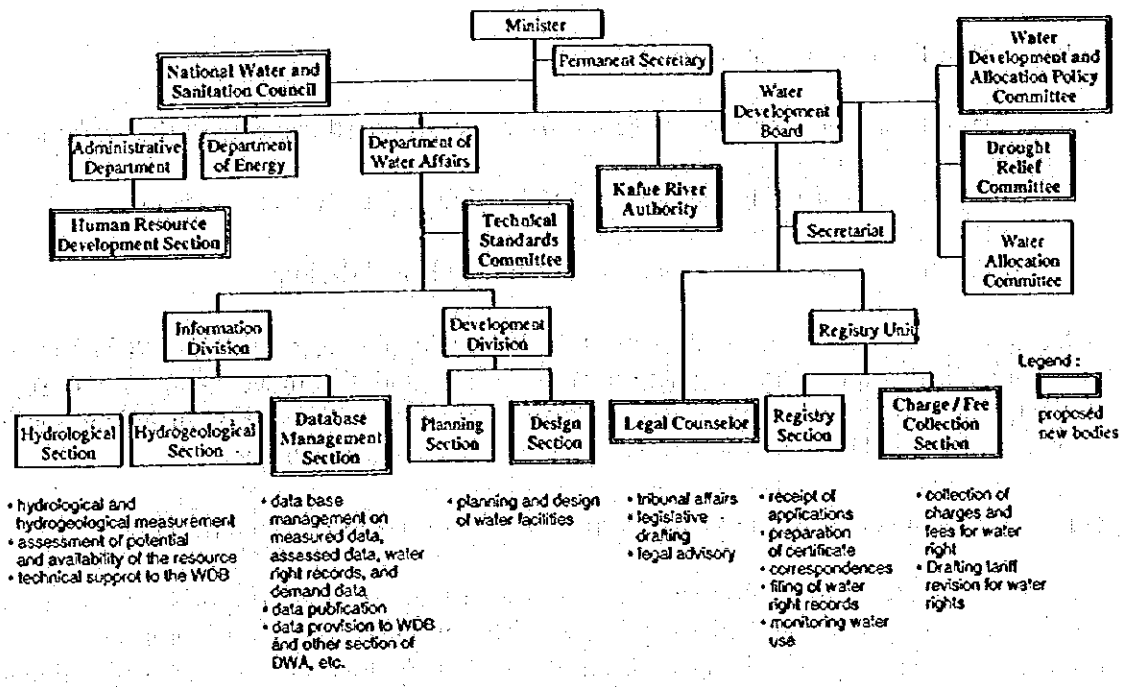

Figure 4-2 Proposed Organisation of Water Resource Sector

(6) Re-organisation of Water Supply and Sanitation Sector

The Water Sector Development Group under Programme Co-ordination Unit is studying the re-organisation of the water supply and sanitation sector. The following principles set by the Group are agreeable the above targets.

1) Separation of water resources management from water supply and sanitation
2) Separation of regulatory and executive (operational) functions within the water supply and sanitation sector
3) Devolution of authority to local authorities and private enterprises
4) Achievement of full cost recovery for water supply and sanitation services (capital recovery, operation and maintenance) through user charges in the long run
5) Human resources development leading to more efficient institutions
6) Technology appropriate to local conditions
7) Increased GRZ priority and budget spending to the sector

(7) Re-organisation of Water Resource Conservation Sector

Clarification and demarcation of responsibility between the Department of Natural Resources (DNR) in the Ministry of Environment and Natural Resources and the Environmental Council of Zambia (ECZ) would be necessary. After the responsibility assignment, some of the staff could move to the ECZ from the DNR.

CHAPTER 5 ACTION PLAN

5.1 Action Plan for Water Supply Sector

Action Plans are formulated after selection from the proposed projects in the water supply sector, applying the following criteria:

1) Projects requiring urgent implementation due to great water shortage
2) Projects serving higher populations
3) Projects which require longer periods for study and design

Selected projects are 1)Commencement of the Water Supply Project for Lusaka Urban Area, including Northern Lusaka Production Well Project and Chongwe Dam Water Supply Project, and 2)Establishment of Groundwater Development System, including Drilling Center Projects and Groundwater Development Training Centre Project.

