4.2 Water Demand of Irrigation Project

Water demand of irrigation is estimated at peak irrigation requirement of 1.00 lit/sec/ha. The irrigation area and water requirement necessary to be developed by the year 2015 for the Base Scenario - Agricultural Expansion are 60,820 ha and 5,254,000 m^3/day, respectively . This area and water requirement are the maximum of the three scenarios. Water requirement for the Conservative Scenario of 3,300,000 m^3/day is the lowest of the three scenarios and corresponds to about 63 % of the Base Scenario - Agricultural Expansion.

Table 4-11 Requirement of Irrigation Area and Water in 2015

Province	Present Situation (1993)	Base Scenario - Agricultural Expansion		Base Scenario - Industrialisation		Conservative Scenario	
		Developed	Total	Developed	Total	Developed	Total
Irrigation Area (Unit : ha)							
Lusaka	5,670	2,720	8,390	2,720	8,390	2,720	8,390
Copperbelt	9,290	10,120	19,410	8,850	18,140	10,700	19,990
Central	6,530	5,000	11,530	5,000	11,530	0	6,530
N/Western	520	6,590	7,110	3,590	4,110	2,590	3,110
Western	0	7,010	7,010	6,010	6,010	3,510	3,510
Southern	19,230	8,540	27,770	8,540	27,770	8,540	27,770
Luapula	2,140	12,140	14,280	12,140	14,280	3,140	5,280
Northern	9,140	7,190	16,330	5,490	14,630	5,490	14,630
Eastern	500	1,510	2,010	1,510	2,010	1,510	2,010
Total	53,020	60,820	113,840	53,850	106,870	38,200	91,220
Irrigation Water Requirement (Unit : 1000m^3/day)							
Lusaka	490	235	725	235	725	235	725
Copperbelt	803	874	1,677	765	1,567	924	1,727
Central	564	432	996	432	996	0	564
N/Western	45	569	614	310	355	224	269
Western	0	606	606	519	519	303	303
Southern	1,661	738	2,399	738	2,399	738	2,399
Luapula	185	1,049	1,234	1,049	1,234	272	456
Northern	790	621	1,411	474	1,264	474	1,264
Eastern	43	130	173	130	173	130	173
Total	4,581	5,254	9,835	4,652	9,232	3,300	7,881

4.3 Facility Plan of Irrigation Project

4.3.1 Design Policy of Irrigation Project

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 groundwater 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 followed from aspects of types of projects, scale of project size and water sources for projects:

< Project Type >
- ASIP Rehabilitation Projects: Rehabilitation of existing irrigation by the Government for smallholder farmers
- Expansion Projects: Expansion of existing irrigation by commercial sector
- New Projects: Newly developed projects in potential areas for irrigation

< Scale of Projects >
- Large 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
- Small 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

4.3.2 Design Criteria of Irrigation Project

(1) Design Year

Design year is set up for 1/5year-drought taking the cost investment for drought into consideration.

(2) Irrigation Efficacy

- Conveyance Efficiency: 80%
- Application Efficiency: 60% (for furrow irrigation)
- Overall Efficiency: 50%
- Efficiency in aqua-culture: 100% of application efficiency, then 80% of overall efficiency

(3) Facility Plan

Irrigation facilities are classified into water resource, intake, conveyance, and terminal irrigation facilities. Each facility is composed of following works:

Water Resources Facility:	Dam or Diversion Weir
Intake Facility:	Pump or Gravity Intake
Conveyance Facility:	Canal or Pipeline
Terminal Irrigation Facility:	Furrow/ Basin or Overhead Irrigation

Required irrigation facilities are summarised in Table 4-12, and major projects are illustrated in Figure 4-3 and 4-4. The basic considerations for irrigation facilities are as follows:

(a) Dams

Dams are selected considering the economical viewpoint, based on following criteria:

- Multi-purpose : all multi-purpose dams are selected for irrigation development, taking scale and possibility of advanced peri-urban agriculture into consideration.

- Irrigation only : only the dams whose cost corresponds to an equivalent unit cost of less than US$20,000/ha of irrigable area, and where water can be conveyed by gravity, are selected. Two dams, namely Lufubu dam (D-1) and Lundazi dam (D-18) are selected as irrigation development dams.

(b) Diversion Weirs

Diversion weirs have been considered for abstracting water where the river water depth becomes shallower than 1.7 metres during drought flow conditions. Standard size of weir is assumed to be 50 metres width for 1,000 ha of irrigation area. However, where river depth is adequate for water abstraction, construction of a weir is not necessary. Such development sites are to be as follows:

<Possible Projects not premising Diversion Weirs>

- Luapula :	River is assumed to be deeper than 1.7 metres during drought flow. (P-45 Luapula)
- Kabompo :	30 small pumps are to be provided along the river. Each intake is small compared to the river flow. (P-82 Kabompo)
- Zambezi :	There are many rapids and the river is confined in a narrow channel below Senanga. These rapids are able to act as natural weirs. (P-16 Katima Mulilo, P-84 Ngambwe Rapid, P-86 Manto Rapid, P-88 Sioma Rapid)
- Zambezi Floodplain :	There are many artificial or natural channels running in the floodplain and it is possible to intake water at several suitable locations. (P-23 Zambezi Left Bank Floodplain)
- Kafue Floodplain :	Kafue River is fully controlled by Kafue Gorge Dam. Water can be abstracted without weirs. (O-13 Kaleya Small-holders Irrigation Scheme, O-18 Nakambala Sugar Estates, O-20 Nanga Irrigation Scheme)

(c)Pumps and Pipelines

Pump capacity has been considered to be 1.0 lit./sec/ha when provided in connection with night storage reservoir. Standard pump for 1,000 ha of irrigation is considered to have a capacity of 1.0m3/sec, static head of 100m and serves a single 5km length of steel pipe. This standard is applied for potential irrigation projects and operational large scale irrigation projects.

(d) Terminal Irrigation Method

Furrow or basin irrigation method is principally applied as a standard terminal irrigation method in this study. However, other irrigation methods (overhead irrigation) like as sprinkler or drip irrigation are also applied in such cases where soils are so permeable that furrow irrigation is not applicable or particular crops like flowers are introduced.

Overhead irrigation will be applied to the projects in Western and North-western Provinces. Following 5 projects will be applied with overhead irrigation:

<Western Province>: 16 : Katima Mulilo, P-84 : Ngambwe Rapid, P-86 : Manto Rapid, P-88 : Sioma Rapid

<North-western Province>:P-82 : Kabompo

Table 4-12 Major Facilities for Irrigation Projects
(Base Scenario - Agricultural Expansion)

Project Category/ Project Name		Irrigable Area (ha)			Major Facilities for the Project					
		Gravity	Pump	Total	Dam	Weir	Canal	Pump (m^3/s)	Pipeline	Irrigation Method
ASIP Rehabilitation Project		**10**	**257**	**267**						
N-1	Chipapa	10		10	Small dam		open	0		Furrow
N-2	Ipafu		80	80		Fixed Type	pipeline	0.080	PVC,2km	Furrow
O-9	Chapula		60	60		Fixed Type	pipeline	0.060	PVC,2km	Furrow
O-14	Buleya Malima		57	57		Fixed Type	pipeline	0.034	PVC,2km	Furrow
O-15	Siatwinda		22	22		Fixed Type	pipeline	0.004	PVC,2km	Furrow
O-21	Nakandabwe		10	10	Small dam		pipeline	0.010	PVC,2km	Furrow
O-28	Makungwa		5	5	Small dam		pipeline	0.004	PVC,2km	Furrow
O-30	Vuu		13	13	Small dam		pipeline	0.010	PVC,2km	Furrow
O-31	Lusowe		10	10	Small dam		pipeline	0.010	PVC,2km	Furrow
Expansion of Existing Projects		**3,427**	**13,057**	**16,484**						
I-1	Nakatoya	0	10	10		Fixed Type		0.010	PVC,2km	Furrow
I-2	Mansa Pilot Scheme	0	10	10		Fixed Type		0.010	PVC,2km	Furrow
N-4	Chiyabi	0	10	10		Fixed Type		0.010	PVC,2km	Furrow
N-5	Kenani Vegetable Scheme	8	0	8		Fixed Type	open	0	PVC,2km	Furrow
N-6	Chiposa Mubende Scheme	0	10	10		Fixed Type		0.010	PVC,2km	Furrow
N-7	Chembe Vegetable Scheme	0	10	10		Fixed Type		0.010	PVC,2km	Furrow
N-8	Chama Vegetable Scheme	0	10	10		Fixed Type		0.010	PVC,2km	Furrow
O-1	Chiawa	0	20	20		Fixed Type		0.020	PVC,2km	Furrow
O-2	Chanyanya	0	800	800		no weir		0.800	SP,4km	Furrow
O-3	Masstock	0	1,000	1,000		no weir		1.000	SP,5km	Overhead
O-5	Kaunga	80	0	80		Fixed Type			ACP,5km	Furrow
O-6	Mpongwe (G/W)	0	2,200	2,200		sinkhole		2.200	SP,11km	Overhead
O-7	Munkumpu	2,000	0	2,000		Gate Type	open			Overhead
O-11	Ikelenge Pineapple	290	0	290		Gate Type	open			Furrow
O-13	Kaleya Small Holders	0	300	300		no weir		0.300	SP,1.5km	Furrow
O-18	Nakambala Sugar Estates	0	7,000	7,000		no weir		7.000	SP,35km	Furrow
O-20	Nanga	0	1,140	1,140		no weir		1.140	SP,5.7km	Overhead
O-22	Kawambwa Tea	0	47	47		Fixed Type		0.047	SP,0.25km	Overhead
O-24	Mulumbi Coffee	60	0	60		Fixed Type	open			Furrow
O-25	Lukulu North	989	0	989		Gate Type	open			Furrow
O-27	Kateshi Coffee	0	490	490		Fixed Type		2.5	2.94	Overhead
Potential Irrigation Project										
Dam Project		**8,480**	**6,590**	**15,070**						
D-1	Lufubu	7,000		7,000	Irrigation	open, siphon				Furrow
D-7	Mutondu		1,560	1,560	Multi-Pur.			1.560	SP,10km	Furrow
D-10	Kafubu		4,220	4,220	Multi-Pur.			4.220	SP,20km	Furrow
D-16	Chongwe	0	810	810	Multi-Pur.			0.810	SP,10km	Fur,Drip
D-18	Lundazi	1,480		1,480	Irrigation	open, siphon				Furrow
Run-of-River Project		**3,500**	**25,500**	**29,000**						
P-1	Machiya		5,000	5,000		Gate Type	pipeline	5.000	SP,25km	Furrow
P-79	Mwombeshi	500	500	1,000		Gate Type	pipeline	0.500	SP,2.5km	Furrow
P-80	Mwinilunga	1,150	1,150	2,300		Gate Type	pipeline	1.150	SP,5.75km	Furrow
P-82	Kabompo		3,000	3,000		no weir	pipeline	3.000	SP,15km	sprinkler
P-16	Katima Mulilo		1,000	1,000		no weir	pipeline	1.000	SP,5km	sprinkler
P-23	Zambezi F.plain (Left Bank)		3,000	3,000		no weir	75 km	3.105		Basin
P-84	Ngambwe Rapid		1,000	1,000		no weir	pipeline	1.000	SP,5km	sprinkler
P-86	Manto Rapid		1,000	1,000		no weir	pipeline	1.000	SP,5km	sprinkler
P-88	Sioma Rapid		1,000	1,000		no weir	pipeline	1.000	SP,5km	sprinkler
P-37	Mushota Island	1,000	1,000	2,000		Gate Type	pipeline	1.000	SP,5km	Furrow
P-45	Luapula		2,000	2,000		no weir	pipeline	2.000	SP,10km	Furrow
P-52	Chinakila	850	850	1,700		Gate Type	pipeline	0.850	SP,4.25km	Furrow
P-65	Chilbula South		5,000	5,000		Gate Type	pipeline	5.000	SP,15km	Furrow
Total		**15,417**	**45,404**	**60,821**						

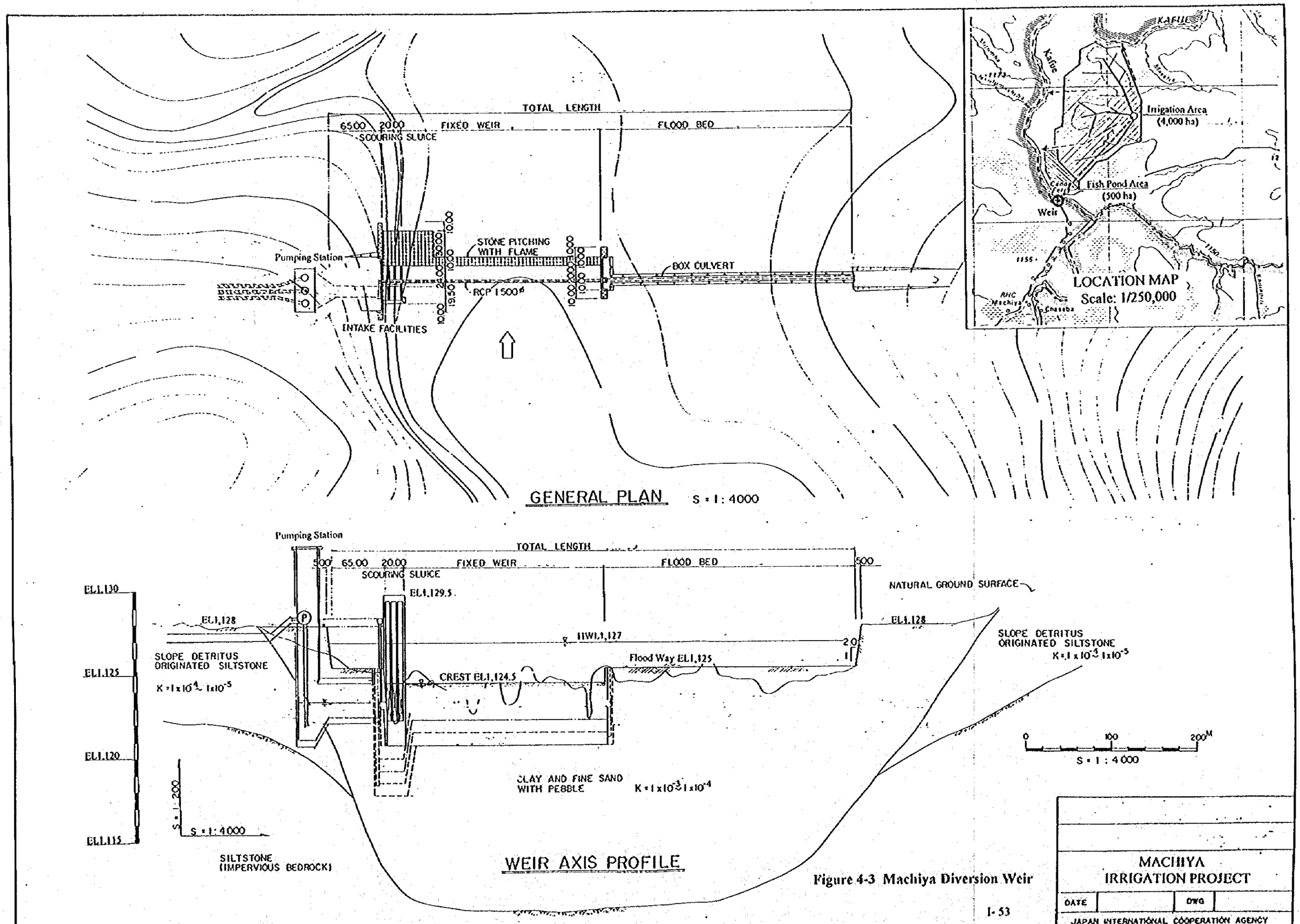
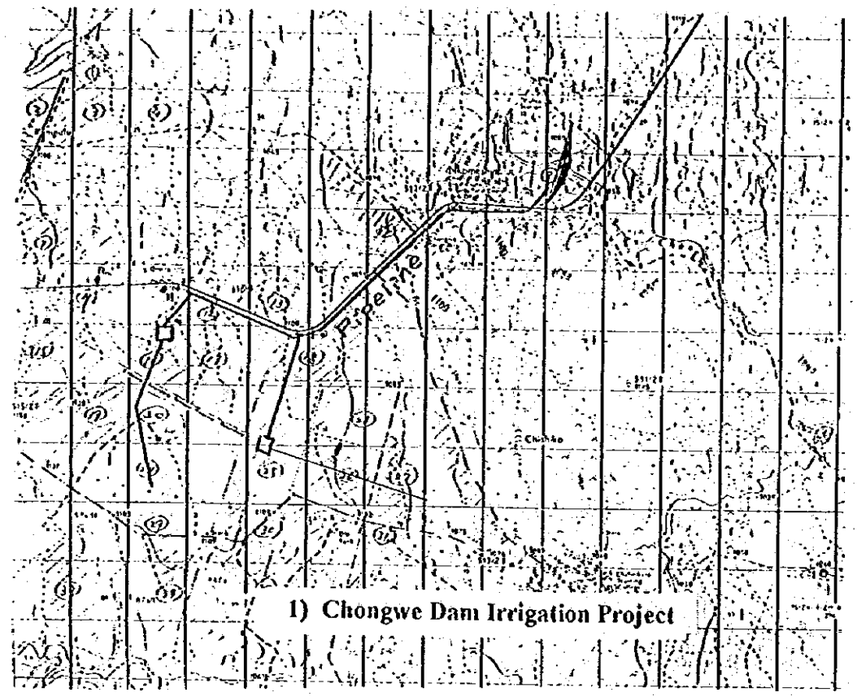


