The Study on the Integrated Development Master Plan of the Angonia Region

Sector Report 4: Infrastructure

Part 2: Telecommunications

Contents

List of Figures

Appendix

Sector Report 4: Infrastructure

Part 2: Telecommunications

Chapter 1. Telecommunications Sector in Mozambique

1.1. Existing Conditions

Ministry of Transport and Communications is responsible for the development policies and strategies in telecommunication sector. The national Five Year Plan and the sector's Three Year Plan (1997-2000) set out the development objectives in expanding services to new locations in Mozambique. Telecomunicacoes de Mo cambique (TDM) is still fully owned by the Government of Mozambique. It is the only operator in telecommunications sector in the country, covering fixed phone lines, telex and other services, but TDM competes with other licensed operators in providing complementary and value-added telecommunications services. TDM is one of the largest employers in the country. As in other sectors, the development in telecommunications is still at a formative stage.

Recognizing its importance in the socio-economic development, TDM has devoted efforts to expand and modernize the network. In 1999 the total number of telephones, including attended public telephones, increased by 7 percent to reach 4.6 phones per 1000 inhabitants. This is still considerably lower than the levels in most neighboring countries. The following table compares economic growth rate, the number of telephone lines per population, revenue and cost among selected countries including Mozambique.

International Comparison

Countries	GDP growth (90-97, %/year)	Phone line (/10^3 pers.), 1997	Phone line in large city (/10^3 pers.)	Waiting list (10^3)	Waiting time (Years)	Revenue ($/line)	Cost of local call $/3-min.
USA	3.0	644	-	-	-	1,015	0.20
Japan	1.5	479	991	-	-	1,443	0.08
South Africa	1.5	107	415	116	0.4	942	0.07
Zambia	1.0	9	24	116	-	1,780	0.09
Zimbabwe	1.8	17	62	109	4.2	639	0.03
Malawi	3.6	4	33	30.9	*	900	0.03
Mozambique	4.9	4	24	16.9	5.9	1,073	0.04

* < 10 years
Source: World Development Indicators, 1999.

Internet access has been provided to Internet service providers (ISP) since August 1997. By the end of 1999, several service providers were operating in the country. The total national and international telephone traffic generated in 1997 increased by 32 percent and 24 percent, respectively. The increase in volume is partly triggered by the reduction of international call tariffs by about 25 percent in 1997 and further reduction in 1998. The

following table presents an outline of telecommunications services and usage in Mozambique.

Telecommunications Statistics of Mozambique

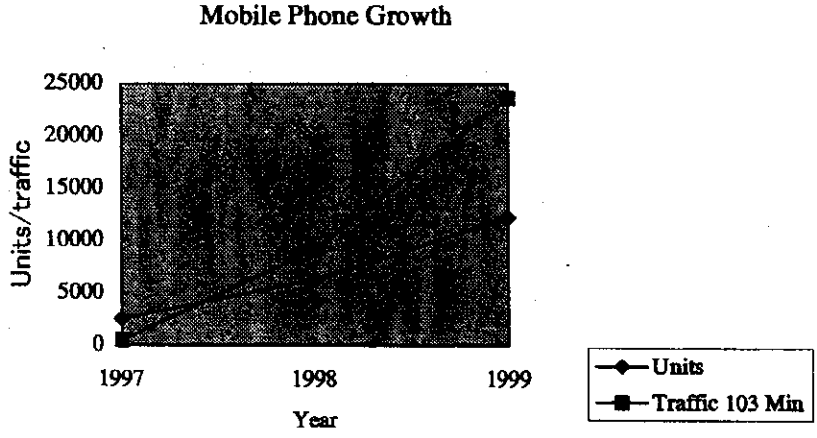
		1993	1994	1995	1996	1997	1998	1999	Annual growth (%)
Lines		92,507	97,347	97,347	103,753	104,556	10,920	113,606	3%
Circuits		3,465	3,542	3,562	8,615	8,745	8,995	17,017	30%
Digital:	Exchange (%)	68	71	72	91	95	99	99	6%
	Lines (%)	74	85	85	86	90	97	98	5%
Line per 1,000 (unit)		3.6	3.5	3.4	3.4	4.2	4.6	4.6	4%
Total connected lines (unit)		55,463	57,490	59,819	61,175	6,5606	75,354	78,072	6%
Int'l tel. traffic (10^3 min)		11,044	12,225	12,375	13,245	16,390	18,882	20,792	11%
Nat'l tel. Traffic (10^3 pulses)		425,149	452,532	466,598	421,997	555,698	591,844	600,721	6%
Total phone demand (unit)		60,627	71,550	73,904	77,801	82,975	91,094	117,758	8%
Satisfied (%)		66	73	76	75	79	83	33	-11%
Collection rate (%)		56	65	65	67	76	70	70	4%