(1) Commencement of the Water Supply Project for Lusaka Urban Area

The Lusaka Water Supply Project is the largest in scale of the large urban water supply projects and is given the highest priority. This project consists of Northern Lusaka Production Well Project, Chongwe Dam Water Supply Project and the Kafue Pipeline Project. Two proposed projects, the Production Well Project and the Chongwe Dam Project are programmed in the first five year stage up to the year 2000.

Northern Lusaka Production Well Project

The development potential of the groundwater basin in northern Lusaka is estimated at about 38,000m3/day and is barely developed at the moment. Northern Lusaka Production Well Project, comprising 50 wells of 20,000m3/day (serving population: 107,000) pumpage, corresponding to 53% of the development potential, and estimated to cost about 16 million US$, is recommended. The supervising ministry in charge of water supply projects, the Ministry of Local Government and Housing, and the implementing agencies, Lusaka City Council and Lusaka Water and Sewerage Company, should commence this project immediately.

Chongwe Dam Water Supply Project

Chongwe Dam is a multi-purpose dam project to supply domestic and industrial water and irrigation schemes. Chongwe Dam Water Supply Project will provide 100,000m3/day (serving population: 400,000) potable water to the Lusaka waterworks. The estimated cost for this project is 109.87 million US$. This project is promising as a new multi-purpose source development. Feasibility Study of this project should be commenced at an early stage by the supervising ministry, the Ministry of Energy and Water Development and the implementing agency, the Department of Water Affairs.

The above two projects proposed in the action plan were examined regarding project viability through financial internal rate of return (FIRR). They are (1) Lusaka water supply system of which water source comes from northern wells (Northern Wells Case); and (2) Lusaka water supply system of which water source come through Chongwe dam (Chongwe Dam Case). The items are summarised as follows:

Table 5-1 Financial Conditions and FIRR of Proposed Water Supply Projects

(Unit: US$ Million)

Items	Northern Wells Case	Chongwe Dam Case
Capital Investment Cost	15.75	109.87
Annual O/M Cost *1	0.788	5.494
Revenue of Water Supply Services *2	249	1,234
- Domestic Water	67	334
- Municipal Water	84	419
- Industrial Water	98	480
FIRR (%)	10.0	5.2

Note: *1 In addition, replacement costs such as machinery and equipment in stations are added in every 20 years.

*2 Average water consumers are assumed as follows on the basis of the present water tariff. 80% of consumers was assumed to pay for their water charges.

Domestic water	Average consumption volume	Unit rate
Domestic water	115 lit/capita/day	K217 /m³
Municipal water	50 m³/facility/day	K338 /m³
Industrial water	100 m³/facility/day	K288 /m³

FIRR of the Northern Wells Case was 10.0%, as seen in the above table. This rate corresponds to the rates of 8% to 10% applied by the World Bank and African Development Bank, although it is less than market interest rates in Zambia. Thus, as far as the water supply services are managed under the present water tariff and the investment funds are procured from the public financing organisations such as WB and AfDB, the project will be feasible from the financial point of view.

FIRR of the Chongwe Dam Case was 5.2%. The project will not be feasible from the financial point of view, in the case that the project funds are procured even from the public financing organisations. Although detailed countermeasures may be discussed in the next stage analysis of feasibility study, the following proposals could make the project acceptable as a viable project in the future.

1) Approximately 40% (around 44 Mil.us$) of the capital investment cost is granted;
2) Loan at an annual interest rate of less than 5.2% is available; and
3) Water consumers have a willingness to pay of 25% higher charge for potable water.

Actually, the above countermeasures could be mixed in the case that one measure could not be applied fully for the case. In any case, these countermeasures are considered to be affordable. At present, LWSC has the following management problems on its water supply and sewage services.

1) Net worth is too small and excessively relies on long-term liabilities for capital investment. At present, an interest burden seems to be relatively low but this condition causes cash flow difficulty in the future when the repayment of loan will begin. Thus, LWSC would rather increase net worth as much as possible, which comprises own capital, internal reserves and contribution in aid of construction from beneficiaries. In addition to that, the company should try to find favourable terms of loans for supplemental funds of construction works.
2) In 1993, the company spent the large amount of K2.37 billion for administrative expenses. This lies heavy on the management. The heaviest component was bad debt losses. Thus, the company has to exert all possible efforts to charge water tariff correctly and to recover uncollected charges.