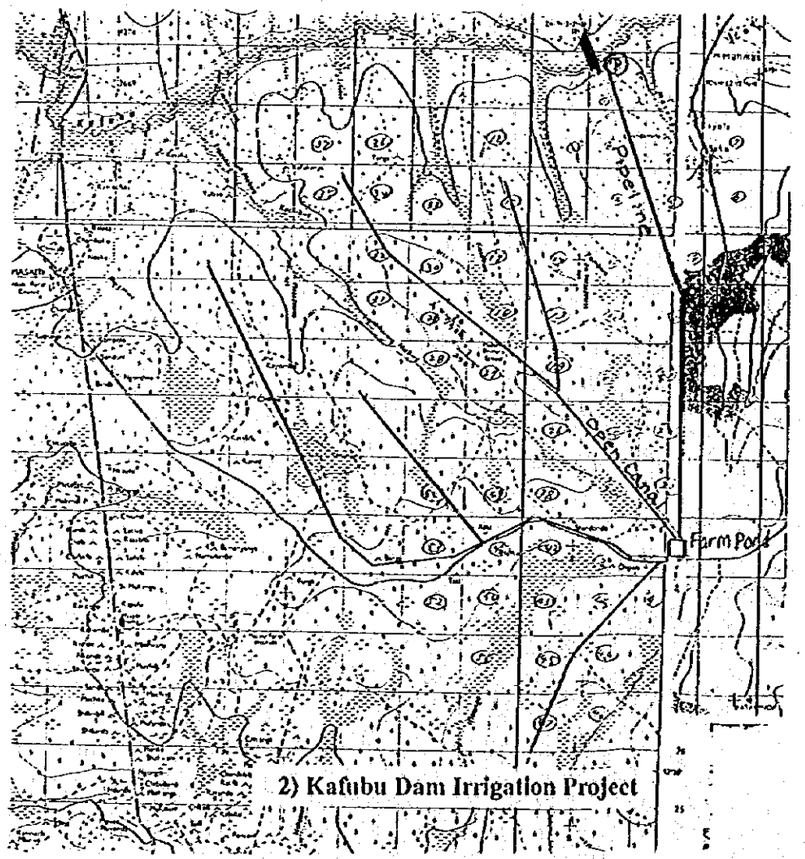
Figure 4-3 Machiya Diversion Weir

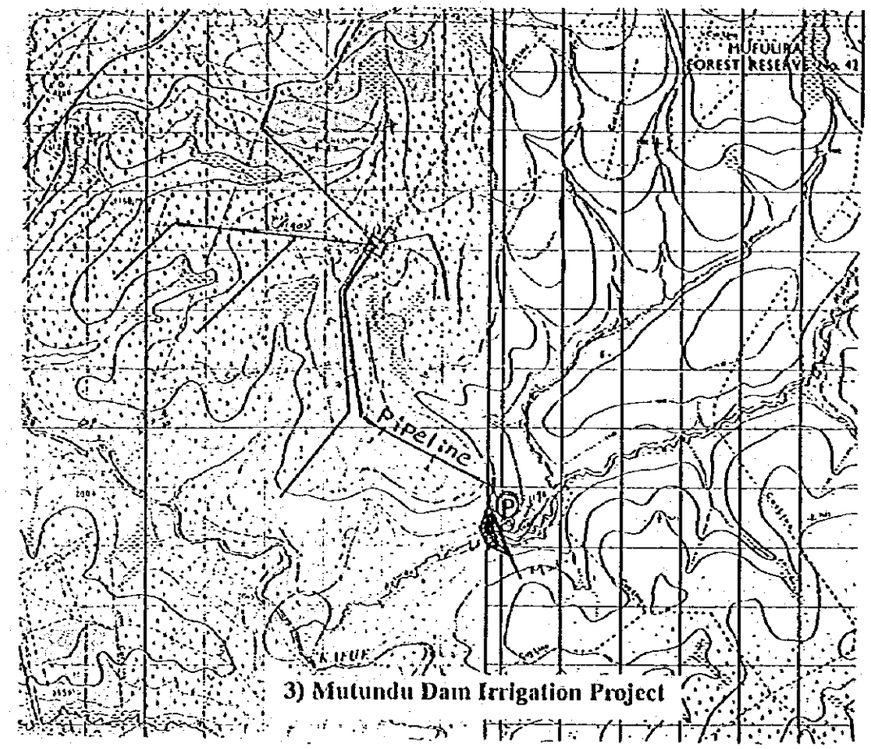
MACHIYA
IRRIGATION PROJECT

DATE | DWG

JAPAN INTERNATIONAL COOPERATION AGENCY







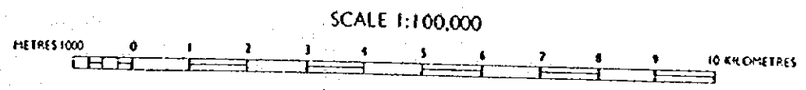


Figure 4-4 Plan of Irrigation Projects of Multipurpose Dam Development

CHAPTER 5 COST ESTIMATION OF IRRIGATION PROJECTS

5.1 Cost Estimation of Model Area

For estimating construction costs of proposed projects, some model areas are supposed. Costs 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

5.1.1 Basic Unit Cost of Irrigation Project

For estimating development cost of irrigation project, following basic unit costs are applied:

Land Reclamation :	US$4,000/ha (lands for new reclamation)
Land Consolidation :	US$2,000/ha (lands are utilised as farm presently)
Excavation:	K2,000/m^3 (swampy bulldozer)
Terminal Irrigation Facilities	
Furrow Irrigation:	US$1,200/ha
Overhead Irrigation:	US$1,500/ha
Low Lift Pump:	US$1,500/set (Q=5.0 lit/sec, H = 7m, 0.75 KW)
Electricity :	K23/Kwh
Dam Cost :	US$37.5/$m^3$

5.1.2 Standard Cost of Run-of-River Development Project

Cost of the projects has been estimated based on the model area assumed to meet the local conditions where pumps and weirs are required. Project scale is assumed for 1,000ha scale of irrigation project. The cost is mostly based on this estimation.

<Assumed Cost for 1,000 ha scale Pump Irrigation Project>		
Pumps (incld. house and related)	M'US$ 5.10	(US$ 5,100/ha)
Pipe cost	M'US$ 6.00	(US$ 6,000/ha)
Diversion dam	M'US$ 2.50	(US$ 2,500/ha)
Total	M'US$13.60	(US$13,600/ha)
<Pump Operation Cost>		
Electricity and Operator Cost	M'US$ 0.22/yr	(US$ 220/ha)
<O/M Cost of Facilities>:	2% of facility cost per annum	
<Replacement>:	20 years for pumps and pipeline	
<Assumed Condition>:		
Pumps	H = 100m, Q = 1.00 m^3/sec	
Pipeline (steel pipe)	L = 5 km	
Terminal irrigation system	Furrow or Basin Irrigation	

(Note) 1) Land consolidation cost to be added to above cost.

5.1.3 Standard Cost of Floodplain Development Project

<Assumed Cost for 100 ha scale Development>		
Land consolidation:	US$4,000/ha * 100ha	US$ 400,000
Intake canal:	US$120/m * 5,000 m	US$ 600,000
Canalisation:	US$1,200/ha * 100ha	US$ 120,000 (field canal)
Pumps:	US$1,500/set * 40 sets	US$ 60,000
Total		US$1,180,00 (US$11,800/ha)
<Pump Operation Cost>		
Electricity and Operator Cost		US$9,700/100ha (US$97/ha)
<O/M Cost of Facilities>:		2% of capital cost
<Replacement>:		20 years for pumps and pipeline
<Assumed Condition>		
Pumps	40 low lift pumps/100ha (H =7m, Q = 5 lit/sec/set)	
Intake canal	L = 5 km for 100ha (d = 3.5m, B = 2.0m bottom)	
Terminal irrigation system	Basin Irrigation	
Water requirement:	2.00 lit/sec/ha (average of rice and vegetables in dry season)	
Flood protection:	No particular flood protection facilities	

5.2 Cost Estimation of Irrigation Project

5.2.1 Total Construction Cost of Irrigation Project

Total construction cost of irrigation projects amounts to US$ 1,190 million in the Base Scenario-Agricultural Expansion, comprising US$ 6.55 million (0.55%) for the ASIP Rehabilitation Project, US$ 301 million (25%) for Existing Expansion Project, US$ 281 million (24%) for the Dam Project and US$ 601 million (50%) for the Run-of-River Irrigation Project. Total construction cost in the Base Scenario-Industrialisation and in the Conservative Scenario are US$ 956 million and US$ 763 million, respectively, or 80% and 64%, compared to that in the Base Scenario-Agricultural Expansion.

Table 5-1 Total Construction Cost of Irrigation Project (Unit: US$ million)

Base Scenario - Agricultural Expansion						
Province	ASIP Rehabilitation	Existing Expansion	Multipurpose Dam Project	Irrigation Dam Project	Run of River Project	Total
Lusaka	0.09	38.64	34.74	-	-	73.47
Copperbelt	3.27	63.82	163.58	-	-	230.67
Central	-	-	-	-	103.40	103.40
N/Western	-	2.46	-	-	200.90	203.36
Western	-	0.21	-	-	103.18	103.39
Southern	2.42	175.12	-	-	-	177.54
Luapula	-	10.80	-	56.96	65.01	132.77
Northern	-	10.31	-	-	128.18	138.49
Eastern	0.77	-	-	26.13	-	26.90
Total	6.55	301.36	198.32	83.09	600.67	1,189.89
Base Scenario - Industrialisation						
Province	ASIP Rehabiritation	Existing Expansion	Multipurpose Dam Project	Irrigation Dam Project	Run of River Project	Total
Lusaka	0.09	38.64	34.74	-	-	73.47
Copperbelt	3.27	63.82	123.33	-	-	190.42
Central	-	-	-	-	103.40	103.40
N/Western	-	2.46	-	-	48.11	50.57
Western	-	0.21	-	-	87.12	87.33
Southern	2.42	175.12	-	-	-	177.54
Luapula	-	10.80	-	56.96	65.01	132.77
Northern	-	10.31	-	-	103.49	113.71
Eastern	0.77	-	-	26.13	-	26.90
Total	6.55	301.36	158.07	83.09	407.04	956.10
Conservative Scenario						
Province	ASIP Rehabiritation	Existing Expansion	Multipurpose Dam Project	Irrigation Dam Project	Run of River Project	Total
Lusaka	0.09	38.64	34.74	-	-	73.47
Copperbelt	3.27	63.82	179.91	-	-	247.00
Central	-	-	-	-	-	0.00
N/Western	-	2.46	-	-	33.53	35.99
Western	-	0.21	-	-	48.51	48.72
Southern	2.42	175.12	-	-	-	177.54
Luapula	-	10.80	-	-	29.15	39.95
Northern	-	10.31	-	-	103.40	113.71
Eastern	0.77	-	-	26.13	-	26.90
Total	6.55	301.36	214.65	26.13	214.59	763.28

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).

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.

Table 5-2 Unit Construction Cost and Water Cost of Irrigation Project

	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

Construction costs and water cost for irrigation projects are shown in Table 5-3.

Table 5-3 Water Cost by Type of Irrigation Project

Province	Base Scenario-Agricultural Expansion			Base Scenario-Industrialisation			Conservative Scenario		
	Developed Water ($1000m^3$/day)	Const. Cost (US$ million)	Unit Price (US$/m3/day)	Developed Water ($1000m^3$/day)	Const. Cost (US$ million)	Unit Price (US$/m3/day)	Developed Water ($1000m^3$/day)	Const. Cost (US$ million)	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
North-western	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	56.96	94.15	605	56.96	94.15	0	0.00	0.00
Extension Project	99	10.80	109.09	99	10.80	109.09	99	10.80	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	103.40	239.35	432	103.40	239.35	432	103.40	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	4,654	956.10	205.44	3,300	763.28	231.30

5.2.2 Construction and O/M Costs of Individual Project

Construction cost of each project has been calculated together with project benefit. The results are summarised in Table 5-4. Project cost of each project is shown only for Base Scenario- Agricultural Expansion, because Base Scenario- Agricultural Expansion is maximal in development scale among three scenarios and covering all proposed projects.

Table 5-4 Summary of Cost and Benefit of Irrigation Project
(Base Scenario - Agricultural Expansion) (1/2)

Project Category	Project Name	Beneficial Area (ha)	Capital Cost (MUS$)	Total incld. E/S (MUS$)	Replacement Cost (MUS$)	O/M cost (1000US$/y)	Benfit	Proposed Land Use	Present Land Use
<Multipurpose Dam Projects>									
Lusaka									
D-16	Chongwe	810	31.58	34.74	4.13	810	6,917	Veg(70%)-Flower(30%)	Maize
Copperbelt									
D-10	Kafubu	4,220	94.08	103.49	21.52	2,810	27,050	Veg-Veg	Maize
D-7	Mutundu	1,560	54.63	60.09	7.96	1,436	10,000	Veg-Veg	Forest
Sub-total		6,590	180.29	198.32	33.61	5,056	43,967		
<Irrigation Dam Projects>									
Luapula									
D-1	Lufbu	7,000	51.78	56.96	0.00	1,036	24,850	*1)	Forest
Eastern									
D-18	Lundazi	1,480	23.75	26.13	0.00	475	9,487	Veg-Veg	Maize
Sub-total		8,480	75.53	83.09	0.00	1,511	34,337		
Dam Project Total		15,070	255.82	281.41	33.61	6,567	78,304		
<ASIP Rehabilitation>									
Lusaka									
N-3	Chipapa	10	0.08	0.09	0.00	2	64	Veg-Veg	Maize
Copperbelt									
N-2	Ipafu	80	1.51	1.66	0.41	48	513	Veg-Veg	Maize
O-9	Chapula	60	1.46	1.61	0.46	42	385	Veg-Veg	Maize
Sub-total		140	2.97	3.27	0.87	90	898		
Southern									
O-14	Buleya Malima	57	1.39	1.53	0.44	40	365	Veg-Veg	Maize
O-15	Siatwinda	22	0.55	0.61	0.17	16	141	Veg-Veg	Maize
O-21	Nakandbwe	10	0.25	0.28	0.08	7	64	Veg-Veg	Maize
Sub-total		89	2.19	2.42	0.69	63	570		
Eastern									
O-28	Makungwa	5	0.13	0.14	0.04	4	32	Veg-Veg	Maize
O-30	Vuu	13	0.32	0.35	0.10	9	83	Veg-Veg	Maize
O-31	Lusowe	10	0.25	0.28	0.08	7	64	Veg-Veg	Maize
Sub-total		28	0.70	0.77	0.22	20	179		
Total		267	5.94	6.55	1.78	173	1,711	Veg-Veg	Maize
Expansion of Existing Projects									
Lusaka									
O-1	Chiawa	20	0.374	0.414	0.100	12	39	Wheat-GN	Maize
O-2	Chanyanya	800	15.040	16.540	4.080	477	1,552	Wheat-GN	Maize
O-3	Masstock	1,000	19.100	21.010	5.100	602	1,940	Wheat-GN	Maize
O-5	Kaunga	80	0.616	0.676	0.000	12	155	Wheat-GN	Maize
Sub-total		1,900	35.130	38.640	9.280	1,103	3,686		
Copperbelt									
O-6	Mpongwe (G/W)	2,200	42.020	46.220	11.220	1,324	4,268	Wheat-GN	Maize
O-7	Munkumpu	2,000	16.000	17.600	0.000	320	3,880	Wheat-GN	Maize
Sub-total		4,200	58.020	63.820	11.220	1,644	8,148		
N/Western									
O-11	Ikelenge Pineapple	290	2.238	2.458	0.000	45	563	Wheat-GN	Maize
Western									
I-1	Nakatoya	10	0.192	0.212	0.050	6	19	Wheat-GN	Maize
Southern									
N-4	Chiyabi	10	0.192	0.212	0.050	6	19	Wheat-GN	Maize
O-13	Kaleya Small Holde	300	5.640	6.200	1.530	179	441	Sugarcane	Maize
O-18	Nakambala Sugar Es	7,000	131.600	144.760	35.700	4,172	10,290	Sugarcane	Maize
O-20	Nanga	1,140	21.770	23.950	5.810	686	2,212	Wheat-GN	Maize
Sub-total		8,450	159.202	175.122	43.090	5,043	12,962		
Luapula									
I-2	Mansa Pilot Scheme	10	0.192	0.212	0.050	6	19	Wheat-GN	Maize
N-5	Kenani Vegetable Sc	8	0.060	0.070	0.000	1	16	Wheat-GN	Maize
N-6	Chiposa Mubende S	10	0.192	0.212	0.050	6	19	Wheat-GN	Maize
N-7	Chembe Vegetable S	10	0.192	0.212	0.050	6	19	Wheat-GN	Maize
N-8	Chama Vegetable Sc	10	0.192	0.212	0.050	6	19	Wheat-GN	Maize
O-22	Kawambwa Tea	47	0.901	0.991	0.240	28	91	Wheat-GN	Maize
O-24	Mulumbi Coffee	60	0.462	0.512	0.000	9	116	Wheat-GN	Maize
O-25	Lukulu North	989	7.617	8.377	0.000	152	1,919	Wheat-GN	Maize
Sub-total		1,144	9.807	10.797	0.440	214	2,218		
Northern									

Table 5-4 Summary of Cost and Benefit of Irrigation Project
(Base Scenario - Agricultural Expansion) (2/2)

Project Category	Project Name	Bene-ficial Area (ha)	Capital Cost (MUS$)	Total incld. E/S (MUS$)	Replacement Cost (MUS$)	O/M cost (1000US$/yr)	Benfit	Proposed Land Use	Present Land Use
O-27	Kateshi Coffee	490	9.365	10.305	2.500	295	951	Wheat-GN	Maize
Total		16,484	273.954	301.354	66.580	8,350	28,547		
Potential Irrigation Projects									
Central									
P- 1	Machiya	5,000	94.00	103.40	25.50	2,980	17,750	*1)	new
Sub-total		5,000	94.00	103.40	25.50	2,980	17,750		
N/Western									
P- 79	Mwombeshi	1,000	13.25	14.58	2.55	375	3,550	*1)	new
P- 80	Mwinilunga	2,300	30.48	33.53	5.87	863	8,165	*1)	new
P- 82	Kabompo	3,000	138.90	152.79	63.00	3,438	10,650	*1)	new
Sub-total		6,300	182.63	200.90	71.42	4,676	22,365		
Western									
P- 16	Katima Mulilo	1,000	14.60	16.06	5.10	512	3,550	*1)	farm
P- 23	Zambezi Floodplain	3,000	35.40	38.94	1.80	1,368	8,700	*2)	farm
P- 84	Ngambwe Rapid	1,000	14.60	16.06	5.10	512	3,550	*1)	farm
P- 86	Manto Rapid	1,000	14.60	16.06	5.10	512	3,550	*1)	farm
P- 88	Sioma Rapid	1,000	14.60	16.06	5.10	512	3,550	*1)	farm
Sub-total		7,000	93.80	103.18	22.20	3,416	22,900		
Luapula									
P- 37	Mushota Island	2,000	26.50	29.15	5.10	750	7,100	*1)	new
P- 45	Luapula	2,000	32.60	35.86	10.20	1,092	7,100	*1)	new
Sub-total		4,000	59.10	65.01	15.30	1,842	14,200		
Northern									
P- 52	Chinakila	1,700	22.53	24.78	4.34	638	6,035	*1)	new
P- 65	Chilbula South	5,000	94.00	103.40	25.50	2,980	17,750	*1)	new
Sub-total		6,700	116.53	128.18	29.84	3,618	23,785		
Total		29,000	546.06	600.67	164.26	16,532	101,000		
Grand Total		60,821	1,081.77	1,189.98	266.23	31,622	209,562		

(Note) Benefit:

1) Vegetable-Vegetable=K3,909,000/ha=US$6,410/ha
2) *1) Vegetable 20%, Wheat 40%, Tree Crop 40% = K2,164,000/ha = US$3,550/ha
   *2) Wet Season: Rice (100%) + Dry Season: Rice (50%) + Veg. (50%)
   =K505,600/ha+(K576,000/2 + K1,955,000/2)/ha
   =K505,600/ha + K1,265,500/ha = K1,771,100/ha = $2,900/ha
3) Wheat - Groundnuts = K1,181,000/ha = US$1,940/ha
4) Sugarcane = K896,200/ha = US$1,470/ha
5) Vegetable (70%) - Flower (30%) = K5,209,000/ha = US$8,540/ha