Source: TDM, *Annual Report 1999*.

Mozambique Cellular (mCel) started operation of the mobile telephone service in September 1997 with about 1,000 clients on a trial basis. Commercial operations began in November of the same year. As of the end of 1999, 23,683 subscribers were registered as shown in the table below. The mobile service covers Maputo and Xai-Xai cities. It is expected that Tete city be served in early 2001.

Mobile Phone Growth

	1997	1998	1999	
Units	2,500	6,275	12,243	121.3%
Traffic, 10^3 Min	454	9,134	23,683	622.3%



In late 1999, TDM has selected a contractor to lay fiber optic cables along the coast, from Maputo to Beira. TDM's priority is to cover the coast area with fiber optic cables (from Beira to Pemba). There is no plan to connect Tete to Maputo with fiber optic cables.

1.2. Tariff

According to CPI, fixed phone installation fees in the world can be classified into three groups: US$ 32.55 and US$ 0.51/0.48 (Weekends) for Zone A (South African countries), US$ 0.98/0.94 for Zone B (Most of the South African countries), and US$ 1.74/1.66 for Zone C (Rest of the world).

In Mozambique, mobile phone connection fee is US$ 30.77, while monthly fee is US$ 17.73 for economic package and US$ 88.71 for executive package.

1.3. Government's Policies related to Telecommunications Sector

According to the latest Five Year Plan between 2000-2004, the Mozambican economy is envisaged to achieve a sustainable economic growth at 7 to 8 percent per annum, while maintaining a balanced development between cities and rural areas. This expected growth rate could provide an insight into telecommunications development prospect in the Study Area.

In telecommunications sector, the government will continue the modernization and expansion of the telecommunications network and improve the legal framework that establishes the basis for opening up the sector to free competitions.

The level of investment projected in the TDM's three-year plan between 1998-2000 was approximately MT 2,063,000 million as follows:

(Unit: $Mt.10^6$)

1998	1999	2000	Total
791,168	979,514	293,219	2,063,901

According to the three-year plan, the priority was placed on developing the network through promoting the following priority projects: introduction of IDSN at the national level, introduction of a support network for leased digital data circuits and the extension of Internet access to a national level; introduction of public credit card telephone booths and video conferencing services at the national level, expanding the existing network to handle the distribution of radio and television programs, improving the quality of communications with neighboring countries, expanding and modernizing rural telephone network, and digitalization of all provincial capitals and other important district centers.

Chapter 2. Telecommunications Sector in the Study Area

2.1. Current Situation and Constraints in the Study Area

Because of the low population density and low economic development, Tete province ranks at the bottom in terms of telephone service coverage by districts. While the national average was 78.7 percent in 1998, only 50 percent of the districts in Tete province were covered by telephone service as shown below.

Tete and National Average

	Tete	National Average/Total
Coverage of District in %	50.0	78.7
Phone Service Subscribers	2,128	75,354
Phone Line per 1,000 population	1.7	3.5

Source: TDM, 1998.