3) The improvement of operation and maintenance is a key issue to keep the plant machinery and piping network in good condition. This would extend their economic lives and decrease not only O/M costs but also depreciation of the facilities hopefully. It could make water tariff keeping low and steady. As a result, this management policy would get people's dependence on the water supply system and finally recover their reliance on the company.

To implement the aforesaid projects, LWSC has to improve its own management characteristics in addition to the favourable loans mentioned above. For pursuance of the projects, every body concerned to the projects including the central and local government, LWSC and beneficiaries has to co-operate to make the projects implement.

(2) Establishment of Groundwater Development System

For the smooth implementation of the future groundwater development, the promotion projects for groundwater development are proposed in the Master Plan for the water supply sector. The projects are composed of the Drilling Centre Projects and the Groundwater Development Training Centre Project. Priority shall be given to these projects.

Drilling Centre Projects

The objective of the drilling centre is to promote the implementation of groundwater development in whole Zambia, by increasing the capacity of drilling through the centre established in each province. The groundwater development plan proposed in the Master Plan will be realised through these centre. The functions of the centre are: 1)Preparation of drilling plan 2)Selection of well field 3)Drilling 4)Construction of water supply facilities 5)Improvement of existing well 6)Repair and maintenance of drilling equipment 7)Instruction of rural water supply and so on. The drilling centre projects are summarised as shown in Table 5-2.

Table 5-2 Drilling Centre Projects

(1) Centre Location, Trainees, Establishment Schedule

Province	Town	Party and Trainees (P:party, T: trainee)					Establishment Sche.	
		Well Location	Well Drilling	Equipment Maintenance	Rural/W/S Instructor	Total	Centre	New Rigs
Lusaka	Lusaka	P=1,T=8	P=2, T=16	P=2, T=10	T= 8	T=42	New	
Copperbelt	Ndola	P=1,T=8	P=3, T=24	P=2, T=10	T=14	T=56	New	2
Central	Kabwe	P=1,T=8	P=3, T=24	P=2, T=10	T= 20	T=62		
N/western	Solwezi	P=1,T=8	P=3, T=24	P=2, T=10	T= 12	T=54	New	2
Western	Mongu	P=1,T=8	P=2, T=16	P=1, T=5	T= 20	T=49		
Southern	Monze	P=2,T=16	P=5, T=40	P=3, T=15	T= 26	T=97		
Ruapula	Manza	P=1,T=8	P=3, T=24	P=2, T=10	T= 12	T=54	New	2
Northern	Kasama	P=2,T=16	P=5, T=40	P=3, T=15	T= 20	T=91	New	3
Eastern	Chipata	P=3,T=24	P=6, T=48	P=4, T=20	T= 28	T=120	New	4
Total		P=13,T=104	P=2, T=16	P=2, T=10	T= 160	T=625	6 Centres	13 rigs

(2) Operation and Maintenance

Cost	Initial Cost (Drilling Equipment, Construction of Centre)	41.64 Million us$
	Well Drilling(1,200 wells/year), Maintenance of Centre)	7.32 Million us$ /year
Income	Selling of Production Wells (1,200 wells/year)	10.12 Million us$ /year
Balance	Selling Profit of Production Wells = 2.80 Million us$ /year. 15 years after the centre establishment, total selling profit of production wells and initial cost will be balance.	

Groundwater Development Training Centre Project

The objective of the groundwater development Centre is to train groundwater engineers for the smooth and effective implementation of the groundwater development projects proposed in the Master Plan. The training courses include hydrogeology, well drilling, mechanics, rural water supply instructors and so on. This project is composed of three phases. The first phase of the project should be promoted in co-operation with MLGH and MEWD. Project description is summarised in Table 5-3.