Table 5-5 Cost Estimation of ASIP Rehabilitation Project

Projects	Irrigable Area (ha)			Present	Weir	Canal	Pump	Pipeline	Furrow	Sprinker	Landscape	Sub-total	E/S	Total	O/M Cost	Unit Cost
	Gravity	Pump	Total	Land Use	(M'US$)	(M'US$)	(M'US$)	(M'US$)	(M'US$)	(M'US$)	(M'US$)	(M'US$)	(M'US$)	(M'US$)	(1000US$/yr)	($/ha)
N- 1 Chipapa	10		10	Farm	0.03	0	0	0	0.01	0	0.04	0.08	0.01	0.09	2	9,000
N- 2 Ipafu		80	80	Farm	0.2	0	0.41	0.48	0.1	0	0.32	1.51	0.15	1.66	48	21,000
O- 9 Chapula		60	60	Farm	0.15	0	0.46	0.54	0.07	0	0.24	1.46	0.15	1.61	42	27,000
O- 14 Bulcya Malima		57	57	Farm	0.14	0	0.44	0.51	0.07	0	0.23	1.39	0.14	1.53	40	27,000
O- 15 Siatwinda		22	22	Farm	0.06	0	0.17	0.2	0.03	0	0.09	0.55	0.06	0.61	16	28,000
O- 21 Nakandabwe		10	10	Farm	0.03	0	0.08	0.09	0.01	0	0.04	0.25	0.03	0.28	7	28,000
O- 28 Makungwa		5	5	Farm	0.01	0	0.04	0.05	0.01	0	0.02	0.13	0.01	0.14	4	28,000
O- 30 Vuu		13	13	Farm	0.03	0	0.1	0.12	0.02	0	0.05	0.32	0.03	0.35	9	27,000
O- 31 Lusowe		10	10	Farm	0.03	0	0.08	0.09	0.01	0	0.04	0.25	0.03	0.28	7	28,000
Total	10	257	267		0.68	0	1.78	2.08	0.33	0	1.07	5.94	0.61	6.55	173	25,000

Table 5-6 Cost Estimation of Existing Expansion Project

		Gravity	Pump	Total	presen	Weir	Canal	Pump	Pipeline	Furrow	Sprinkler	Landscape	Sub-total	E/S	Total	O/M Cost	Unit Cost
O-	1 Chiawa	0	20	20	Maize	0.05		0.1	0.12	0.024	0	0.08	0.374	0.04	0.414	12	21000
O-	2 Chanyanya	0	800	800	Maize	2		4.08	4.8	0.96	0	3.2	15.04	1.5	16.54	477	21000
O-	3 Masstock	0	1000	1000	Maize	2.5		5.1	6	0	1.5	4	19.1	1.91	21.01	602	21000
O-	5 Kaunga	80	0	80	Maize	0.2		0	0	0.096	0	0.32	0.616	0.06	0.676	12	8000
O-	6 Mpongwe (G/W)	0	2200	2200	Maize	5.5		11.22	13.2	0	3.3	8.8	42.02	4.2	46.22	1324	21000
O-	7 Munkumpu	2000	0	2000	Maize	5		0	0	0	3	8	16	1.6	17.6	320	9000
O-	11 Ikelenge Pineapple	290	0	290	Maize	0.73		0	0	0.348	0	1.16	2.238	0.22	2.458	45	8000
I-	1 Nakatoya	0	10	10	Maize	0.03		0.05	0.06	0.012	0	0.04	0.192	0.02	0.212	6	21000
N-	4 Chiyabi	0	10	10	Maize	0.03		0.05	0.06	0.012	0	0.04	0.192	0.02	0.212	6	21000
O-	13 Kaleya Small Holders	0	300	300	Maize	0.75		1.53	1.8	0.36	0	1.2	5.64	0.56	6.2	179	21000
O-	18 Nakanbala Sugar Estates	0	7000	7000	Maize	17.5		35.7	42	8.4	0	28	131.6	13.16	144.76	4172	21000
O-	20 Nanga	0	1140	1140	Maize	2.85		5.81	6.84	0	1.71	4.56	21.77	2.18	23.95	686	21000
I-	2 Mansa Pilot Scheme	0	10	10	Maize	0.03		0.05	0.06	0.012	0	0.04	0.192	0.02	0.212	6	21000
N-	5 Kenani Vegetable Schem	8	0	8	Maize	0.02		0	0	0.0096	0	0.03	0.0596	0.01	0.0696	1	9000
N-	6 Chiposa Mubende Schem	0	10	10	Maize	0.03		0.05	0.06	0.012	0	0.04	0.192	0.02	0.212	6	21000
N-	7 Chembe Vegetable Schei	0	10	10	Maize	0.03		0.05	0.06	0.012	0	0.04	0.192	0.02	0.212	6	21000
N-	8 Chama Vegetable Schem	0	10	10	Maize	0.03		0.05	0.06	0.012	0	0.04	0.192	0.02	0.212	6	21000
O-	22 Kawambwa Tea	0	47	47	Maize	0.12		0.24	0.28	0	0.0705	0.19	0.9005	0.09	0.9905	28	21000
O-	24 Mulumbi Coffee	60	0	60	Maize	0.15		0	0	0.072	0	0.24	0.462	0.05	0.512	9	9000
O-	25 Lukulu North	989	0	989	Maize	2.47		0	0	1.1868	0	3.96	7.6168	0.76	8.3768	152	8000
O-	27 Kateshi Coffee	0	490	490	Maize	1.23		2.5	2.94	0	0.735	1.96	9.365	0.94	10.305	295	21000

Table 5-7 Cost Estimation of Dam Irrigation Project
(Base Scenario - Agricultural Expansion)

Dam No. / Dam Name	Dam Volume (10^3m^3)	Dam Cost (MUS$)	Water (m3/sec) Urban Water	Water (m3/sec) Irrigation	Dam Allocation (MUS$)	Water Use (m3/s)	Water Use (m3/day)	Irrigable Area (ha) Gravity Area	Irrigable Area (ha) Pump Area	Irrigable Area (ha) Total	Present Land Use	Cost of Irrigation Facilities (Million$) Weir	Pump	Pipeline/ Canal	Furrow Irrigation	Land Scape (*1)	Land Scape (*2)	Total	Eng. Service (MUS$)	Grand Total (MUS$)	Unit Cost ($/ha)	O/M Cost (1000US$/yr)
1 Lufubu	410	15.38	0	14.02	15.38	7.0	604,800	7,000		7,000			0	0	8.4	28	0	51.78	5.18	56.96	8,000	1,036
2 West Lunga	1,263	47.36	0	28.51	47.36	2.5	216,000		2,500	2,500			12.75	15	3	10	0	88.11	8.81	96.92	39,000	2,312
3 Lukupa	1,079	40.46	0	2.07	40.46	0.0	0			0			0	0	0	0	0	0	0	0	0	0
4 Kapemba	451	16.91	0	0.24	16.91	0.0	0			0			0	0	0	0	0	0	0	0	0	0
5 Solwezi	578	21.68	0	1.02	21.68	1.0	86,400	1,000		1,000			0	0	1.2	4	0	26.88	2.69	29.57	30,000	538
6 Kafue	1,469	55.09	0	14.61	55.09	1.8	155,520		1,800	1,800			9.18	10.8	2.16	7.2	0	84.43	8.44	92.87	52,000	2,085
7 Mutundu	981	36.79	0.46	1.563	29.2	1.6	134,784		1,560	1,560			7.96	9.36	1.87	6.24	0	54.63	5.46	60.09	39,000	1,436
8 Lubi							0			0			0	0	0	0	0	0	0	0	0	0
9 Lufupa	472	17.7	0	0.47	17.7	0.5	43,200	500		500			0	0	0.6	2	0	20.3	2.03	22.33	45,000	406
10 Kafubu	795	29.81	1.04	4.225	25.3	4.2	364,608		4,220	4,220			21.52	25.32	5.06	16.88	0	94.08	9.41	103.49	25,000	2,810
11 Lunsemfwa	650	24.38	0	4.28	24.38	4.3	371,520		4,300	4,300			21.93	25.8	5.16	17.2	0	94.47	9.45	103.92	24,000	2,835
12 Mwomboshi	1,030	38.63	0	0.78	38.63	0.8	69,120		800	800			4.08	4.8	0.96	3.2	0	51.67	5.17	56.84	71,000	1,209
13 Kopyonga	566	21.23	0	0.37	21.23	0.4	31,968	370		370	farm		0	0	0.44	0	0.74	22.41	2.24	24.65	67,000	448
14 Muchito	695	26.06	0	0.03	26.06	0.0	0			0			0	0	0	0	0	0	0	0	0	0
15 Kanakantapa	328	12.3	0	0.08	12.3	0.0	0			0			0	0	0	0	0	0	0	0	0	0
16 Chongwe	1,315	49.31	1.22	0.81	20	0.8	69,984	0	810	810	farm	0.00	4.13	4.86	0.97	0.00	1.62	31.58	3.16	34.74	43,000	810
17 Mwapula	246	9.23	0	0.29	9.23	0.3	25,920	300		300			0	0	0.36	1.20	0	10.79	1.08	11.87	40,000	216
18 Lundazi	428	16.05	0	1.48	16.05	1.5	127,872	1,480		1,480			0	0	1.78	5.92	0	23.75	2.38	26.13	18,000	475
19 Lukusashi	896	33.6	0	5.01	33.6	0.0	0			0			0	0	0	0	0	0	0	0	0	0
20 Lutembwe	2,210	82.88	0	2.76	82.88	2.8	241,920	2,800		2,800			0	0	3.36	11.2	0	97.44	9.74	107.18	38,000	1,949
21 Katete	517	19.39	0	0.12	19.39	0.1	8,640	100		100			0	0	0.12	0.4	0	19.91	1.99	21.9	219,000	398
22 Zambezi (Mongu)										0			0	0	0	0	0	0	0	0	0	0
23 Zambezi (Livingstone)										0			0	0	0	0	0	0	0	0	0	0
24 Luongo	2,508	94.05	0	18.42	94.05	0.0	0			0			0	0	0	0	0	0	0	0	0	0
25 Lwombe	316	11.85	0	0		0.0	0			0			0	0	0	0	0	0	0	0	0	0
26 Bengwa	2,417	90.64	0	1.35	90.64	1.3	112,320	1,300		1,300			0	0	1.56	5.2	0	97.4	9.74	107.14	82,000	1,948
27 Kalomo	910	34.13	0	0.31	34.13	0.3	25,920	300		300			0	0	0.36	1.2	0	35.69	3.57	39.26	131,000	714

Table 5-8 Cost Estimation of Run of River Irrigation Project

(Base Scenario - Agricultural Expansion)

Province / Projects	Irrigable Area (ha) Gravity	Pump	Total	Present Land Use	Weir (M'US$)	Canal (M'US$)	Pump (M'US$)	Pipeline (M'US$)	Furrow (M'US$)	Sprinker (M'US$)	Landscape (M'US$)	Sub-total (M'US$)	E/S (M'US$)	Total (M'US$)	O/M Cost (1000US$/yr)	Unit Cost ($/ha)
Central																
P- 1 Machiya		5,000	5,000	new	12.50		25.50	30.00	6.00		20.00	94.00	9.40	103.40	2,980	21,000
Sub-total	0	5,000	5,000		12.50		25.50	30.00	6.00	0.00	20.00	94.00	9.40	103.40	2,980	
N/Western																
P- 79 Mwombeshi	500	500	1,000	new	2.50		2.55	3.00	1.20		4.00	13.25	1.33	14.58	375	15,000
P- 80 Mwinilunga	1,150	1,150	2,300	new	5.75		5.87	6.90	2.76		9.20	30.48	3.05	33.53	863	15,000
P- 82 Kabompo		3,000	3,000	new			63.00	59.40		4.50	12.00	138.90	13.89	152.79	3,438	51,000
Sub-total	1,650	4,650	6,300		8.25		71.42	69.30	3.96	4.50	25.20	182.63	18.27	200.90	4,676	
Western																
P- 16 Katima Mulilo		1,000	1,000	farm			5.10	6.00		1.50	2.00	14.60	1.46	16.06	512	16,000
P- 23 Zambezi F.plain (Left B.)		3,000	3,000	farm		18.00	1.80		3.60	(*2)	12.00	35.40	3.54	38.94	1,368	13,000
P- 84 Ngambwe Rapid		1,000	1,000	farm			5.10	6.00		1.50	2.00	14.60	1.46	16.06	512	16,000
P- 86 Manto Rapid		1,000	1,000	farm			5.10	6.00		1.50	2.00	14.60	1.46	16.06	512	16,000
P- 88 Sioma Rapid		1,000	1,000	farm			5.10	6.00		1.50	2.00	14.60	1.46	16.06	512	16,000
Sub-total	0	7,000	7,000		0.00	18.00	22.20	24.00	3.60	6.00	20.00	93.80	9.38	103.18	3,416	
Luapula																
P- 37 Mushota Island	1,000	1,000	2,000	new	5.00		5.10	6.00	2.40		8.00	26.50	2.65	29.15	750	15,000
P- 45 Luapula		2,000	2,000	new			10.20	12.00	2.40		8.00	32.60	3.26	35.86	1,092	18,000
Sub-total	1,000	3,000	4,000		5.00	0.00	15.30	18.00	4.80	0.00	16.00	59.10	5.91	65.01	1,842	
Northern																
P- 52 Chinakila	850	850	1,700	new	4.25		4.34	5.10	2.04		6.80	22.53	2.25	24.78	638	15,000
P- 65 Chilbula South		5,000	5,000	new	12.50		25.50	30.00	6.00		20.00	94.00	9.40	103.40	2,980	21,000
Sub-total	850	5,850	6,700		16.75	0.00	29.84	35.10	8.04	0.00	26.80	116.53	11.65	128.18	3,618	
Total	3,500	25,500	29,000		42.50	18.00	164.26	176.40	26.40	10.50	108.00	546.06	54.61	600.67	16,532	21,000

5.3 Implementation Schedules of Irrigation Project

Implementation schedules of irrigation development projects is shown in Table 5-9.

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 5-9 Implementation Schedule of Irrigation Development Projects for Base Scenario - Agriculture Development

Project	Water Developed ($1000m^3$/day)		Irrigation Area (ha)		Cost mil. US$	Implementation Schedule
	2005	2015	2005	2015		96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15
Lusaka Prov.	235	235	2,720	2,720	73.47	
Chongwe Dam	70	70	810	810	34.74	
ASIP Rehabilitation	1	1	10	10	0.09	
Expansion Project	164	164	1,900	1,900	38.64	
Copperbelt Prov.	375	875	4,340	10,120	230.67	
Kafubu Dam	0	365	-	4,220	103.49	
Mutundu Dam	0	135	-	1,560	60.09	
ASIP Rehabilitation	12	12	140	140	3.27	
Expansion Project	363	363	4,200	4,200	63.82	
Central Prov.	432	432	5,000	5,000	103.40	
New Project : P-1	432	432	5,000	5,000	103.40	
North western Prov.	224	569	2,590	6,590	203.36	
Expansion Project	25	25	290	290	2.46	
New Project : P-79	0	86	-	1,000	14.58	
New Project : P-80	199	199	2,300	2,300	33.53	
New Project : P-82	0	259	-	3,000	152.79	
Western Prov.	303	606	3,510	7,010	103.39	
Expansion Project	1	1	10	10	0.21	
New Project : P-16	86	86	1,000	1,000	16.06	
New Project : P-23	130	261	1,500	3,000	38.94	
New Project : P-84	86	86	1,000	1,000	16.06	
New Project : P-86	0	86	-	1,000	16.06	
New Project : P-88	0	86	-	1,000	16.06	
Southern Prov.	738	738	8,539	8,539	177.54	
ASIP Rehabilitation	8	8	89	89	2.42	
Expansion Project	730	730	8,450	8,450	175.12	
Luapula Prov.	272	1,050	3,144	12,144	132.77	
Lufubu Dam	0	605	-	7,000	56.96	
Expansion Project	99	99	1,144	1,144	10.80	
New Project : P-37	173	173	2,000	2,000	29.15	
New Project : P-45	0	173	-	2,000	35.86	
Northern Prov.	189	621	2,190	7,190	138.49	
Expansion Project	42	42	490	490	10.31	
New Project ; P-52	147	147	1,700	1,700	24.78	
New Project : P-65	0	432	-	5,000	103.40	
Eastern Prov.	2	130	28	1,508	26.90	
Lundazi Dam	0	128	-	1,480	26.13	
ASIP Rehabilitation	2	2	28	28	0.77	
Total	2,770	5,256	32,061	60,821	1,190.0	16% 25% 40% 19%

CHAPTER 6 BENEFIT AND CAPACITY TO-PAY OF IRRIGATION PROJECT

6.1 Benefit of Irrigation Project

6.1.1 Crop Benefit

For evaluating the irrigation projects, benefit of the projects are estimated depending on crop benefit. Crop benefit has been estimated excluding the water cost from the gross margin of crops, because water cost is involved in annual repayment of the construction cost and annual operation and maintenance (O/M) cost. Gross margins of crops, which are estimated in the Supporting Report -H, accounting water cost in variable cost. Therefore, crop benefit is estimated excluding water cost from variable cost. Table 6-1 shows benefits and water cost of crops. Water cost is estimated applying unit water cost of K50/m^3 to irrigation amount of crops. Irrigation amount refers water requirements of crops in Table 2-3.

Table 6-1 Water Cost and Crop Benefit of Irrigated Crops

Crops	Yield	Price	Gross Earning	Variable Cost (*1)	Gross Margin	Irrigation Amount	Water Cost (*2)	Crop Benefit
			(1)	(2)	(3)=(1)-(2)	(4)	(5) = (4)*K50/m3	(6)=(3)+(5)
	(ton/ha)	(K/ton)	(K1,000/ha)			(m3/ha)	(K1,000/ha)	
Dry Season Crops								
Vegetables								
Tomato	24.80	166,700	4,134	2,100	2,034	17,050	853	2,887
Onion	20.00	150,000	3,000	2,363	637	11,450	573	1,210
Cabbage	20.00	150,000	3,000	1,053	1,947	10,300	515	2,462
Lettuce	20.00	80,000	1,600	1,059	541	10,300	515	1,056
Carrots	18.00	150,000	2,700	1,056	1,644	10,300	515	2,159
Wheat	5.07	242,000	1,227	958	269	9,925	496	765
Rice	4.50	187,500	844	773	70	20,200	505	575
Perennial Crops								
Sugarcane	108.00	16,900	1,825	1,877	-52	18,950	948	896
Coffee	2.00	1,530,000	3,060	1,129	1,931	12,850	643	2,574
Tea	4.44	740,000	3,286	1,324	1,962	12,850	643	2,604
Orange	17.50	120,000	2,100	1,097	1,003	12,850	643	1,646
Banana	4.14	240,000	994	892	102	12,850	643	744
Wet Season Crops								
Rice	4.00	187,500	750	567	183	12,900	323	506
Maize	5.40	92,560	500	526	-26	2,300	58	31
Potato	17.70	250,000	4,425	2,071	2,354	6,000	300	2,654
Groundnuts	1.84	441,250	812	446	366	1,000	50	416

(Note) (*1): Variable cost is referring Gross Margin Budget (Appendix-2, Supporting Report-H.)
(*2): Unit water cost of rice is estimated at K50/m3 (MAFF Estimation) except rice.
K25/m3 for rice because lower cost both for construction and operation/maintenance.