Telecommunications development in Tete is limited, relying on out-of-date equipment. The service is not reliable with long waiting service. Internet service is available but very slow, because of the low data transmission capacity. Tete City, the capital of the province, is linked to Maputo and Beira through satellite and to Moatize through wire lines. Among the six districts, Angonia (Ulongue), Macanga (Furancungo, Kazula), Moatize (Moatize, Zobue), are linked to Tete city through HF radios as shown in Figure 2.1. The following table summarizes the telecommunications equipment operational in Tete Province.

Telecommunications Equipment in Tete Province

Exchange Name	Type & Model	Year of Commission	Capacity		
			Installed	Connected	Unused
Tete CTA	D/AXE-10	1989	2,304	1,567	737
Songo	D/AZE-10	1989	1,280	353	927
Moatize	D/AXE-RSS	1989	256	140	116
Matundo	D/AXE-RSS	1989	512	111	401
		Total	4,352	2,171	2,181

Source: TDM Tete.

As part of national telecommunications expansion plan, major district towns, including Chifunde and Tsangano, will be linked through microwave or HF/VHF/UHF (Figure 2.2). The project budget is estimated at US$ 6.2 million. BADEA will be financing US$ 4.8 million, while TDM will cover the remaining US$ 1.4 million

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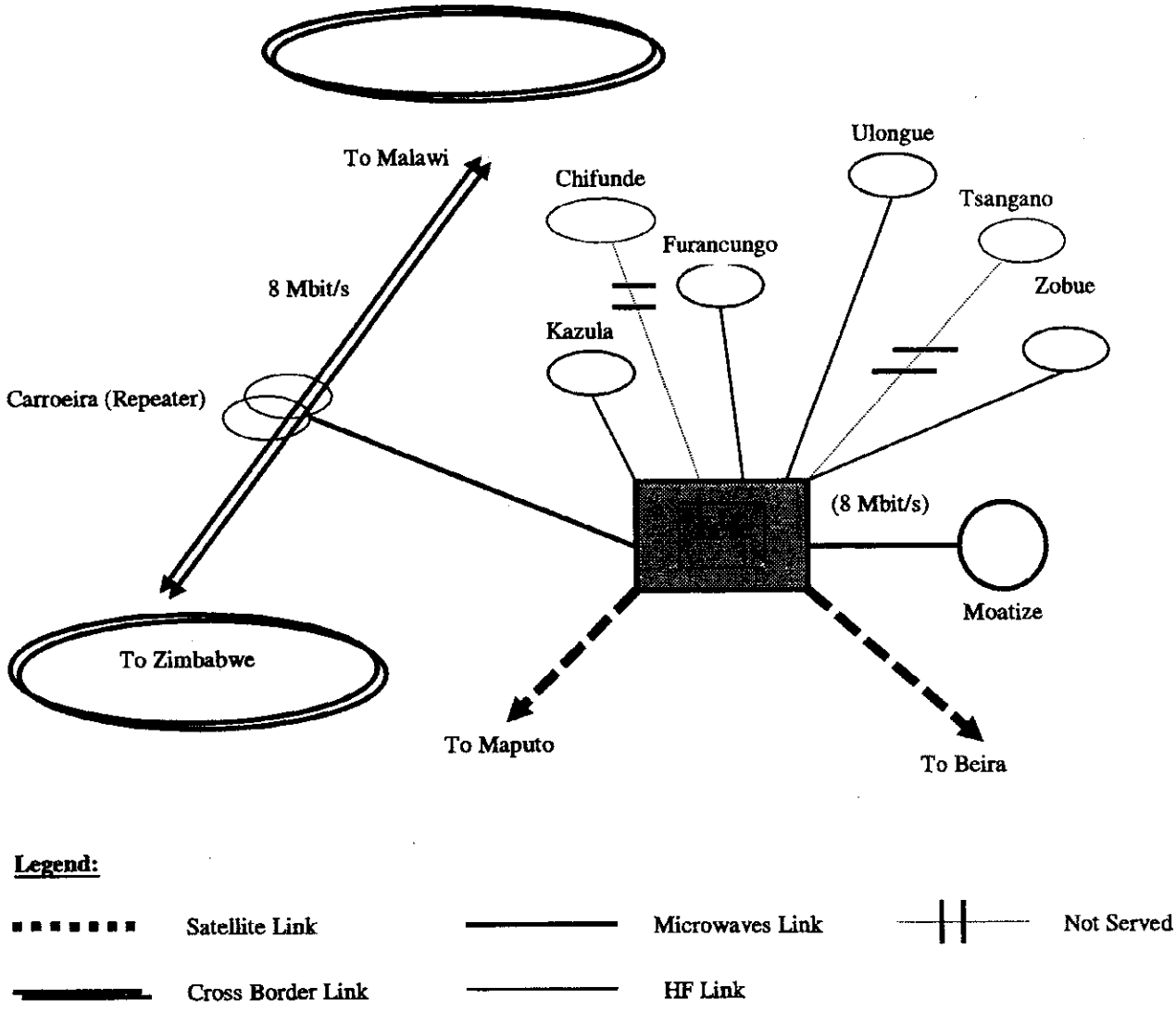
Figure 2.1. Current Telecommunications Linkage in the Study Area (Major District Towns)