Table 5-3 Groundwater Development Training Centre Project

Items	Stage-1	Stage-2	Stage-3
(1) Period	1996 - 1998 (3 years)	1999 - 2003 (5 years)	2004 -
(2) Targets of Stage	- Establishment of Centre - Initial Training	- Training of Zambian trainers by foreign experts - Training of engineers	- Training of Zambian trainees
(3) Job Description	< Centre Establishment > a) Construction of Centre - Building: 3,000m2 b) Equipment Supply - 2 rigs (DTH type) etc. c) Staffing 30 Zambian Staffs < Initial Training > a) Objectives - Training for Zambian Staff - Feasibility Study of Northern Lusaka Well Fields - Arrangement of O/M system b) Trainers 4 Foreign experts dispatched by consultant c) Trainees Zambian staff who are key persons in Stage-2	a) Trainers - 3 long term experts - Several short term experts - Qualified Zambian staffs b) Trainees 470 mon.month Zambian trainees covering - Hydrogeology Course: 10 persons/year (10 persons/yr x 1 cycle) - Drilling Course: 10 persons/year (10 persons/yr x 1 cycle) - Mechanical Course: 20 persons/year (10 per./ 6 mon.x 2cycles) - Village Instructor Course: 110 persons/year (10 per./mon. x 11 cycles)	a) Trainers - Qualified Zambian experts b) Trainees 470 mon.month Zambian trainees covering - Hydrogeology Course: 10 persons/year (10 persons/yr x 1 cycle) - Drilling Course: 10 persons/year (10 persons/yr x 1 cycle) - Mechanical Course: 20 persons/year (10 per./ 6 mon.x 2 cycles) - Village Instructor Course: 110 persons/year (10 per./mon. x 11 cycles)
(4) Financial Status			
(Cost)	a) Initial Input 16.400 mil.us$ - Center Establishment 14.800 - Initial Training 1.600 b) Ope.and Maintenance 0.100 mil.us$	a) Initial Input 0.000 mil.us$ b) Ope.and Maintenance 0.264 mil.us$/yr	a) Initial Input 0.000 mil.us$ b) Ope.and Maintenance 0.264 mil.us$/yr
(Income)	a) Initial input is to be donated b) 0.073 mil.us$ through production wells completed in initial training	a) Cost for foreign trainers is to be donated b) Cost for spare parts: 0.164 mil.us$/yr is to be donated. c) 0.100 mil.us$/yr through production wells completed in initial training	a) 0.094 mil.us$/yr (200 us$/man.month) through training charge b) 0.170 mil.us$/yr through production wells completed in initial training
(Balance)	a) Zambian Government bears cost for land acquisition b) O&M cost: 0.027mil.us$/yr is to be born by Zambian Government	Level	Level

5.2 Action Plan for Agricultural Sector

Investment for agricultural development should be made with the initiative of the private sector. The role of the government is to regulate, induce, encourage and support the private sector's investment in accordance with the national agricultural policy. Although the Study proposes agricultural development plan for crop production, fishery and livestock breeding, the national food security relies most on crop production. Investment for fishery and livestock breeding development should basically be carried out by the private sector corresponding to changes in standards or preference of the food consumption of the people. Supporting services by the government to the private sector, such as the fish breeding centre project and the technical assistance programme to the field of veterinary science, donated by the Government of Japan is important and should be promoted further. The most important subject for the Zambian agricultural sector is to establish drought resistant agriculture. Immediate actions should concentrate on the promotion of irrigation. In this point, agricultural action plans are selected from the irrigation projects applying the following criteria:

1) Economically feasible projects (EIRR > 10%) which contribute the economic growth of the agricultural sector and are expected to be invested by private sectors
2) Projects whose technical knowledge is accumulated for implementation and realisation is confirmed technically
3) Projects to improve the regional disparity of income of farmers and food balance within the region
4) Projects contributing to improvement of the balance of payments of the country by production of export crops or materials for agro-processing industry

(1) Implementation of ASIP Rehabilitation Project

It is recommended to implement the ASIP Rehabilitation Project at the earliest possible date. This project is evaluated as high priority, because quick realisation of effect is expected. Rehabilitation of projects is recommended to be completed by the year 1999 within the first phase of the ASIP Programme. The Rehabilitation Project is composed of 9 individual projects, totalling 267 ha of beneficial area. The construction cost will amount to 6.55 million US$. It is proposed to introduce double cropping of vegetables aiming at peri-urban agriculture. Benefit of this Project is expected to be 1.71 million US$/year, with average EIRR of 14% . The features of each project are as follows:

Table 5-4 ASIP Rehabilitation Projects

Project (code)	Location	Area (ha)	Cropping	Facility	Cost*	Annual Benefit*	EIRR (%)
(1) Chipapa (N-1)	Lusaka	10	Vegetable	Diversion Weir	0.09	0.064	28.7
(2) Ipafu (N-2)	Copperbelt	80	- ditto -	Pump, Pipeline	1.66	0.513	15.3
(3) Chapula (O-9)	- ditto -	60	- ditto -	- ditto -	1.61	0.385	12.1
(4) Buleya Malima (O-14)	Southern	57	- ditto -	- ditto -	1.53	0.365	12.1
(5) Siatwinda (O-15)	- ditto -	22	- ditto -	- ditto -	0.61	0.141	11.6
(6) Nakandabwe (O-21)	- ditto -	10	- ditto -	- ditto -	0.28	0.064	11.3
(7) Makungwa (O-28)	Eastern	5	- ditto -	- ditto -	0.14	0.032	12.0
(8) Vuu (O-30)	- ditto -	13	- ditto -	- ditto -	0.35	0.083	12.2
(9) Lusowe (O-31)	- ditto -	10	- ditto -	- ditto -	0.28	0.064	11.3
Total		267			6.55	1.711	14.0

Note: *: estimated at market price, unit Million us$

(2) Chongwe Dam Irrigation Project

Chongwe Dam is proposed for Lusaka Water Supply Project to be implemented in 1998 and completed in 2000. Since the Chongwe dam is close to the large market of Lusaka, high value crops, such as vegetables, can be grown in the project. It will be necessary to implement the feasibility study in parallel with the water supply project study. The Project features, investment cost and EIRR are as follows:

Chongwe Dam Irrigation Project	
Beneficial Area:	810 ha
Beneficial Farm:	400 farm houses
Facilities :	Intake Pump ($Q=0.81m^3/s$, H=100m)
	Pipeline (L=10km)
	Furrow Irrigation for Vegetables and
	Drip Irrigation for Flowers
Investment Cost :	US$ 34.74 million
Crops :	Vegetables (70%), and Flowers (30%)
EIRR :	10.5 %

(3) Implementation of Zambezi Left Bank Floodplain Rice Irrigation Project

Western province is the least developed province for irrigation development due to distance from large markets, although there is high water resources potential in the form of the Zambezi River. It is proposed to start the Zambezi Floodplain Rice Irrigation Project (defined as P-23) with 1,500 ha to be implemented in the Left Bank Floodplain by 2005. This represents half of the total potential area of about 3,000 ha in the left bank flood plain, because hydrological observation will be necessary to identify the maximum potential area. Relating to this project, verification study has been conducted by JICA. The construction cost is estimated at about 19.47 million US$, with a benefit of about 4.35 million US$ annually with rice double cropping. EIRR is estimated at about 10.8%.
The Project features are outlined as follows:

Zambezi Floodplain Rice Irrigation Project	
Beneficial Area :	1,500 ha (field reparation: 1,500 ha)*
Beneficial Farm:	1,100 farm houses
Facilities :	Intake Canal: 75 km
	Land consolidation: 1,500 ha
	Low Lift Pumps : $3.02 m^3/s$
Investment Cost:	US$ 19.47 million
Crops :	Rice (1,500 ha) in Wet Season)
	Rice (750 ha) and Vegetable (750ha) in Dry Season
EIRR :	10.8%

* Land ownership should be solved for smooth project implementation

(4) Financial Examination of Irrigation Projects

The above three categories of projects proposed in the action plan were examined regarding project viability through financial internal rate of return (FIRR). The items are summarised as in Table 5-5. FIRR of ASIP rehabilitation projects including nine schemes was 0.4%, as seen in the above table. The project will not be feasible from the financial point of view, in the case that the project funds are procured even from the public financing organisations.

The following countermeasures would be necessary to implement ASIP schemes: 1) To enlarge an irrigation land area for a farm household, so the household would pay more water charge because of its capacity-to-pay increase. 2) To procure a construction fund of either grant or loan with terms of almost no interest rate. In fact, MAFF is going to implement a part of ASIP projects by means of procurement of no interest loans through international financing organisations. Anyhow, the central government has to make an endeavour to accomplish ASIP projects by the target year by means of various countermeasures including the same kind of fund procurement.