Benefit has been estimated based on present irrigated yield level, because future increase of yield depends mostly on improvement of cultivation and improved seeds by research and extension works. In this study, any necessary costs such as for extension works are not counted.

6.1.2 Selection of Crops for Irrigation Project

As shown in Table 6-1, crop benefit varies by crops. Vegetables, coffee, tea and potatoes earn high benefit, while maize earn negligible small benefit. Gross margin of maize is negative for farmers. Although irrigation to maize is certainly necessary as discussed in Section 2.2, maize is seldom irrigated in the country. Consequently, maize will be excluded from irrigation taking economical aspect into consideration.

6.1.3 Crop Benefit applied for Project Evaluation

Table 6-2 shows the benefit of crops which are considered its introduction into the irrigation project.

Table 6-2 Applied Crop Benefit for the Study

Crops	Descriptions			Applied Benefit
	Crops	Benefit (K1000/ha)		
1. Vegetables (Single)	Tomato Onion Cabbage Lettuce Carrot	2,887 1,210 2,462 1,056 2,159	Average =K1,955/ha or US$3,205/ha	US$3,205/ha
2. Vegetables (double)			US$3,205/ha x 2 =	US$6,410/ha
3. Wheat - Groundnut	Wheat Groundnut	765 416	Total = K1,181/ha or US$1,940	US$1,940/ha
4. Tree Crops	Coffee Tea Orange	2,574 2,604 1,646	Average = K2,274/ha or US$3,730/ha (Banana excluded)	US$3,730/ha
5. Rice-Rice	Wet Seas. (100) Dry Seas. (50)	506 575	Total = K793/ha or US$1,300/ha	US$1,300/ha
6. Vegetable (20%),Wheat (40%), & Tree Crops (40%)	Veg.-Veg (20%) Wheat-G.nut(40%) Tree crop(40%)	3,909 1,181 2,274	Weighed Ave. K2,164/ha or US$3,550/ha Veg-Veg, Weat-Gnut Tree Crop assumed	US$3,550/ha
7. W.S.Rice - D.S.Rice (50%) W.S.Rice - Vegetable (50%)	W.S.Rice (100% D.S.Rice (50%) Vege. (50%)	506 576 1,955	Weighed Ave. K1,771/ha or US$2,900/ha	US$2,900/ha
8 Sugarcane			K896,000 /ha or US$1,470/ha	US$1,1,470/ha
9. Vegetable (70%)-Flower(30%)	Vegetables (70) Flower (30%)	3,909 8,242	Weighed Average K5,209/ha or US$8,540/ha	US$8,540/ha Flower assumed

For the peri-urban projects, like ASIP Rehabilitation and Multipurpose Dam Project, double cropping of vegetables is applied. Such application is considered as follows:

<Application of Crops>:
- ASIP Rehabilitation Project : Vegetables - Vegetables
- Multipurpose Dam Project: Vegetables - Vegetables
  in case Chongwe dam, flower is introduced 30% of area
- Existing Expansion Projects: Wheat - Groundnuts
  (Sugarcane was applied to Kaleya Small Holder and Nakanbala Sugarcane Estate)
- Irrigation Dam Project and Run of River Project:
  Vegetable (20%), Wheat (40%), Tree Crops (40%)
  Lundazi dam (Vegetable - Vegetable)

6.1.4 Project Benefit

Total benefit of irrigated crops is summarised in Table 6-3. Total benefits of irrigated crops are US$ 210 million in Base Scenario- Agricultural Expansion, US$ 207 million in base scenario-industrialisation, and US$136 million per year.

Table 6-3 Benefit of the Irrigation Project

Province	Base Scenario-Agricultural Expansion	Base Scenario-Industrialisation	Conservative Scenario
	(US$1,000)		
Lusaka	10,667	10,665	10,665
Copperbelt	46,096	37,955	49,814
Central	17,750	17,750	0
N/Western	22,928	12,278	8,728
Western	22,919	21,319	12,444
Southern	13,532	16,963	16,963
Luapula	41,268	61,288	9,318
Northern	24,736	18,701	18,701
Eastern	9,666	9,666	9,666
Total	209,562	206,585	136,299

Project benefit is estimated together with project cost in Table 5-4.

6.2 Capacity to-Pay of Irrigation Water

Capacity to-pay of irrigation water has been estimated for selected irrigation projects in Action Plan. Analysis has been given to the ASIP Rehabilitation Project, Chongwe Dam Irrigation Project and Zambezi Floodplain Rice Irrigation Project.

Capacity to-pay is estimated to be born from total gross margin of crops subtracting necessary household expenditure. Family labour is counted as income of household. Therefore, calculated capacity to-pay is considered to be maximum of it.

Household expenditure is K600,000 per annum in rural area, and K1,000,000 in metropolitan area. (Supporting Report - H, Section 1.2) Metropolitan household expenditure is applied to the ASIP Rehabilitation Project and Chongwe Dam Irrigation

Project which are located close to urban areas. On the other hand, rural household expenditure is applied to the Zambezi floodplain Rice Irrigation Project.

Crops are considered to be vegetables for the ASIP Rehabilitation Project and Chongwe Dam Irrigation Project, and rice and vegetables for the Zambezi Floodplain Rice Irrigation Project.

Cultivation area per household is assumed at 2.00 ha for the ASIP Rehabilitation Project and Chongwe Dam Irrigation Project as standard land allocation. While, in the Zambezi Floodplain Rice Irrigation Project it is estimated at 1.37 ha per household in average. For the ASIP Rehabilitation Project, however, irrigated area is limited to 0.25 ha which is equivalent to one fourth of cultivation area of one household.

Under above conditions, taking family labours into considerations, capacity to-pay is calculated as shown in Table 6-4 to 6-6. It is estimated at K80/m3 or K980,000/ha for ASIP Rehabilitation Project, K282/m3 or 3,470,000/ha for Chongwe Dam Irrigation Project, and K49/m3 or K1,440,000/ha for Zambezi Floodplain Rice Irrigation Project

Table 6-4 Capacity to-Pay in ASIP Rehabilitation Project

	Composition (Kwacha/ha)			Water	Cropping
Crps	Gross Earning	Fixed Cost	Gross Margin	m3/ha	Area (ha)
	(1)	(2)	(3)=(1)-(2)		
Vegetables (Wet seaso	2,886,500	931,885	1,954,615		0.25
Vegetables (Dry seaso	2,886,500	931,885	1,954,615	12,300	0.25
Rainfed Maiz	225,743	142,500	83,243		1.75
2crops/yr	1,838,300	715,318	1,122,983	3,075 for 2ha	

Average Owned Area =	2	ha/household (as average in the country)
Workers/household=	1.66	/household (as average in the country)
Labour Cost=	500	K/day
Cultivation Period =	7	monthes (for two vegetables)
Workable days=	244	70%
Value of finily labour=	122,000	Kwacha
Water necessary=	12,300	m3/ha= 3,075 m3 for 0.25ha
House expenditure=	1,000,000	K/household/yr in Metropolitan Area (nearby Rural City)

						Available for Water		
G.E	Cost	G.M.	family labour	total income	expenditure	Total	K/m3	K/ha
1,838,300	715,318	1,122,983	122,000	1,244,983	1,000,000	244,983	80	979,932
								Total/0.25ha

Table 6-5 Capacity to-Pay in Chongwe Dam Irrigation Project

Crps	Composition (Kwacha/ha) Gross Earning (1)	Fixed Cost (2)	Gross Margin (3)=(1)-(2)	
Tomatoes	4,132,500	1,246,040	2,886,460	
Onions	3,000,000	1,790,625	1,209,375	
Cabbage	3,000,000	538,042	2,461,958	
Lettuce	1,600,000	543,525	1,056,475	
Carots	2,700,000	541,194	2,158,806	
Average	2,886,500	931,885	1,954,615	(for one crop)
2crops/yr	5,773,000	1,863,770	3,909,230	

Average Owned Area = 2 ha/household (as average in the country)
Workers/household= 1.66 /household (as average in the country)
Labour Cost= 500 K/day
Cultivation Period = 7 monthes (for two vegetables)
Workable days= 244 70%
Value of fmily labour= 122,000 Kwacha
Water necessary= 12,300 m3/ha= 24,600 m3 in total
House expenditure= 1,000,000 K/household/yr in Metropolitan Area

G.E.	Cost	G.M.	family labour	total income	expenditure	Available for Water Total	K/m3	K/ha
11,546,000	3,727,540	7,818,460	122,000	7,940,460	1,000,000	6,940,460	282	3,470,230

Table 6-6 Capacity to-Pay in Zambezi Floodplain Rice Irrigation Project

Crps	Composition (Kwacha/ha) Gross Earning (1)	Fixed Cost (2)	Gross Margin (3)=(1)-(2)	Water m3/ha	Cropping Area	
Wet Season Rice	750,000	244,380	505,620	12,900	1	
Dry Season Rice	844,500	268,330	576,170	20,200	0.5	
Dry Season Vegetables	2,886,500	931,885	1,954,615	12,300	0.5	
Total	2,615,500	844,488	1,771,013	29,150	(for one year)	

Average Owned Area = 1.37 ha/household (as average in Western Province)
Workers/household= 1.51 /household (as average in Western Province)
Labour Cost= 500 K/day
Cultivation Period = 9 monthes (for two vegetables)
Workable days= 285 70%
Value of fmily labour= 142,500 Kwacha
Water necessary= 29,150 m3/ha= 39,936 m3 in total
House expenditure= 600,000 K/household/yr in Non-metropolitan Area

G.E.	Cost	G.M.	family labour	total income	expenditure	Available for Water Total	K/m3	K/ha
3,583,235	1,156,949	2,426,288	142,500	2,568,788	600,000	1,968,788	49	1,437,071

6.3 Economic Evaluation of Irrigation Project

The annual benefit of agricultural development schemes is estimated as a difference of net production values under with- and without-project conditions. The net production values for major crops are estimated as a difference of agricultural products' value and production cost at 1995 economic prices. The products' values are estimated by a product of unit price and unit yield under with- and without-project conditions. The production costs under without-project condition are derived from the production costs through the present cropping pattern. The production costs under with-project condition are estimated on the basis of projected cropping patterns.

For irrigation projects, economic farm gate price of major crops during the evaluation period is estimated in Section 3.4 in Main Report. Unit yield, gross value, production cost and net value are estimated by with- and without-conditions. The hectareage of newly reclaimed land and upgraded lands from rainfed cultivation to irrigated or control drained farming, single crop to double crop and minor scheme to major scheme are estimated for the future. Then the irrigation benefit is obtained as the incremental net production value.

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 terms 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 6-7 shows the results of the examination. Of the 48 schemes, the EIRR of 29 schemes exceeded 10%, the opportunity cost of capital.

Table 6-7 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	15.7	20.60	1.66
ASIP Rehabilitation					
Lusaka	N-1	Chipata	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
North-western	O-11	Ikelenge Pineapple	11.8	0.47	1.19
Western	I-1	Nakaloya	2.2	-0.13	0.42
Southern	N-4	Chiyabi	2.2	-0.13	0.42
	O-13	Kaleya Small Holders	--	-3.74	0.45
	O-18	Nakambala Sugar	3.2	-4.52	0.33
	O-20	Nanga	2.4	-80.41	0.39
Luapula	I-2	Mansa Pilot Scheme	2.2	-0.13	0.42
	N-5	Kenani Vegetable Scheme	10.8	0.00	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
North-western	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

Remark: "--" means that EIRR marks less than zero percent.

CHAPTER 7 ACTION PLAN OF IRRIGATION PROJECT

Proposal of water resources development plan for agricultural development toward year 2015, including descriptions of the irrigation development and implementation schedules, was described in Main Report, Chapter 6.

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 relied 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:

ASIP Rehabilitation Projects

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

Note: * estimated at market prices.

(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	Wet Season: Rice 1,500 ha	
	Dry Season: Rice 750 ha, Vegetables 750 ha	
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). They are (1) ASIP rehabilitation projects; (2) Chongwe dam irrigation project; and (3) Zambezi left bank flood plain rice irrigation project. The items are summarised as follows:

Financial Conditions and FIRR of Proposed Projects

Item	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 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.

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

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF ZAMBIA
MINISTRY OF ENERGY AND WATER DEVELOPMENT

THE STUDY

ON

THE NATIONAL WATER RESOURCES MASTER PLAN

IN

THE REPUBLIC OF ZAMBIA

FINAL REPORT

SUPPORTING REPORT [J]

FORESTRY

OCTOBER, 1995

YACHIYO ENGINEERING CO., LTD.
(YEC)

THE STUDY ON NATIONAL WATER RESOURCES MASTER PLAN
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CHAPTER 1 PRESENT STATUS OF FORESTS AND FORESTRY

1.1 Role of Forests

Forests play a significant role in balancing the carbon-dioxide components of the atmosphere. Forests build up and retain soil fertility, protect soil from erosion or degradation, help rainfall to infiltrate smoothly into soil and help in producing a continuous flow of clean water in the rivers, in reducing the danger of flooding and in protecting crops and settlements against desiccating winds or excessive temperatures. Evapotranspiration over large areas of forest sustains humidity to keep moderate climate for crops and humans. Forests contribute to the stability of watersheds by protecting the soil surface from the direct impact of intensive rainstorms.

Deforestation and soil erosion of upstream areas may affect siltation, water usage down stream and power generation. The Zambezi and the Kafue rivers play significant roles in the economic activities of Zambia. From this aspect, watershed management and protection of rivers from erosion and siltation is an important aspect of the master plan.

Forests also provide goods obtained from trunks and other parts of the trees. Wood products are numerous; timber and sawn-wood for furniture, walls, doors and shuttering, pulpwood for pulp and paper, poles, posts, mining timber, railway sleepers and fuelwood. The non wood products are also varied, ranging from fruits, fodder and game meat to pharmaceutical products and honey.

1.2 Forest Distribution and Forest Management

From the analysis of landsat satellite imagery, forests cover an area of 105,700 km^2, equivalent to about 14% of the national land area of 751,851 km^2.

Table 1-1 Forest Cover and Management Status (1993 Level)

(ha)

Province	Provincial Area	Forests	Forest Estate in 1993	Forest to Provincial Area (%)	Forest Estate to Provincial Area (%)	Forest Estate to Forests (%)
10 Lusaka	2,209,426	525,003	30,332	23.8%	1.4%	5.8%
20 Copperbelt	3,121,679	746,234	519,473	23.9%	16.6%	69.6%
30 Central	9,468,439	1,782,327	592,928	18.8%	6.3%	33.3%
40 N/Western	12,528,028	2,183,846	2,417,707	17.4%	19.3%	110.7%
50 Western	12,734,381	1,334,528	618,831	10.5%	4.9%	46.4%
60 Southern	8,519,860	1,138,125	669,903	13.4%	7.9%	58.9%
70 Luapula	4,959,447	593,134	383,037	12.0%	7.7%	64.6%
80 Northern	14,729,191	1,764,429	1,123,147	12.0%	7.6%	63.7%
90 Eastern	6,914,628	502,226	848,137	7.3%	12.3%	168.9%
Zambia	75,185,079	10,569,852	7,203,495	14.1%	9.6%	68.2%

(Data Source)
1) Provincial Area, Forest Area: Landsat Satellite Imagery Analysis
2)Forest Estate 1993: Encroachment of Forests Area, Forest Department, 1994

As shown in Table 1-1, forests cover about 24% of Lusaka and Copperbelt Provinces, where large urban cities are located. Forests in Eastern Province cover only 7.3% of the

land. Since forest covering status is worse among provinces, the Soil Conservation and Agroforestry Extension Programme (SCAFE) was started in this province. Watershed areas covered by forests are higher than national average in Copperbelt and North-Western Provinces, but less than average in Luapula and Northern Provinces. The Forest Department gazetted the forest estates in order to protect and manage forest areas. The forest estates cover some 7,203,495 ha or 9.6% of the national land. From forest management aspect, forest estates account for 68% of national forests. North-Western Province, including the watershed area of the Zambezi River, is covered mostly by forest estates, and managed by the Forest Department. Other water sheds are not widely covered by forest estates.

The present forest estates area amounted to 7,203,495 ha in 1993. The general trend shows that the forest estate area is decreasing from 7,631,491 ha in 1983 (10.2% of National Land) to 7,203,495 ha in 1993 (9.6 %) due to decrease of forests and difficulties in budgetary and staffing arrangements. It is necessary to encourage expansion of forest estates to attain better managed and protected forests. Present composition of forest estates are as follows:

Summary of Forest Estates (Dec. 31, 1993)

Forest Type	Area (ha.)			% of Total Land
	National	Local	Total	
State Forest	939,294	401,359	940,633	1.2
Trust Forest	3,708,360	1,226,562	4,935,422	6.6
Reserve Forest	789,308	538,132	1,327,440	1.8
Total	5,037,442	2,166,053	7,203,495	9.6

1.3 Vegetation

The major vegetation of the country can be divided into four types. Characteristics of each type can be summarised as follows:

1) The dense Miombo woodland of the plateau, divided by grass and swamps along dambos, covering Northern, Copperbelt, Luapula and North-western Provinces.
2) Kalahari Chipya alternating with grass in the south and west.
3) The Mopane Woodlands of the lower Luangwa and Zambezi Valleys.
4) The dry evergreen woodlands and their Chipya derivatives in the northwest on the Kalahari Sands and northeast on lake basin soils in Luwinsy and Kasama.

Miombo woodland accounts for 80% of the forested area, the dominant species being Brachystegia, Isoberlinia and Julberna. The distribution of these forests is influenced by the climate which is subtropical, moderated by altitude. The distribution also follows the three agro-ecological zones based on rainfall, described in the irrigation section of this report.

According to the classification of Forest Department, over 70% of the country's land area (55 million ha.) is covered by productive forests and woodlands. Forests are divided into two indigenous groups, namely the closed forests of southern and western parts of the country called teak forests, and the open forests of Miombo woodland.

In 1988, an estimate of the standing merchantable timber in teak forests stood at 1.7 million m^3 for Mukusi and 0.8 million m^3 for Mukwa in areas within 50km radius of major mills. Without affecting the ecological balance, 63,000m^3 of round wood can be harvested from these forests which can sustain 19,000m^3 sawntimber output per annum. Production in the mills operating in the area in 1991 was 9,700m^3 per annum.

The Miombo forests are more extensive and contain more commercial species. The 1985 Forest Resource Survey showed the extent of the forest as 35 million ha. The merchantable timber in Miombo forests was estimated at 5 - 10m^3/ha in undisturbed areas. The same survey indicated an availability of 4 billion m^3 of timber in these forests.

The forests in North-western Province appear not to have been disturbed (see Table 1-1). Great potential for setting up primary forest industries exists and are waiting for exploitation.

1.4 Deforestation

The Government is aware of the alarming deforestation taking place and its consequences for the livelihood of the people, the environment and the country's economy. The Government is also aware of the constraints related to these issues, as well as the lack of resources (finance, institution, equipment, personnel, etc.) to bring about the necessary changes to enable the forestry sector to play its appropriate role.

(1) Present Forest Cover and Deforestation

The present forest cover and rate of deforestation are given in the following table, based on the project FAO/TCP/ZAM/4401, 1986.

Table 1-2 Evaluation of Wooded Areas (1975 - 1990)

(Unit: 1,000 ha.)