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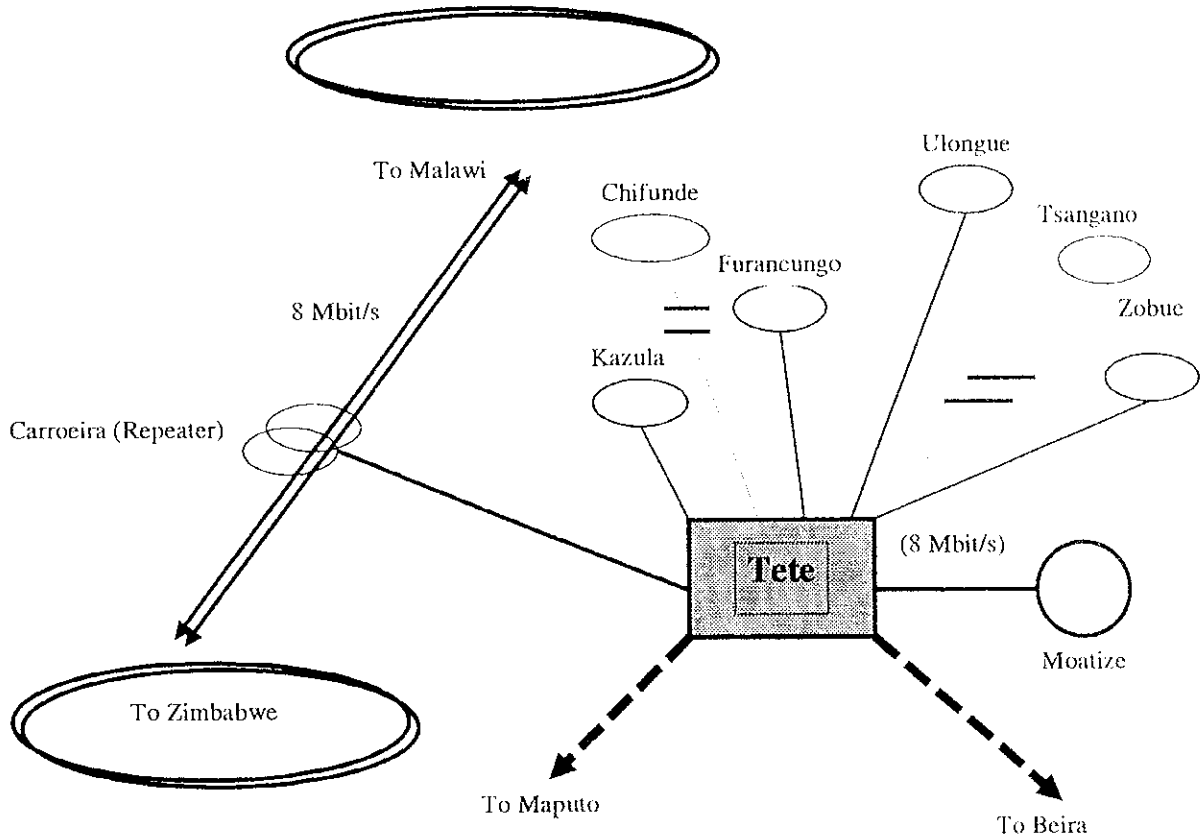
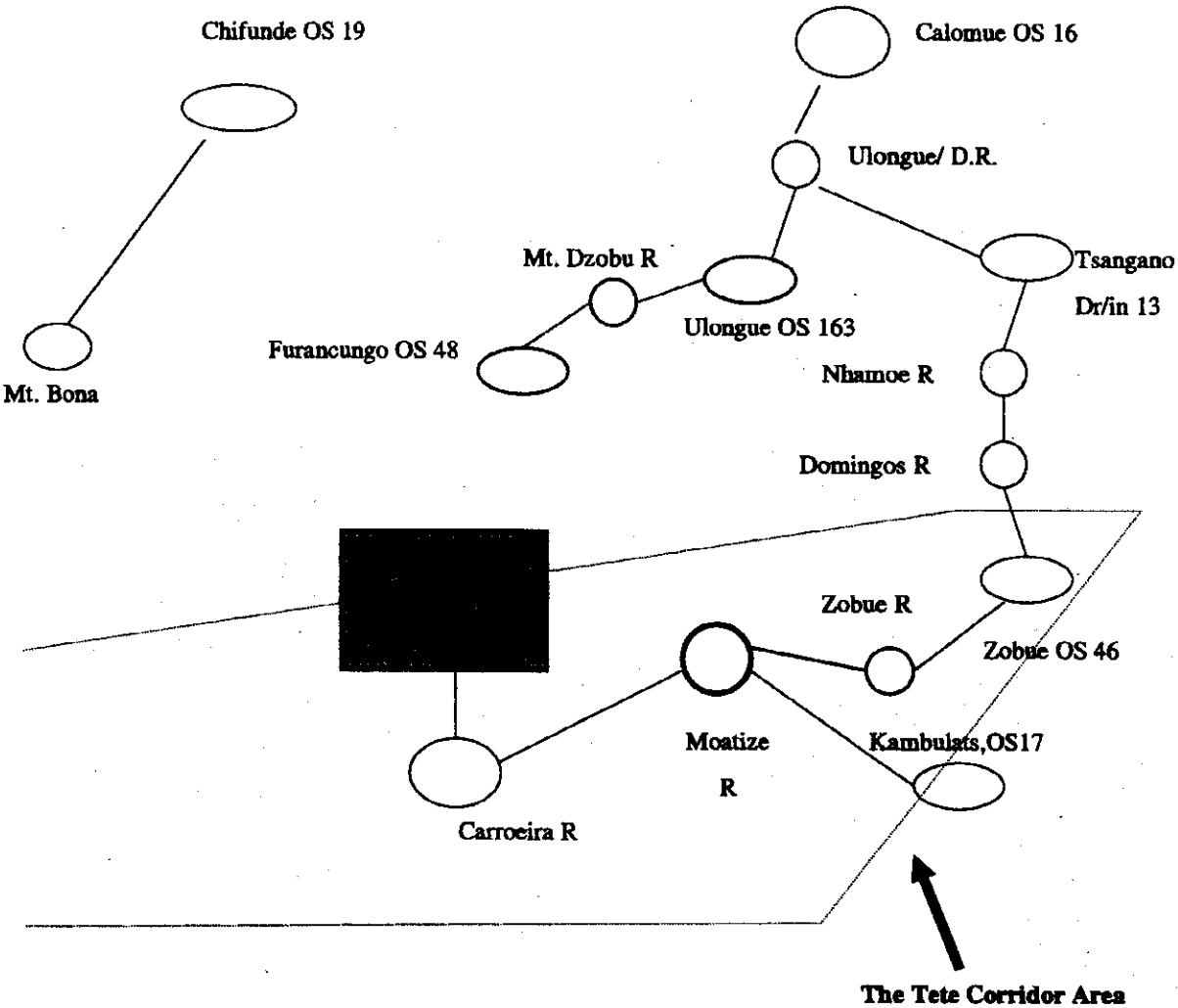