Table 5-5 Financial Conditions and FIRR of Proposed Agricultural Projects

Items	ASIP Rehabilitation Projects	Chongwe Dam Irrigation Project	Zambezi Rice Irrigation Project
Capital Investment Cost (US$ Million)	6.55	34.74	38.94
Annual O/M Cost (US$ Million) *1	0.17	0.81	1.37
Revenue of Water Charge*2 (US$ Million)	0.43	4.61	7.07
- Irrigation Water (Million m³/year)	3.28	9.96	87.45
- Unit Water Rate (Kwacha/m³)*3	80	282	49
FIRR (%)	0.4	7.4	10.0

Note: *1 In addition, replacement costs such as machinery and equipment in stations are added in every 20 years.
*2 A product of unit water rate and annual water consumption volume
*3 Unit water rate was estimated on the basis of a capacity-to-pay of beneficial farmers. These values were estimated in Section 6.2 of Supporting Report Part-I "Irrigation".

FIRR of the Chongwe dam irrigation project was 7.4%. The project will have some difficulty from the financial point of view, even if the project funds are procured from the public financing organisations. Although detailed countermeasures may be discussed in the next stage analysis of feasibility study, the following proposals could make the project acceptable as a viable project in the future. 1) approximately 15%~20% of the capital investment cost is granted; 2) a loan at an annual interest rate of less than 7.4% is available; and 3) water consumers have a willingness to pay of 25% higher charge for potable water. Since the unit water rate was set at the highest level taking capacity-to-pay of beneficiaries into consideration, it would be difficult to augment the water rate. Accordingly, the above two countermeasures or the both measures combined together might be effective for the implementation of the project.

FIRR of the Zambezi left bank flood plain rice irrigation project was 10.0%. This rate corresponds to the rates of 8% to 10% applied by the World Bank and African Development Bank, although it is less than market interest rates in Zambia. Then, if the water rate is kept and the investment funds are procured from the public financing organisations such as WB and AfDB, the project will be feasible from the financial point of view.

5.3 Institutional Establishment Programmes

For the implementation of proposed programmes for institutional improvement and projects for water resources development, implementation methods and procedure should be immediately determined. For effective and efficient implementation of project proposed in the Master Plan, as well as for the consequent operation and management, training and database arrangement should be started immediately.

(1) General Preparation for the Implementation of the Programmes

Since the institutional improvements recommended in the Master Plan are related to many sectors of the Government, mutual discussion or consultation among the sectors, as well as the strong initiative of the prime institutes; mainly DWA/MEWD for Water Resource Sector, Water Sector Development Group (WSDG) for Water Supply and Sanitation Sector, and ECZ/DNR for the Conservation Sector, will be required. Because of the close inter-relation among the recommendations of the Master Plan, general co-ordination would be necessary with the leadership of the Minister or the Permanent Secretary, and implemented by the DWA. Formulation of procedures for re-organisation should be determined before execution through inter-ministerial meetings attended by the relevant bodies and held by the responsible entity.

(2) Formulation of Human Resource Development Plan and Conducting Training

Implementation of projects proposed in the Master Plan and the consequent operation and maintenance will require huge numbers of staff. The following two types of training will be necessary. 1) Training of Core Staff: for the implementation of new types of projects and programmes, for policy formulation and promotion of the enforcement, or training of trainers; 2) Training of Staff for Project and Programme implementation: for rapidly growing number of staff for operation and maintenance, especially for water supply projects

(3) Database Arrangement for Equitable Policy Formulations and Revisions

As clarified throughout the Study, formulation, revisions and enforcement of equitable water resources development plan or policies for the resources management, as well as effective and efficient planning and implementation of projects or programmes require various and much information, which can be obtained through the analysis of data and records collected over long period. Database arrangement should be started immediately.