Province	Total Land Area	Annual Decrease (%)	Wooded Area 1975	1980	1985	1990
Lusaka	2,187	2	2,065	1,866	1,687	1,528
Copperbelt	3,101	2	2,063	2,353	2,165	2,033
Central	9,439	6	7,329	7,597	7,371	7,151
North-western	12,614	2	10,220	10,120	10,020	9,920
Western	12,638	2	9,539	9,444	9,349	9,254
Southern	8,528	7	6,603	6,375	6,155	5,943
Luapula	5,056	5	3,523	3,438	3,353	3,268
Northern	14,799	3	12,205	12,023	11,843	11,665
Eastern	6,899	5	6,617	6,453	6,293	6,137
Total	75,261		60,704	59,669	58,236	57,169

In the absence of a national forest inventory, the last one being undertaken in 1952, the rate of deforestation differs depending on the source of information. On the basis of the above table, the country has lost 139 thousand ha. of forest every year for the past 15 years (1975 - 1990).

(2) Main Causes of Deforestation

Among the various causes of deforestation, the main ones include clearing for firewood, charcoal, timber, poles, medicine and agriculture. Most of these are taking place in the areas with high concentrations of population. The problems of deforestation have been compounded by various factors, including the following :

- high population growth
- forest fires which occur in dry months of August to October
- over grazing
- cultural heritage, such as Chitemene cultivation
- demand for fuel wood and building poles, which account for 80% of domestic forest products consumption

(3) Impact of Deforestation

Deforestation has been threatening the environment on which agriculture for food production depends. In some areas, the effects of deforestation, such as soil erosion, silting and drying up of streams and rivers, general land degradation and shortage of forest products, are already becoming critical.

(4) Solutions to Deforestation

The Forest Department wishes to protect its forests for rational utilisation of forestry resources by present and future generations. The Department is also aware of the importance of forests for water resource conservation, in particular those in the northern parts of the Kafue and Zambezi catchment areas.

The Forest Department lacks quantitative data and information on forests and forestry for effective planning and management. Insufficient forest resource supply planning has resulted in low production levels of forestry industries.

The Department is considering a donor funded project to update the National Forest Inventory to allow effective and efficient formation of short and long term programmes.

A community forestry strategy and project framework were drawn up as part of the FAO/DOF Community Forest Project, which started in August 1987 and ended in December 1989. The main objective of this strategy is to establish a basis for nationwide community forestry. In order to implement the strategy, donor funds would be necessary.

1.5 Forest Plantation

Until 1983, the Industrial Plantation Division was part of the Forest Department, but since then, it has been changed to a public company, assuming the corporate title of Zambia Forestry and Forest Industries Corporation (ZAFFICO) under Zambia Industrial and Mining Corporation (ZIMCO). The company was established to sustain plantation and utilisation of timber for mining and other timber using industries.
In 1962, the Forest Department created a plantation establishment in Copperbelt and began a long term plantation programme of pines and eucalyptus. In 1968, the Government of Zambia obtained the first loan for industrial plantation from the World Bank. By 1984, the

project had planted approximately 50,000 ha. of exotic forest plantations, 40,000 ha for pine and 10,000 ha. for eucalyptus. The Department also embarked on the Rural Plantation Programme and has planted 7,000 ha. to date distributed throughout the country.

The ownership of forest plantations can be divided into two classifications : (a) private forest plantations and (b) public forest plantations.

(1) Private Forest Plantations

Private forest plantations are owned wholly or partly by private individuals or non-governmental organisations, including the following :

- commercial farmers
- small scale farmers
- Lusume Services of Magoye
- Development Assistance from People to People Projects
- missionaries or religious organisations

These plantations are insufficient for industrial supply as they are scattered throughout the country, and represent less than 1% of the total established plantations.

(2) Public Forest Plantation

The public plantations are wholly or partly owned by the Government and include those under the charge of the following entities :

- Forest Department in rural areas (Rural Plantation)
- ZAFFICO Ltd.
- Department of Agriculture at agricultural stations
- Ministry of Health at some hospitals and health centres
- Ministry of Education in schools
- Local Governments through their township, city or municipal councils
- Tobacco Authority
- Kawambwa Tea Estate Ltd.

(3) Rural Plantations

The rural plantation programme is faced with problems, especially since 1978 mainly as a result of general decline in the national economy. Problems include the following :

- inadequate allocation of funds
- insufficient priority to the programme
- maintaining low prices for plantation products below production costs, since the schemes have been regarded as service projects

As a consequence of the above problems, many rural plantations have been damaged, abandoned or have not received any silvicultural maintenance to sustain production of high quality timber. Only an estimated 20 - 30% of total planted area is said to be maintained.

1.6 Forest Product

Although sawmilling based on plantation grown raw timber is relatively new in the country, it has reached to around 60% of the total sawmilling activities. The most important mills are

run by ZAFFICO, who own most of the country's plantations. In 1991, the company had 80,000 m3 built in capacity in its sawmills. The plantations run by ZAFFICO, however, have a potential of producing well over 500,000m^3 round wood per annum. The company currently produces 59,000m^3 of sawntimber which forms 50% of the total production timber in the country.

In addition, natural forest based sawmills are estimated to produce 51,700m^3 timber per annum, roughly 40% of the total production. Most of natural forest based mills are privately owned.

Both plantation based and natural forest based sawmills are suffering from low operation rates, having installed capacities of 208,500m^3 and 158,000m^3, while the actual production is 62,300m^3 and 51,700m^3 respectively. The operation rate can be estimated at about 30% for both types of sawmilling.

The production of forestry related industries as of 1991 can be summarised as shown in the following table.

Table 1-3 Production of Forests by Category (1991)

Category	Amount	Unit
a. Fuelwood	17,082	m^3
b. Charcoal	4,550	tonnes
(wood used)	108,469	m^3
c. Sawlog	252,200	m^3
d. Peeler Log	55,218	m^3
e. Pulp and Particles made of Wood	34,000	tonnes
(waste paper available locally)	2,500	tonnes
f. Sawn Wood and Sleepers	12,916	m^3
h. Wood based Panel		
- Veneer Sheets	929	m^3
- Plywood	101,500	sheets
- Particle Board	21,750	sheets
- Block Board	20,400	sheets
- Wood Wool Cement Board	25,000	sheets
i. Paper and Paper Board		
- Tissue	1,400	tonnes
- Craft and Wrapping	1,500	tonnes
- Other(Writing, Envelopes)	1,100	tonnes

CHAPTER 2 FOREST CONSERVATION FROM WATER RESOURCES DEVELOPMENT ASPECT

2.1 Watershed Management in Important River Basins

As stated above, forests have an important role in protecting watersheds of the rivers from soil erosion and in maintaining continuous stable flow in the river. Watershed areas of the Zambezi and the Kafue are comparatively better maintained than the watersheds of the Chambeshi and the Luapula. Forests are suffering from deforestation caused by collection of the fuelwoods and by natural disasters such as fire. As fuelwoods is the only source of heat for rural people, it is difficult to reduce this cause of deforestation without providing alternative fuel sources.

2.2 Forest Conservation Measures

Studies show that there is higher consumption of wood-fuel in the form of charcoal in urban areas of Zambia, while firewood is consumed more in rural areas. For both urban and rural areas there is little available wood for fuel substitution in the near future. In order to ensure sustainable supply of fuelwood in rural areas, small holder farmers and villagers must take up tree growing and management for multiple purpose needs including agroforestry. This is the most practical and economical way of solving the problem. In addition large scale distribution of efficient wood stoves, research in agro-processing and other wood based rural industries can contribute significantly in reducing wood-fuel demand.

In urban areas, production and supply of wood-fuel is commercialised. Better control of harvesting and directing charcoal producers to surplus areas should be encouraged. Establishment of fuelwood farms and agro-forestry projects in peri-urban areas and nearby rural areas could contribute to solving fuelwood problems.

CHAPTER 3 AGROFORESTRY

3.1 Introduction

The Soil Conservation and Agroforestry Extension Programme (SCAFE) was started in Eastern Province as a result of the growing concern over the acceleration of deforestation which gives rise to two main groups of problems:

- land degradation resulting in low food productivity and
- shortage of forest products such as firewood and building materials.

The programme was also started because of the need to redress these problems. The interdependence of agriculture and forestry is more readily recognised when faced with increased deforestation and associated problems. Indeed some of the problems that have increased awareness of the importance of forests and trees to the rural people include environmental degradation, food shortage, forest products scarcities and poverty. More and more people are concerned about the role of forests in maintaining environmental stability. Thus deforestation becomes a social problem in both cause and effect. The longer the problems are ignored or neglected, the more acute and widespread they become. These problems have lead to the need for new approaches, strategies and knowledge in solving them. People's participation through community and agroforestry is one such approach and strategy. More people will participate in tree planting if tree planting becomes part of farming activities and if trees are integrated in the farming systems. Agroforestry plays an important part in the development of ecologically and economically sustainable agriculture and forestry.

Agroforestry is a land use system in which trees and shrubs are part of the overall farming system whether they are deliberately left in the field or actively planted. Thus, agroforestry is defined as a land use system in which trees or shrubs are grown together with crops and/or livestock on the same piece of land. The mix can be either a spatial one or in terms of a time sequence. Normally, there is both biological and economic interaction. The interaction between trees/shrubs and crops or livestock must be positive if agroforestry is to benefit the farmers.

3.2 The Need for Agroforestry in Eastern Zambia

Much deforestation has occurred in the last 40years. This has been due to rapid population increase which results in:

- Clearing forests for agricultural production and settlement
- Cutting of trees for charcoal production
- Collection of firewood for home as well as commercial purposes
- Late burning of forests
- Overgrazing by livestock in some areas, e.g.Kagono, Chief Kawaza's area, Chief Saili's area, etc.

Some of the consequences of these activities are:

- Shortage of construction poles and timber
- Fuelwood problems
- Lack of/shortage of fodder during the dry season
- Silting and flooding of streams
- Declining soil fertility leading to low crop yields
- Increased soil erosion problems.

3.3 Benefits of Agroforestry

Agroforestry has the potential to solve some of these problems. Some of the main benefits of agroforestry are:

- Supply of good quality poles and timber
- Provision of fruits and other food
- Improvement of soil fertility
- Fodder
- Fuelwood
- Control of soil erosion
- Stabilisation of stream and riverbanks, etc.

(1) Forest Resources

The Miombo (Brachystegia) woodland is the major vegetation type in Eastern Province. The predominant tree genera are Brachystegia, Julbernardia and Isoberlinia. Colophospermum mopane (Mupane) and scrub woodlands are found in the valley areas.

The total gazetted forest area is approximately 847,297ha, equivalent to 12.3% of the land area. It is protected and managed by the Forest Department. There is also a substantial area of ungazetted forest in traditional (trust) lands. Some 600ha of Eucalyptus plantation and a smaller area of pines have been established.

(2) Wood Industries

The Minga Timber Company is the major private company involved in the exploitation of forestry resources in Eastern Province, mainly indigenous trees. The Forest Department has a portable sawmill based at Chimtengo plantation in Sinda, which saws pine timber. There are many pit-sawyers in the province who mainly exploit Pterocarpus angolensis (Mlombe), Pericopsis (Muwanga), and Afzelia quanzensis (Mpapa,Mupapa). Pit-sawyers are mainly concentrated in Petauke District. A number of carpentry workshops have been established in towns throughout the province. Building construction is a major consumer of timber and poles.

(3) Woodfuel

The main source of domestic fuel is firewood and demand increases as the population rises. Charcoal production is a commercial activity and is rising rapidly with increasing household incomes and urbanisation. The National Breweries in Chipata is a major user of fuelwood, and so are education institutions, local hotels and restaurants scattered throughout the province.

3.4 Strategies for Promotion of Agroforestry

(1) National Policies

Currently, per capita land availability in the Eastern Province is approximately 8ha. Such farm size would be sufficient if the population was evenly distributed, but this is not the case. It is in the densely populated areas that deforestation has occurred and pressure on forestry and tree resources is most intense. These are the areas most likely to benefit from the practice of agroforestry.

Zambia's national development policy calls for the national management of existing natural forests on a sustainable basis, the continued establishment of forest plantations and the introduction of trees on cropped land. This national policy must be translated into action down to village levels. Extension staff must play a major part in articulating the policy and achieving the set goals.

(2) Understanding Farmers' Practices and Needs

The small-scale farmer in Eastern Zambia has practised agroforestry for a long time. He integrates trees into his fields and also practised other agroforestry measures such as boundary planting, live fences, home gardens, small woodlots and leaves trees standing in grazing areas. In this way he gains the benefits of these agroforestry systems.

Extension workers should take the opportunity of the farmer's interest and indigenous knowledge in agroforestry and assist him/her in the better design and management of agroforestry systems. Each extension worker must, however, clearly understand the farmer's needs before making recommendations.

CHAPTER 4 GUIDELINES FOR SELECTION OF TREE SPECIES

Selection of appropriate tree species is extremely important. Failure to identify the right species results in poor survival in the field or nursery, and in failure to fulfil farmers' expectations. Thus the whole idea of tree planting may be rejected by the farmers.

The following factors should be taken into account when selecting tree species:

4.1 Site and Product Requirements

- The tree or shrub should provide the farmer with required products (poles, timber, fruit, firewood, etc.). Ideally it should have multiple uses.
- The tree species should be suited to the local ecological conditions (mean annual rainfall, altitude, temperatures, soils, and the length of the dry season).

4.2 Silvicultural Requirements

- Resistance to fire, livestock damage, and termites where these are prevalent.
- Resistance to frost.
- Ability to coppice.
- Compatibility with crops if the trees/shrubs are to be intercropped.
- Availability of seed.
- Ease of handling(easy to establish, low input requirement, etc.).

4.3 Compatibility Aspects

If the crop yields under or near the trees are higher than, or at least the same as, in the rest of the field, then the tree is compatible with the crop and the farmer gets the tree products as an extra benefit.

If, on the other hand, crop yields are lower under the tree (non-compatible species), then it can still make sense to keep the trees in the field if the value (as the farmer perceives it) of the tree products is higher than the value of the loss in crop yield. Some of the reasons for non-compatibility are that:

- The tree shades the crop too much
- The tree and crop compete for nutrients and water
- The tree produces growth-inhibiting substances.

Tree management (side pruning, pollarding) can reduces the negative effect of the tree'shade on crops.

4.4 Important Species

The following are some of the species of trees which can be left in fields because of the benefits they provide to the farmers:

(1) Species known to be compatible with food crops (not reducing crop yields) and their benefits:

-Acacia albida (Msangu N)	-Improves soil fertility, provides fodder in dry season
-Acacia polyacantha (Ngowe N)	-Improves soil fertility, fodder
-Afzelia quanzensis (Mpapa,Mupapa N)	-Timber
-Pericopsis angolensis (Difficult to cut down)	-Timber, improves soil fertility
-Piliostigma thonningii (Msekese N)	-Improves soil fertility, fodder

(2) Species where it is uncertain whether they reduce crop yields or not (more research is needed):

-Adansonia digitata (Mlambe, Mkulukumba N)	-Fruit, traditional beliefs
-Dichrostachys cinerea (Kalumpangala N)	-Fodder
-Diospyros mespiliformis (Mchenja, Mchenjamusumu N)	-Fruit
-Flacourtia indica (Ntudza N)	-Fruit
-Parinari curatellifolia (Mupundu, Mbula N)	-Fruit
-Parkia filicoidea (Mpeza, Msenya N)	-Fruit
-Pterocarpus angolensis (Mlombwa, Mlombe N)	-Timber, soil fertility
-Strychnos pungens (Chidzaya, Mzai N)	-Fruit
-Uapaca kirkiana (Msuku N)	-Fruit
-Ximenia americana (Ntengele,Mtundulukwa N)	-Fruit

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF ZAMBIA
MINISTRY OF ENERGY AND WATER DEVELOPMENT

THE STUDY

ON

THE NATIONAL WATER RESOURCES MASTER PLAN

IN

THE REPUBLIC OF ZAMBIA

FINAL REPORT

SUPPORTING REPORT [K]

HYDROELECTRIC POWER GENERATION

OCTOBER, 1995

YACHIYO ENGINEERING CO., LTD.
(YEC)

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

SUPPORTING REPORT (K)
HYDROELECTRIC POWER GENERATION

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CHAPTER 1 PRESENT SITUATION OF ELECTRIC POWER SUPPLY AND DEMAND

1.1 Power Stations

In Zambia, electric power is supplied by Zambia Electricity Supply Corporation Ltd. (ZESCO). ZESCO currently supplies power through two systems; namely the interconnected system and various isolated systems. Also Zambia Consolidated Copper Mines (ZCCM) owns private power stations. The location of the existing power stations and transmission lines are illustrated in Figure 1-1. A power system network is shown in Figure 1-2.

1.1.1 ZESCO Interconnected System

The total installed capacity of the interconnected system is 1,623 MW but the total available capacity is 1,608 MW since Lusaka and Mongu Power Station are not used. The working power stations are the hydroelectric schemes such as Kariba North, Kafue Gorge and Victoria Falls Station. Table 1-1 presents the principal data of existing ZESCO Power Station.

Table 1-1 Existing ZESCO Power Stations on Interconnected System

Power Station	Type	Installed Capacity(MW)	Available Capacity(MW)	Year of Commission	Remarks
Kariba North	Hydro	4 x 150	600	1976	
Kafue Gorge 1	Hydro	4 x 150	600	1972	
Kafue Gorge 2	Hydro	2 x 150	300	1977	
Victoria Falls A	Hydro	2 x 3, 2 x 1	8	1934 - 1972	
Victoria Falls B	Hydro	6 x 10	60		
Victoria Falls C	Hydro	4 x 10	40		
Lusaka	Thermal	15	0		not in use
Mongu	Diesel	0.536	0	1959 - 1970	not in use
< Total >		1,623	1,608		

(Source: ZESCO Annual Report) As of Mar. 31, 1993

1.1.2 ZESCO Isolated Systems

Isolated systems, not connected to the National Grid, cover the eastern part and the western part of Zambia. Until 1993, the eastern part was covered by two isolated systems: Lusiwasi and Northern System. In both systems all the working power stations are hydro-power schemes. Other areas are covered by isolated diesel stations. The Lusiwasi System has been supplied only by Lusiwasi Hydro-power Station with available capacity 12 MW. The Northern System has been supplied by three hydro power stations: Chishimba Falls, Lunzua River and Musonda Falls Stations, with total available capacity 11.75 MW. These stations were sometimes unable to meet the winter demand of the areas due to low river flow. In 1994, Serenje Substation Project (330/66kV, 60 MVA) was completed to increase the capacity and to improve the reliability of power supply in Eastern, Northern and Luapula Provinces. By this project, the Lusiwasi and Northern Systems were connected to the interconnected system. Eight isolated diesel power stations still exist in Zambia. These diesel power stations are of small capacity and mostly very old and unreliable. Table 1-2 presents the principal data of ZESCO Isolated Power Stations.