Legend:

Satellite Link — Microwaves Link — Not Served

Cross Border Link — HF Link

Figure 2.2. Planned Telecommunications Expansion in the Study Area (Major District Towns)



Legend:

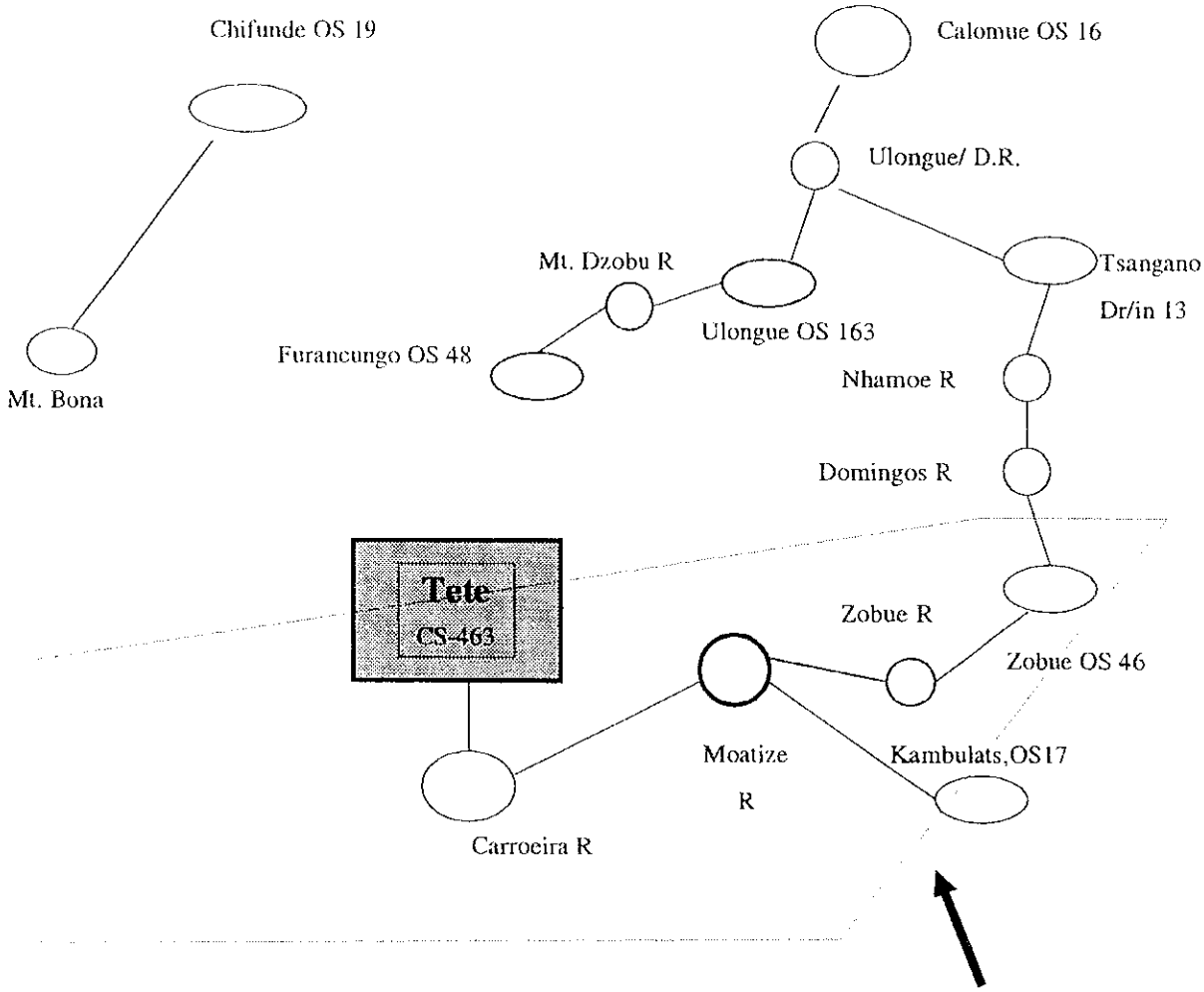
CS = Central Station

R = Repeater

Dr/in 10 = Drop/Insert with 10 Lines

OS 24 = Outstation with 24 Lines

Figure 2.2. **Planned Telecommunications Expansion in the Study Area (Major District Towns)**



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The financing terms are quite favorable: a 10-year repayment period with 4-year grace period at 3 percent annual interest rate. Priority is given to the Tete Corridor Area (Tete Zobue-Tete-Cucham). TDM is also expected to start mobile phone service in Tete soon.

2.2. Prospects for Future Development

Telecommunications sector is very important to regional economic development. Local and international investors will be reluctant to invest in the Study Area if the basic infrastructure — transportation, electricity, and telecommunications — is not available. To facilitate the implementation of the Master Plan, priority should be given to Tete Corridor and Angonia area where the population is concentrated and economic development prospects are high. Tete city should be linked to Maputo/Beira through fiber optical line, and Angonia area should be linked to Maputo/Tete though satellite.

Chapter 3. Objectives, Strategies and Projects

3.1. Development Objectives

The broad development objectives are:

a. To strengthen the economic structure through enhancing agricultural productivity, accelerating industrialization, and promoting service linkages, in order to expand and diversify high earning employment opportunities and to alleviate poverty in association with such opportunities.