(4) Preparation for Expanding Needs in Water Supply Schemes and for Re-structuring the Water Supply and Sanitation Sector

1) Enactment of fundamental laws for Municipal Water Supply and Sanitation Services
   Before the re-structuring of water supply sanitation services, in which various entities are involved in many ways at present, fundamental law should be prepared for well organized implementation or expansion of the services.
2) Standardisation of equipment, facilities, service levels and treatment levels
   Expanding services for the sector will incur a great deal of financial and human resources. For the efficient investment, operation and maintenance, standardisation of equipment, facilities, service and treatment levels, etc., should be promoted.
3) Preparation of Prescribed Procedure for Rural Water Supply Projects
   Rural water supply projects require a different approach from those for urban areas. For sustainable development of the projects with limited financial and human resources, prescribed procedure to promote residents' participation for rural water supply projects would encourage effective and efficient expansion of the project planning and implementation.

CHAPTER 6 RECOMMENDATIONS

(1) Implementation of the Water Resources Development Plan

The Master Plan proposes water resources development projects mainly for water supply for domestic and industrial use and for the agricultural sector. For other sectors, development policies are proposed from the viewpoint of water resources development, based on the analysis of the present status and future projection. Socio-economic development plan, regional development plan and individual sector development plan related to water resources development, such as power development plan, or transportation and road network development plan, as well as the infra-structure development and project plan in the related sectors should be planned taking into account the proposals from water resources development plan.

The projects for water supply for domestic and industrial use and for the agricultural sector are planned for three scenarios of the future socio-economic framework, such as population and GDP. These three scenarios give the maximum, medium and minimum water demand projection. Water demands in the range between the maximum and the minimum will surely occur, and it will be absolutely necessary to meet the demands with construction and extension of water facilities, in order to attain better living standards for the nation and stable economic development.

(2) Review of Water Resources Development Plan

Proposed water resources development plan is formulated based on the projected population and GDP increases, for 20 years towards 2015. Socio-economic development plans are normally formulated every five years with projections of population and target economic growth. Water resources development plan should also be reviewed every five years, if necessary, using these revised projections.

Water supply in the Lusaka urban area, which is the political and economic centre of the country, is estimated to require a large volume of water to be conveyed over a long distance, 45km from the Chongwe Dam or 50km through the Kafue Pipeline. The conveyance facilities from the dam are estimated to cost 24% of the construction cost of the project, and the conveyance facilities from the Kafue River will cost 33% of the project construction cost. Construction cost of conveyance facilities for the two projects will reach US$ 134 million, comprising 13% of the total construction costs of the proposed water supply projects. The construction cost of the water conveyance facilities for both projects corresponds to 4% of Zambia's GDP in 1993. People or industries might move to other places, seeking cheaper water. When the city planning of Lusaka is revised, the water supply projects should also be reviewed.

(3) Implementation of the Action Plans.

The Action Plan proposed in the previous chapter shows the action necessary to be taken now for smooth and steady implementation of the projects proposed for water supply and agricultural development in the Master Plan. Successful implementation of the projects proposed in the Master Plan depends on the achievement of the Action Plan. The Action Plan should be immediately commenced and completed.

(4) Financing the Cost

External debt of the country in 1992 reached US$ 7 billion, and corresponded to double the GDP in that year. Reimbursement for the debt in 1992 amounted to US$ 360 million and the debt service ratio was over 28%, considerably surpassing the dangerous line of 20% set by the World Bank. At present, borrowing from foreign countries would be difficult. In 1992, Zambia received US$ 1.13 billion foreign assistance, with grants of US$ 790 million sharing 69%, and loans of US$ 350 million sharing 31%. This breakdown is typical and grants averaged 73% over the last six years compared to 27% loans. Under the present conditions, the projects should be implemented with grants. In the future, however, implementation of proposed projects by borrowing should be promoted as soon as possible, by reducing external debt with the achievement of stable economic growth.

(5) Encouragement of Public Awareness of Beneficiary-to-Pay Principle and of Saving Water

Construction costs for water supply projects are estimated as US$ 1,010 million in the Base Scenario-Agricultural Expansion. Even though the Government is responsible to obtain the finance, cost recovery for water supply should be promoted to secure funds through revision of water tariffs and improvement in collection. Saving of water will reduce the demands, resulting in an overall decrease in project costs. Public awareness of Beneficiary-to-Pay principle and on Saving Water should be encouraged.