<ZESCO South Service Areas>
Chipata, Choma, Kabwe, Kafue, Kaoma, Livingstone, Luangwa, Lukulu, Lundazi, Lusaka, Mazabuka, Mongu, Monze

<ZESCO North Service Areas>
Chingola, Chinsali, Kasama, Kitwe, Luanshya, Luwingu, Mansa, Mbala, Mpika, Mporokoso, Mufulira, Nakonde, Ndola, Serenje, Solwezi

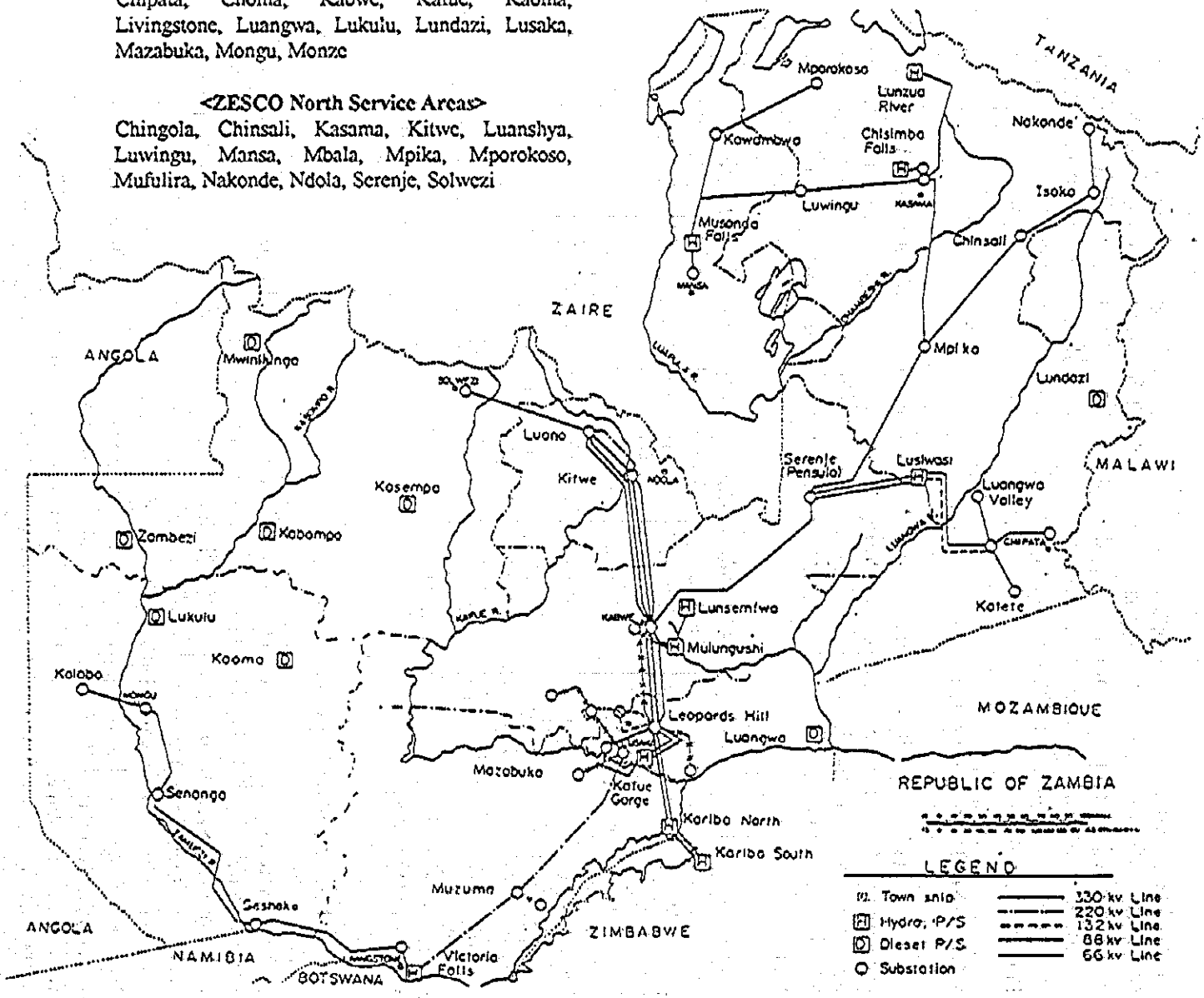


Figure 1-1 Power Stations and Transmission Lines

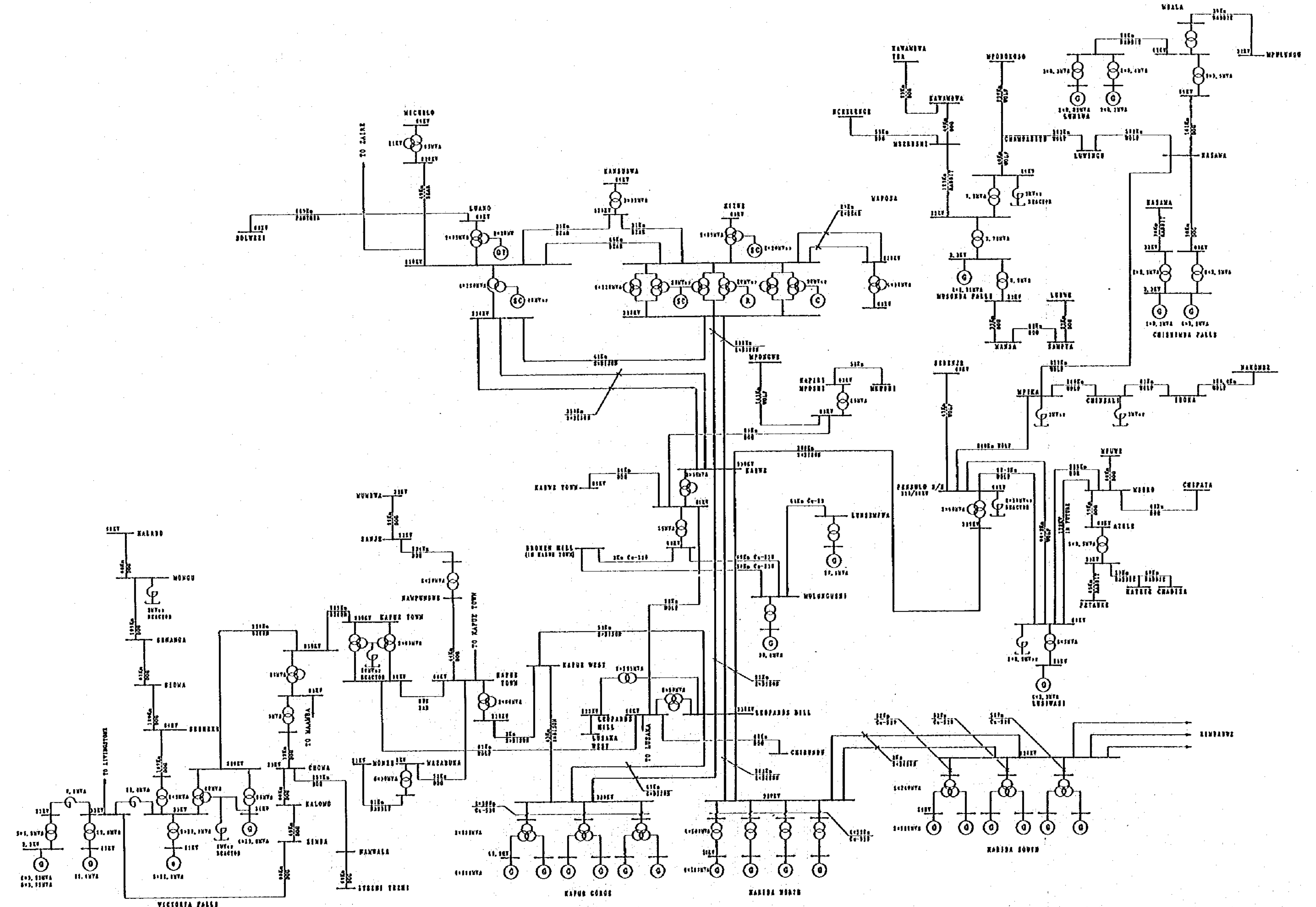


Figure 1-2 Power System Network in Zambia

Table 1-2 Existing ZESCO Power Stations on Isolated System

Power Station	Type	Installed Capacity (MW)	Available Capacity (MW)	Year of Commission	Remarks
(1) Lusiwasi System	Hydro	12	12		
	Diesel	1.983	0		
Lusiwasi	Hydro	12	12	1970-1975	
Mpika	Diesel	0.725	0		not in use
Chipata	Diesel	1.258	0	1951-1970	not in use
(2) Northern Isolated System	Hydro	11.75	11.75		
	Diesel	0.677	0		
Chishimba Falls	Hydro	6	6	1960	
Lunzua River	Hydro	0.75	0.75	1960	
Mbala	Diesel	0.25	0	1971	not in use
Musonda Falls	Hydro	5	5	1960	
Musonda	Diesel	0.427	0		not in use
(3) Isolated Diesel Stations	Diesel	5.775	4.210		
Chinsali	Diesel	0.775	0	1976	not in use
Luangwa	Diesel	0.270	0.270	1976-1979	
Isoka	Diesel	0.420	0	1976	not in use
Kaoma	Diesel	0.440	0.440	1976-1979	
Kasempa	Diesel	0.330	0.330	1971-1979	
Lundazi	Diesel	1.400	1.400	1976-1979	
Mwinilunga	Diesel	0.300	0.300	1971-1979	
Nakonde	Diesel	0.350	0	1976	not in use
Zambezi	Diesel	0.350	0.350	1971-1979	
Kabompo	Diesel	0.440	0.440		
Lukulu	Diesel	0.680	0.680		

(Source: ZESCO Annual Report) As of March 31, 1993

1.1.3 ZCCM Power Stations

Table 1-3 presents all the existing power stations owned by ZCCM. The total installed capacity is 138 MW. Gas turbine and thermal power stations in the Copperbelt are installed for emergency operation in case of electricity failure from the interconnected system. Two hydroelectric power stations in Kabwe are used only to supply the mines. If the mines have a shortage of electricity, power supply from the interconnected system is possible.

Table 1-3 Existing ZCCM Power Stations

Power Station	Type	Installed Capacity (MW)	Available Capacity (MW)	Division of ZCCM
Bancroft	Gas Turbine	20	20	Konkola
Luano	Gas Turbine	40	40	Nchanga
Luanshya	Gas Turbine	10	10	Luanshya
Lunsemfwa	Hydro	18	18	Kabwe
Mufulira	Gas Turbine	10	10	Mufulira
Mulungushi	Hydro	20	20	Kabwe
Nkana	Thermal	20	20	Nkana
<Total>	Gas Turbine	80	80	
	Hydro	38	38	
	Thermal	20	20	
<Grand Total>		138	138	

(Source: ZESCO Annual Report) As of March 31, 1993

1.2 Transmission Lines

In Zambia, 7 voltage levels(330kV, 220kV, 132kV, 88kV, 66kV, 33kV and 11kV) are utilised for the existing transmission lines. The main transmission line networks are as follows:

1) The two major hydropower stations, Kariba North and Kafue Gorge, are both connected to Leopards Hill Substation by two 330kV lines and Kafue Gorge additionally by one 330kV line via Kafue West Substation to Leopards Hill Substation.
2) Three 330kV lines from Leopards Hill to Kabwe. Four 330kV lines from Kabwe to Copperbelt, two of these go straight to Luano, the third one via Kitwe to Luano, and the fourth one terminates at Kitwe. 220kV lines are also used in the Copperbelt between the main substations.
3) Two 330kV transmission lines lead from Kariba North to Kariba South Station.
4) One 330kV line from Kabwe Substation to Serenje Substation. Since completion of Serenje 330/66kV Substation in 1994, Lusiwasi and Northern System are connected to the interconnected network.
5) Victoria Falls Power Station is connected to Kafue town by a 220kV line.
6) In rural areas, distribution voltages are 66kV, 33kV and 11kV.

1.3 Electrical Energy Generation and Consumption

1.3.1 Peak Generation and Demand

Figure 1-3 presents the variation of the annual peak generation at the power stations connected to the Interconnected System together with the peak demand in Zambia and the exports to both Zimbabwe and Zaire. Figure 1-4 presents the variations of the annual domestic peak demand.

< Peak Generation >

The total peak generation of power stations connected to the interconnected system in Zambia in 1992/93 was 1,433 MW. The sources of generation were as follows:

=	Total Interconnected System	:	1,433 MW	98.4 %
	- Kariba North Hydropower Station	:	(598 MW)	(41.1 %)
	- Kafue Gorge Hydropower Station	:	(730 MW)	(50.1 %)
	- Victoria Falls Hydropower Station	:	(105 MW)	(7.2 %)
=	Total Isolated Systems	:	23 MW	1.6 %
	- Hydropower station	:	(20 MW)	(1.4 %)
	- Diesel Power station	:	(3 MW)	(0.2 %)
=	Total in Zambia	:	1,456 MW	100 %

< Peak Demand >

The total peak demand of Zambia's interconnected system in 1992/93 was 1,433 MW. The proportions of demand were divided as follows:

- Domestic Use in Zambia	:	993 MW	70 %
- Exports to Zimbabwe	:	440 MW	30 %
- Exports to Zaire	:	0	0
< Total >	:	1,433 MW	100 %

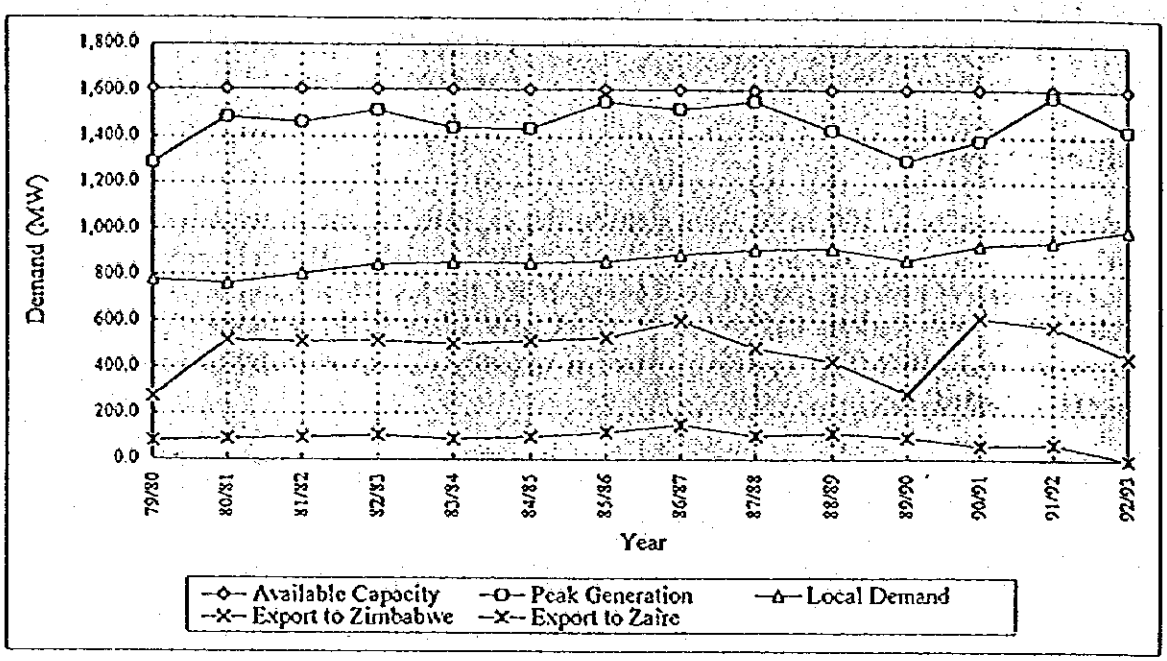


Figure 1-3 Peak Power Generation and Demand in Zambia

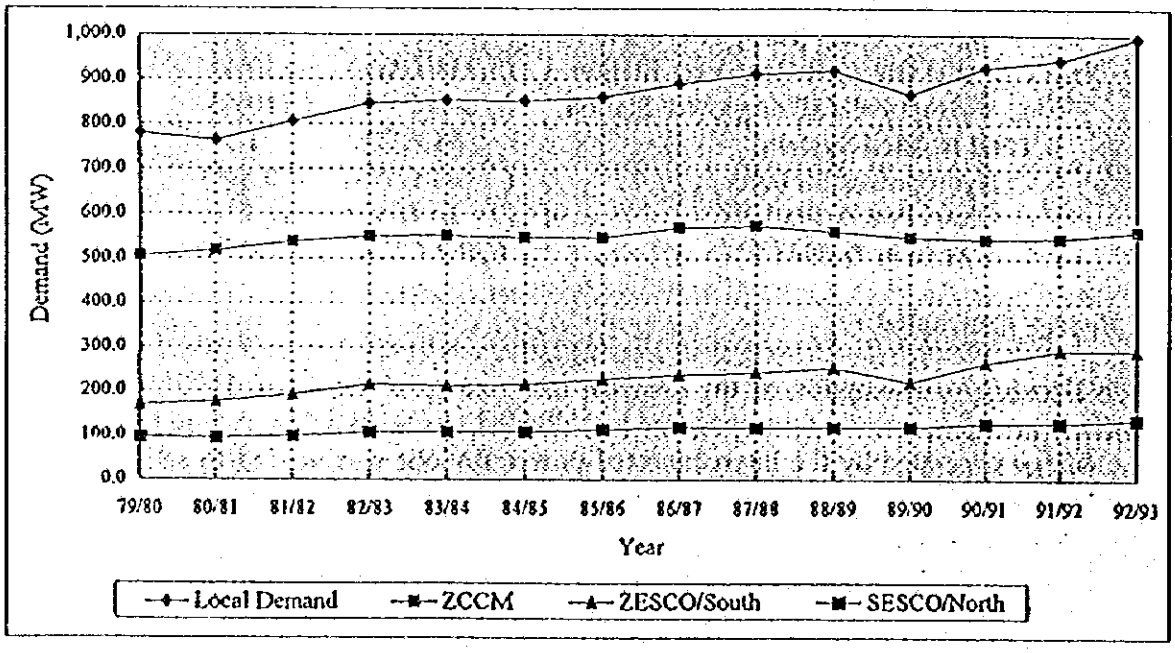


Figure 1-4 Domestic Peak Demand by User

The peak demand on the Zambian system 993 MW was divided between the bulk consumers in the following proportions:

- ZCCM Power Division	:	562 MW	57 %
- ZESCO South	:	293 MW	29 %
- ZESCO North	:	138 MW	14 %
< Total in Zambia >	:	993 MW	100 %

< Reserve Capacity >

A reserve capacity of 150 MW, equivalent to the capacity of one of the largest generation units on interconnected system is required as minimum backup. As can be seen from Figure 1-3, the reserve capacity has not been adequate for the last 10 years or so, as the installed capacity of power stations has stayed at 1,608 MW since 1976, whereas the demand has grown to over 1,500MW. However, reserve capacity can be available depending on the exports to Zimbabwe.

1.3.2 Generated Energy and Consumed Energy

Figure 1-5 presents the variation of the annual generation produced by the Zambian power stations connected to the Interconnected System compared to the gross consumption in Zambia and exports to Zimbabwe and Zaire. Figure 1-6 presents the variation of the annual domestic energy consumption by user.

< Energy Generated >

The total electrical energy generated by the Zambian power stations connected to the Interconnected System in 1992/93 was 6,850 GWh. The sources of generation were as follows.