b. To improve levels and quality of various social services through selectively strengthening rural infrastructure and expanding human resources base with community participation as a means to promote regional integration or social cohesiveness, and

c. To restore and enhance the environmental capacity through establishing environmentally sound and sustainable production systems in rural and urban areas with proper management organizations based on private interests and community participation.

Basic strategies include strengthening the spatial structure, promoting outward-oriented production, and strengthening development administration at regional/local levels.

3.2. Sector Objectives and Strategies

Sector objectives

Minimal infrastructure development and lack of linkage with outside world negatively affect further economic development. The development objectives in telecommunications sector, therefore, are to speed up telephone line development, increase public card phones in the rural areas, and improve Tete's communications linkage with the outside world.

Telecommunications demand forecast

A simple telecommunication development forecast for national telecommunications development was made for this study, following the GDP growth trend. This forecast will be used as a reference for the implementation of development objectives in the Study Area.

Relationship Between GDP Growth and Telecommunications Sector

Index	1994	1995	1996	1997	1998	1999	Average
GDP growth (%)	4.50	1.40	6.20	11.30	12.00	9.00	–
Total connected lines (%)	3.70	4.10	2.30	7.20	14.90	3.60	–
Demand elasticity	0.8	2.9	0.4	0.6	1.2	0.4	1.1

Telecommunications Development Forecast for Mozambique

Item	2000	2005	2015	2025
GDP	8.0%	8.0%	8.0%	8.0%
Demand Elasticity	1.1	1.1	1.1	1.1
Line Growth Rate	8.5%	8.5%	8.5%	8.5%
Connected Line Demand	78,072	117,223	264,273	595,786
Population	15,894,428	18,220,000	22,870,000	28,150,000
Line per 100	4.9	6.4	11.6	21.2