Total Interconnected System	:	6,400 GWh	99 %
- Kariba North Hydropower Station	:	(2,540 GWh)	(39 %)
- Kafue Gorge Hydropower Station	:	(3,211 GWh)	(50 %)
- Victoria Falls Hydropower Station	:	(649 GWh)	(10 %)
Total Isolated System	:	63 GWh	1 %
- Hydropower Stations	:	(49 GWh)	(0.8 %)
- Diesel Power Stations	:	(14 GWh)	(0.2 %)
< Total in Zambia >	:	6,463 GWh	100 %

< Energy Consumed >

The electricity consumption of the Zambian interconnected system in 1992/93 was 6,400 GWh and the proportion of consumption was divided as shown below. More than 100% of the energy generated by the interconnected power stations was needed to satisfy Zambia's own need. About 20% of total consumption was exported to Zimbabwe and the balance imported from Zaire.

- Zambia	:	6,600 GWh	103 %
- Exports to Zimbabwe	:	1,200 GWh	19 %
- Exports / Imports to Zaire	:	-1,400 GWh	-22 % (Import)
< Total >	:	6,400 GWh	100 %

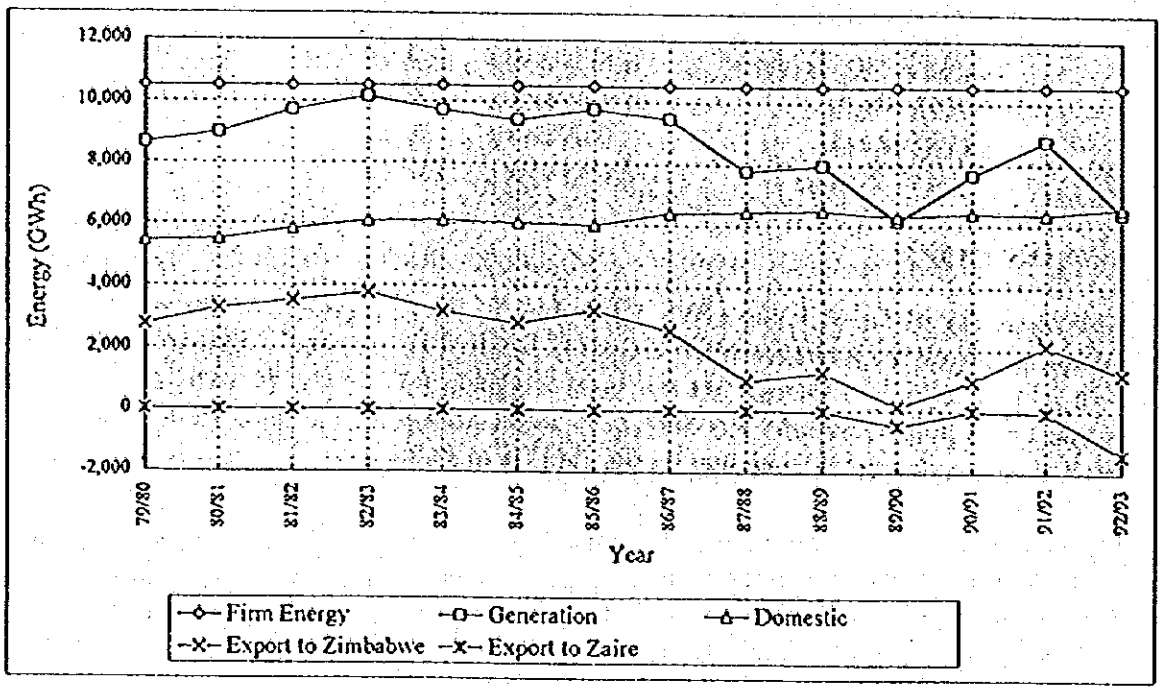


Figure 1-5 Generation and Consumption in Interconnected System

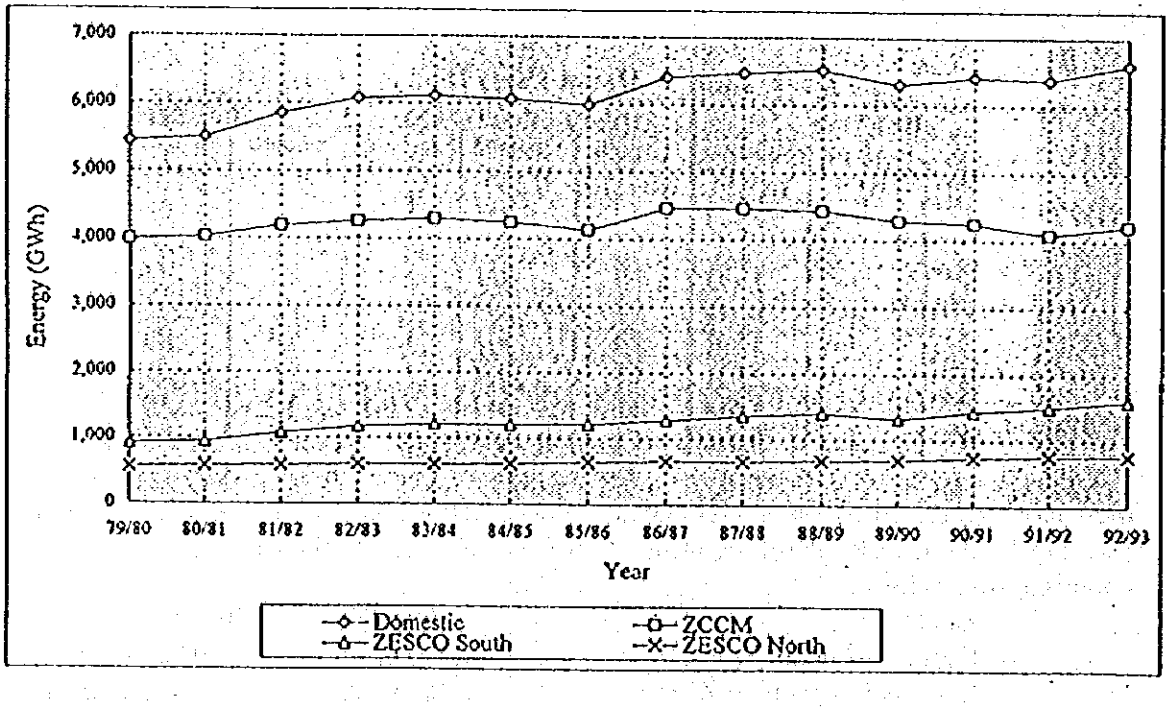


Figure 1-6 Domestic Energy Consumption by User

The electricity consumption of the Zambian interconnected system of 6,600 GWh was divided between the bulk consumers in the following proportions. The energy consumption of ZCCM power division was 4,220 GWh corresponding to 64% of the Zambian total. The total energy consumption by ZESCO was 2,380 GWh corresponding to 36% of the total.

- ZCCM power division	:	4,220 GWh	64 %
- ZESCO South	:	1,610 GWh	24 %
- ZESCO North	:	770 GWh	12 %
<Total in Zambia >	:	6,600 GWh	100 %

< Reserve Energy >

A reserve energy of about 1,000 GWh, equivalent to the firm energy of one of the largest generation units on the interconnected system is required as minimum. As can be seen from Figure 1-5, the reserve energy has not been adequate for the last 10 years or so, as the firm energy of power stations has stayed at about 10,500 GWh since 1976. However, reserve energy is available depending on the exports to Zimbabwe.

CHAPTER 2 ELECTRICITY DEMAND FORECAST

2.1 Future Domestic Demand

The Zambian bulk consumers comprise ZCCM and ZESCO retail users (South and North). Generally, the electricity demand will increase at the same rate as GDP. As shown in Table 2-1, the future electricity demand for ZESCO retail users (ZESCO South and ZESCO North) is estimated according to the changes in GDP described in Supporting Report [A]. As far the future electric demand for ZCCM, it is projected judging from the past records and future development programmes that the current situations (Peak demand: 562 MW, Annual consumed energy: 4,220 GWh, in1992/93 level) will continue.

Table 2-1 ZESCO Retail Users Demand Forecast

Year	Base Case			Industrialisation Case			Conservative Case		
	Growth Rate (%)	Demand (MW)	Consump. (GWh)	Growth Rate (%)	Demand (MW)	Consump. (GWh)	Growth Rate (%)	Demand (MW)	Consump. (GWh)
1993 (Actual)		431	2,380		431	2,380		431	2,380
1994	3.9	448	2,473	4.7	451	2,492	2.2	440	2,432
1995	5.1	471	2,599	5.3	475	2,624	2.7	452	2,498
2000	4.9	598	3,301	5.3	615	3,397	2.4	509	2,813
2005	3.5	710	3,921	4.0	748	4,133	1.9	560	3,090
2010	3.3	835	4,612	4.0	911	5,028	1.7	609	3,362
2015	3.2	978	5,399	4.0	1108	6,118	1.5	656	3,622

2.2 Future Export Demand

At present, Zambia exports electricity to Zimbabwe and Zaire. Increased electric power exports to neighbouring countries have been planned by ZESCO. According to the ZESCO plan, power exports from 1993 to 2015 are assumed as shown in Table 2-2. At the beginning of the 21st century, the export power demand to neighbouring countries will be 840 MW (5,040GWh). This future export demand is equivalent to 85% of 1992/93 domestic peak demand (993 MW) and 76% of 1992/93 domestic energy generated (6,600 GWh).

Table 2-2 Export Plan for Hydro-power up to 2015

Country	Year	Demand (MW)	Energy / Ann (GWh)
Zimbabwe	1993 to 2015	100	600
Botswana	1993 to 2015	30	180
South Africa	1996 to 2015	500	3,000
Namibia	1994 to 1997	2	10
	1998 to 2015	50	300
Tanzania	2000 to 2015	100	600
Malawi	2000 to 2015	60	360
Zaire	1993 to 2015	0	0
	<Total in 1995>	132	790
	<Total from 2000>	840	5,040

(Note) Energy/Ann. estimated as 8,760 hr x (MW/1000) x 0.7 (GWh)

CHAPTER 3 POTENTIAL SITES FOR HYDROELECTRIC POWER GENERATION

Several previous reports have estimated that the total usable hydroelectric potential of Zambia is about 6,000 MW with a firm energy output of 31,000 GWh. So far, less than 1,700 MW (28% of usable potential) has been utilised, corresponding to a firm annual energy of about 10,500 GWh (34 % of usable potential). These reports also proposed the following potential sites for hydroelectric power generation. The location of potential sites is illustrated in Figure 3-1.

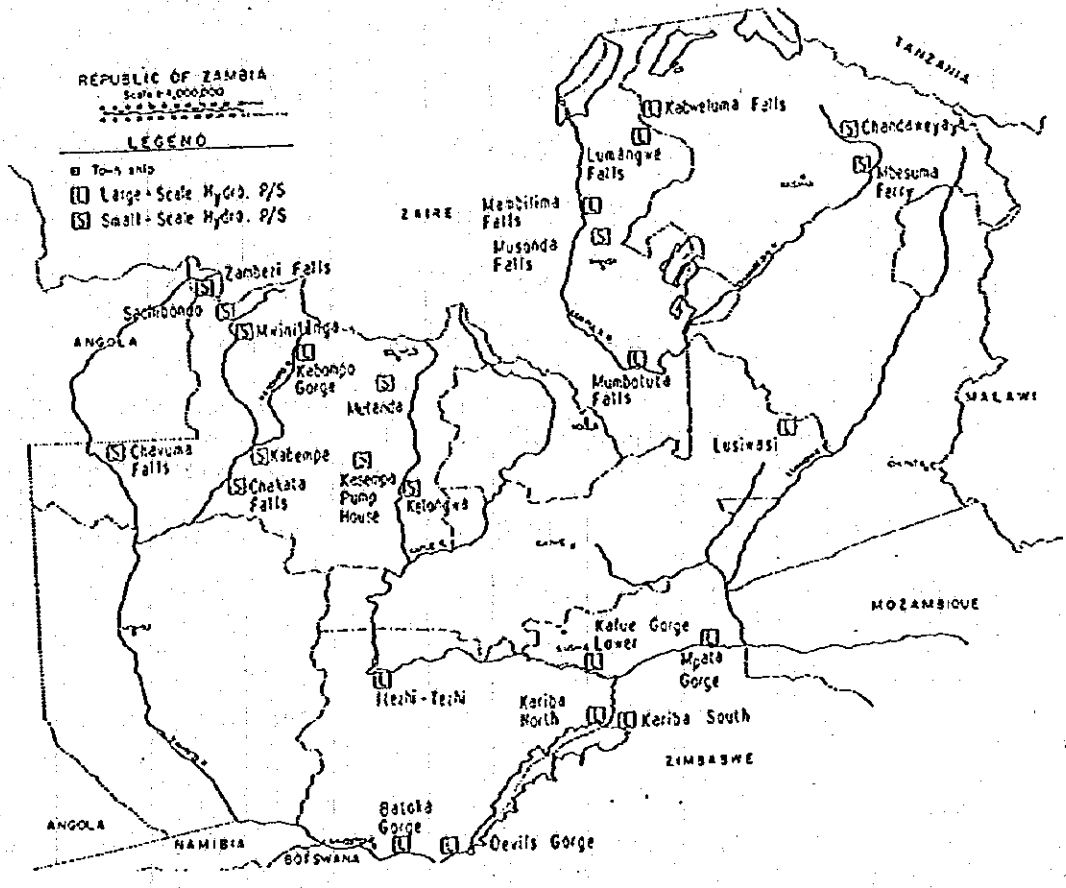


Figure 3-1 Location of Potential Hydropower Stations

3.1 Potential Large Scale Hydroelectric Sites

There are several potential sites on large rivers suitable for large-scale hydroelectric power generation to match the future nationwide demand. Potential sites have been identified on the Zambezi river in the south, forming a common border with Zimbabwe, Kafue river and on Luapula river, which forms a common border with Zaire. The potential sites will be developed in cooperation between the two countries. Refer to Table 3-1.

Table 3-1 Principal Data of Potential Large-Scale Hydroelectric Sites

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
River	Site	Installed Capacity (MW)	Zambia Share of (3) (MW)	Firm Energy (GWh)	Zambia Share of (5) (GWh)	Head (m)	Discharge (m^3/s)	Cost Z.Share (M.us$)	Cost per (4) (us$/kW)	Cost per (6) (us$/kWh)	Const. Period (Year)
Zambezi River	Kariba North Ext	300	150	700	350	-	-	104	700	0.30	5.5
	Kariba South Ext	300	150	700	0	-	-	112	740	-	5.5
	Mpata Gorge	640	320	3,200	1,600	30	-	623	1,947	0.39	10
	Devil's Gorge	1,600	800	8,500	4,250	110	-	1,154	1,443	0.27	10
	Batoka Gorge	1,600	800	9,200	4,600	167	1,110	1,318	1,648	0.29	9
	Victoria Falls Ext	Victoria Falls Extension excluded from further consideration									
	Kabompo Gorge	Kabompo Gorge cannot be justified in the present situation, because of its remote location and lack of potential demand									
Kafue River	Kafue Gorge L.	450	450	2,500	2,500	-	-	486	1,080	0.19	7
	Itezhi-Tezhi	55	55	510	510	-	-	81	1,473	0.16	4
Luapula River	Mumbo-tuta G. & Mambi-lima Falls	850	850	4,800	4,800	-	-	1,857	2,185	0.39	7
Kalung-wishi River	Limangwe Falls & Kabwe-luma Falls	114	114	400	400	-	-	294	2,579	0.74	5
Luangwa River	Lusiwasi Extension	40	40	150	150	530	6.5	75	1,875	0.50	4

3.2 Potential Small-Scale Hydroelectric Sites

There are several potential sites on smaller rivers suitable for local small - scale hydroelectric power generation. The most advantageous places for such development are in the north-western and northern parts of Zambia. Table 3-2 presents the principal data for the promising small-scale hydroelectric sites.

Table 3-2 Principal Data of Potential Small-Scale Hydroelectric Sites

No	River Basin	River	Site	Minimum Discharge (m^3/s)	Mean Discharge (m^3/s)	Head (m)	Firm Capacity (kW)	Installed Capacity (kW)
1	Zambezi	Zambezi River	Zambezi Falls	2.5	9	10~15	350	
2	Zambezi	Zambezi River	Chavuma Falls	100		10		10,000-20,000
3	Zambezi	Luakela River	Sachibondo	1	5	13	200	
4	Zambezi	West Lunga River	Mwinilunga(*-1)	7.5	25	5	400	1,200
5	Zambezi	Kabompo River	Kabempe	30			2,000~3,000	
6	Zambezi	Kabompo River	Chakata Falls	35	200	4	300	1,200
7	Kafue	Lufupa River	Kasempa	0.5	5	4	Too small	
8	Kafue	Lunga River	Mutanda	5	15		Within Solwezi Network	
9	Kafue	Lunga River	Kelongwa	16	120		Lack of local consumption	
10	Chambeshi	Chambeshi River	Chandaweyaya	2	50		Too small	
11	Chambeshi	Chambeshi River	Mbesuma Ferry	20	75		Relatively low head	

(Note) *-1 Dam site is located down stream of Mwinilunga road bridge.

The Study Team also investigated the potential for renovation and extension of the existing Musonda Falls hydro-power station, and for the development of a second station on the Mwinilunga, upstream of the Mwinilunga road bridge. Table 3-3 presents the principal data.

Table 3-3 Principal Data of Musonda Falls and Mwinilunga Potential Hydroelectric Sites

No	River Basin	River	Site	Minimum Discharge (m^3/s)	Mean Discharge (m^3/s)	Head (m)	Firm Capacity (kW)	Installed Capacity (kW)
1	Luapula	Luongo River	Musonda Falls renovation	16	21	30	3,800	5,000
2	Zambezi	West Lunga River	Mwinilunga (up Stream of Mwinilunga road bridge)	16	30	16~20	2,000	4,600

CHAPTER 4 FUTURE PROGRAMME OF HYDROELECTRIC POWER GENERATION

Through the review and examination of earlier study reports, the Study Team identified the following strategic points to be proposed.

1) Promotion of large-scale projects for export of electric power
2) Stabilisation of power supply for the northern parts of Zambia
3) Improvement of rural electrification

4.1 Promotion of Large-Scale Projects for Export of Electric Power

In 1992/93, Zambia exported 440 MW of electric power. This was equivalent to 30 % of the total demand in Zambia. According to the ZESCO programme for power export, the export power will increase to 840 MW as shown below. This is almost double the present demand.

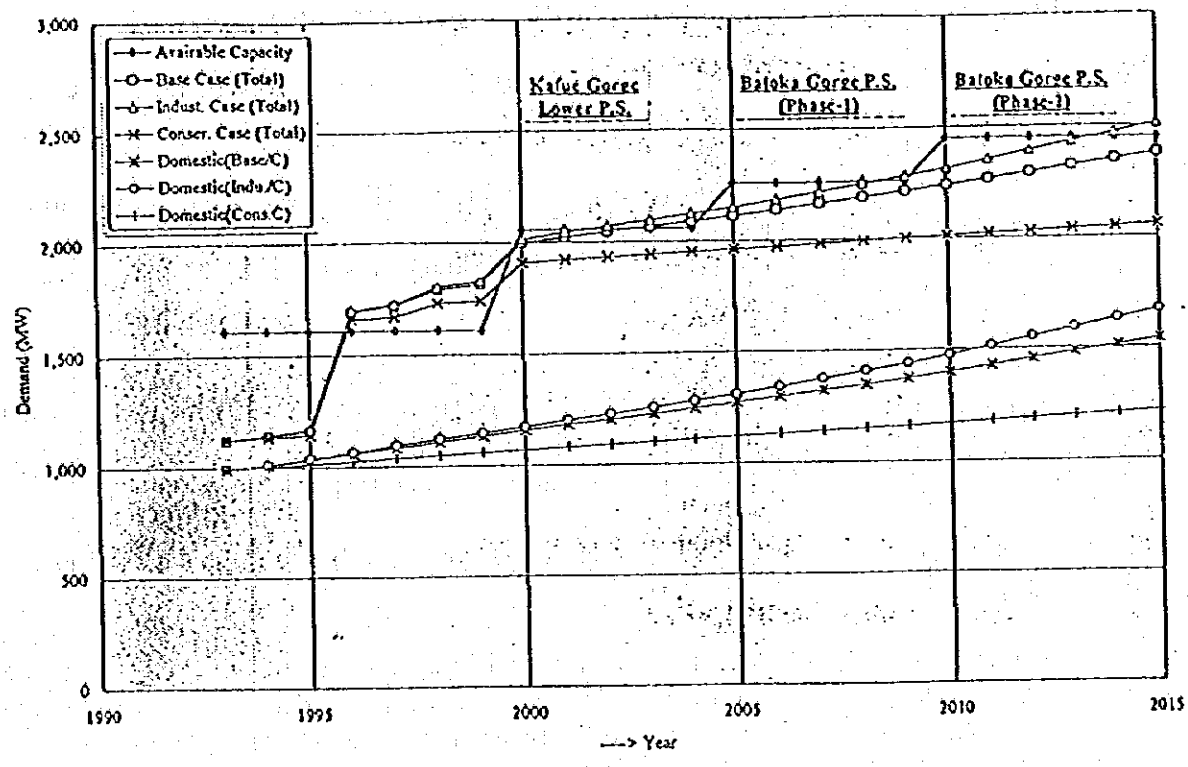
Year	Domestic Demand (Base Case)	Demand for Export	Total
<Demand (MW)>			
- 1993	993 (70%)	440 (30%)	1,433 (100%)
- 2005	1,272 (60%)	840 (40%)	2,112 (100%)
- 2015	1,540 (65%)	840 (35%)	2,380 (100%)
<Consumption (GWh)>			
- 1993 (Actual)	6,600 (104%)	-200 (-4%)	6,400 (100%)
- 2005	8,141 (62%)	5,040 (38%)	13,181 (100%)
- 2015	9,619 (66%)	5,040 (34%)	14,659 (100%)

To accomplish this programme, ZESCO proposed the construction of two projects, namely the Kafue Gorge Lower Project and Batoka Gorge Project to be completed during the coming two decades -see below. Following several studies, the feasibility of both of these projects has been confirmed. After agreement between Zambia and the countries which import power from Zambia, the final decision of project commencement will be made. Refer to Figure 4-1.

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

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

With regard to the promotion of large-scale projects for export of electric power, these programmes are attractive if the electric power export would be agreed between Zambia and each neighbouring country because the power export will contribute greatly to the Zambian economy.



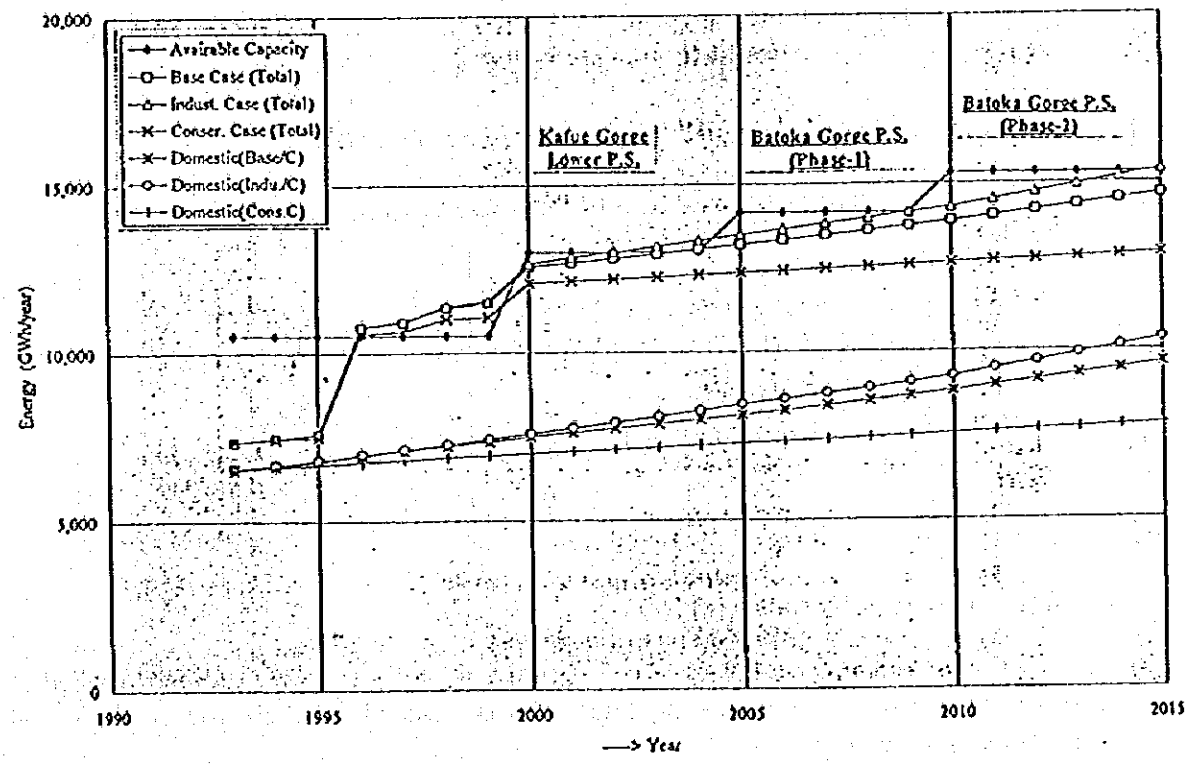


Figure 4-1 Future Electric Power Supply Programme

4.2 Stabilisation of Power Supply for Northern Parts of Zambia

Within the Northern Isolated System of ZESCO, the following problematic issues were highlighted in the ZESCO annual report of 1990/91.

1) Chisimba Falls P.S. - due to low river flow in the dry season, it was found necessary to carry out load shedding.
2) Musonda Falls P.S. - occasional load shedding was carried out during winter season due to the discharge is nil.

Serenje Substation Project was completed during 1994. This substation connected the ZESCO Interconnected System to the Northern Isolated System and Lusiwasi Isolated System. However, because of the long transmission lines to these areas, the line is frequently cut by lightning. Power supply stabilisation is therefore still required.

To alleviate the above situation in the northern areas, the Study Team had been investigated the Musonda Falls renovation as follows:

1) In order to increase capacity in the reservoir, the new dam will be proposed at the intermediate between upstream dam and downstream dam. Consequently, the capacity will be increased to 3 or 5 times from original dam. In this case, the upstream dam shall be under the water.
2) The existing power station will generate the rated capacity to utilise previous design discharge ($21m^3/s$) from the existing intake.
3) The existing civil structures such as downstream dam, intake, channel, tank, penstock and power house will be used without any modifications.

Table 4-1 presents principal data of Musonda Falls renovation plan.

Table 4-1 Musonda Falls Renovation Plan

Items	Figures
Gross head (m)	30
Min. discharge (m^3/s)	16
Mean discharge (m^3/s)	21
Firm capacity (kW)	3,500
Installed capacity (kW)	5,000
Annual production energy (MWh/a) - Minimum - Mean	 20 30

4.3 Improvement of Rural Electrification

In several isolated townships, electric power is supplied by diesel power stations installed at each township. To meet the increasing future power demand for these towns, the diesel power stations should be reinforced.

In this Study, water resources development projects are being investigated. In such projects, multipurpose dams had been studied including small scale hydro-power stations - for example, Mwinilunga Dam Project as shown in Table 4-2.

Table 4-2 Small-Scale Hydropower Project at Mwinilunga

Items	Upstream Site
Gross head (m)	16 - 20
Min. discharge (m^3/s)	16
Mean discharge (m^3/s)	30
Firm capacity (kW)	2000
Installed capacity (kW)	4,600
Annual production energy (GWh/a)	
- Minimum	10.5
- Mean	26.0

[Notes]:
1) Gross head 20m of upstream dam is subject to the level of sewage pump station.
2) Firm capacity (kW) is the minimum generation capacity during the dry season.

4.4 Reduction of Kafue Gorge P.S. Output

Kafue Gorge P.S. with a total installed capacity of 900MW is located in Kafue river.

The outline of Kafue Gorge P.S. is shown as follows:

- Installed capacity : 900MW (6x150MW)
- Gross head : 397m
- Maximum discharge : $252m^3/s$
- Mean annual energy production : 6,150GWh

In the present, the minimum discharge at Kafue Gorge P.S. is regulated as $178m^3/s$ by the Itezhi-tezhi dam. In this Study, the maximum $30m^3/s$ water flow is planned to be used from Kafue Gorge dam, that is, $10m^3/s$ is for water supply in Lusaka township and $20m^3/s$ is for irrigation of sugarcane.

Table 4-3 and Figure 4-2 present the variation of generated power and energy production with relation to the discharge in Kafue Gorge P.S.

The minimum discharge will be reduced from 178 to $148m^3/s$, so that Kafue Gorge P.S. will produce power of 320MW and annual energy production of 2,200GWh.

Therefore, total Zambian power generation and energy production will be reduced as follows:

- Power generation (MW) : 1,288
- Annual energy production (GWh) : 8,300

In line with the reduction of total Zambian power generation and energy production, the export power and energy will be restricted as shown below, even though Kafue Gorge Lower and Batoka Gorge projects will be completed during the coming two decades as shown in Figure 4-3.

Year	Domestic Demand (Base Case)	Demand for Export	Total
<Demand (MW)>			
- 1993 (Actual)	993 (70%)	440 (30%)	1,433 (100%)
- 2005	1,272 (72%)	500 (28%)	1,772 (100%)
- 2015	1,540 (75%)	500 (25%)	2,040 (100%)
<Consumption (GWh)			
- 1993 (Actual)	6,600 (104%)	-200 (-4%)	6,400 (100%)
- 2005	8,141 (73%)	3,070 (27%)	11,211 (100%)
- 2015	9,619 (76%)	3,070 (24%)	12,689 (100%)

Table 4-3 Power Generation and Energy Production

Discharge (m^3/s)	Power Generation (MW)	Annual Energy Production (GWh)	Efficiency of Turbine	Efficiency of Generator
252	913	6,237	0.95	0.98
240	842	5,754	0.925	0.975
230	781	5,338	0.9	0.97
220	723	4,938	0.875	0.965
210	667	4,555	0.85	0.96
200	614	4,193	0.825	0.956
190	564	3,851	0.8	0.953
180	499	3,409	0.75	0.95
170	438	2,993	0.7	0.946
160	382	2,607	0.65	0.943
150	329	2,249	0.6	0.94
140	280	1,914	0.55	0.935
130	235	1,607	0.5	0.93
120	193	1,321	0.45	0.92
110	156	1,064	0.4	0.91
100	105	718	0.3	0.9

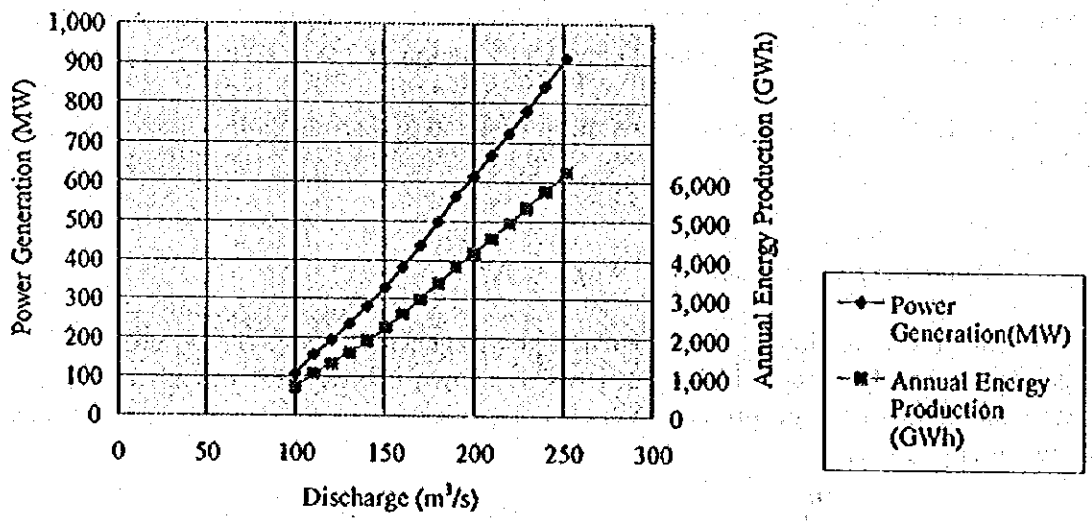
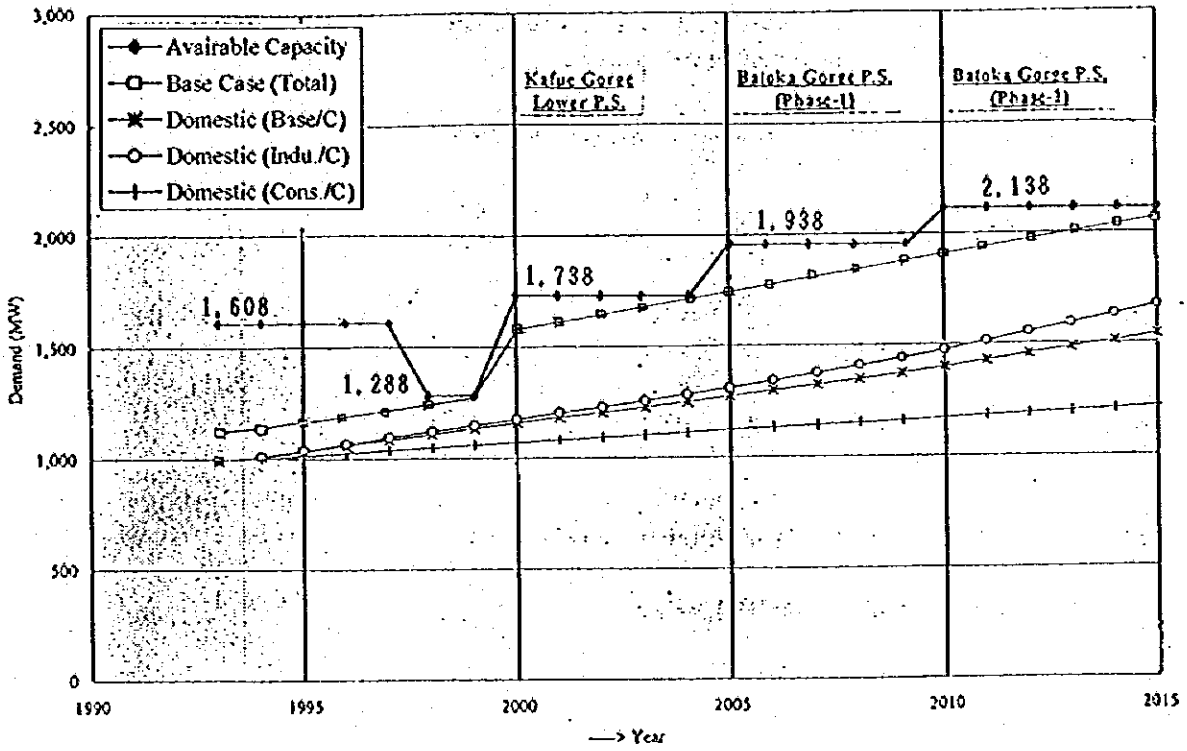


Figure 4-2 Variation of Power Generation and Energy Production



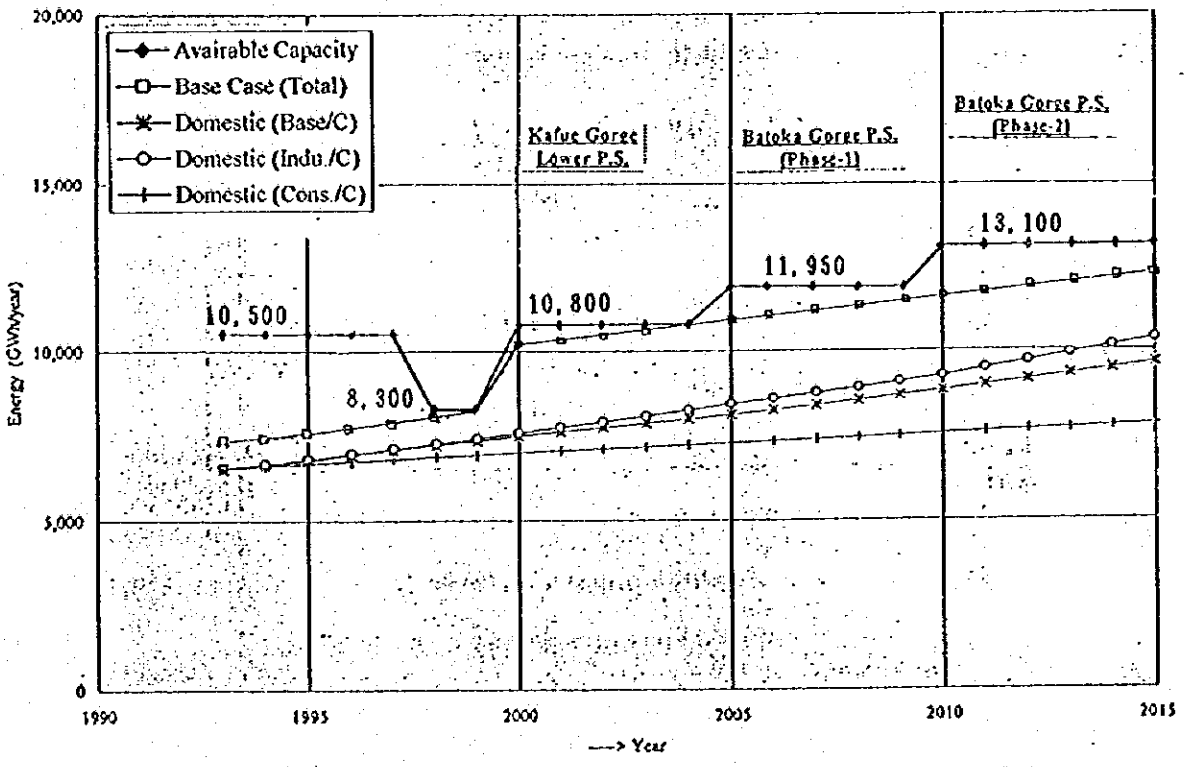


Figure 4-3 Future Electric Power Supply Programme