Phasing Strategy

Specific measures under the basic strategy will be taken in short, medium and long terms. The strategy by broad phase is presented below:

- Short to medium term
  a. Providing basic telephone services to districts; and
  b. Restoring and enhancing Tete City's linkages with the outside world through a repeater station at Carroeira.
- Medium to long term
  a. Expanding telecommunications network into rural areas from Tete City and district capitals; and
  b. Linking Tete City with the coastal areas through fiber optic cables.

3.3. Project Ideas

A District Town Center Telecommunications Development Project will be proposed to provide basic telephone service to the Study Area. Ulongue area will be linked to Tete City with VSAT. Tete City is currently connected to the outside world and its neighboring countries through satellite linkage via Beira and Maputo. The 8 Mbits capacity is far from enough in an information age with Internet and other communications needs.

Theoretically, Tete City could be directly linked to Malawi and Zimbabwe through an 8 Mbit-repeater at Carroeira, but the connections is not working due to technical and financial problems on the Zimbabwe side. The restoration of the linkage should be a priority.

In the long run, Tete city will have to be linked by fiber optical cables to Beira via Chimoio and this should be implemented as soon as Maputo-Beira line is completed.

A separate volume 8 " Project Report " presents the proposed telecommunications projects in detail.

Appendix

Sector Report 4
Infrastructure
Part 2: Telecommunications

Table A-1. SADC Indicators, 1998

	Angola	Malawi	Mozambique	South Africa	Swaziland	Tanzania	Zambia	Zimbabwe
Installed lines	72,244	36,000	75,503	5,000,000	30,000	126,000	80,000	224,248
Phone density (/100 pers.)	0.7	0.4	0.4	11.9	3.2	0.4	1.0	1.8
Cellular access	15,000	10,000	10,000	3,500,000	9,000	30,000	20,000	60,000
Cellular density (/100 pers.)	0.14	0.10	0.05	8.32	0.96	0.12	0.24	0.48
GDP/head (US$)	405	107	108	3,245	1,158	84	370	501

Sources: SADC, *Annual Report 1999* and Transport & Communications Integration Study of Southern Africa.

Table A-2. Phone Servince Coverage, 1998

	Niassa	C. Delgado	Nampula	Zambezia	Tete	Manica	Sofala	Inhambane	Gaza	Maputo	Overall
Coverage (%)	53.3	100	100	87.5	50	66.7	100	75	54.6	100	78.7
Phone servince subscribers	708	843	5,374	2,548	2,128	2,359	7,923	1,489	2,514	49,468	75,354

Source: EDM.

Table A-3. Telephone Line Demand Forecast in Mozambique, 2002 & 2007

Unit: 10^3 direct exchange lines

		Midium		Lines (/100)	High		Lines (/100)
	1995	2002	2007	2007	2002	2007	2007
Mozambique	76.3	145.5	230.7	1.1	189.3	362.2	1.7

Source: TCIS for SA.

The Study on the Integrated Development Master Plan of the Angonia Region

Sector Report 4: Infrastructure

Part 3: Energy

Contents

List of Tables

List of Figures

Appendix

Part 3: Energy

Chapter 1. Energy Sector in Mozambique

1.1. Existing Conditions

Since the end of the Civil War, Mozambique's economy has grown steadily, achieving an average annual growth rate of 6.9% between 1990 and 1999. More important, the growth rate has increased in the last three years, by 11.3% in 1997, 11.8% in 1998 and 9.7% in 1999. In 1998, industry led the economy growing by 9.1%, followed by agriculture sector at 6.1%. Domestic energy reserve, mainly coal, hydro power, and natural gas, is sufficient for its long-term economic development.

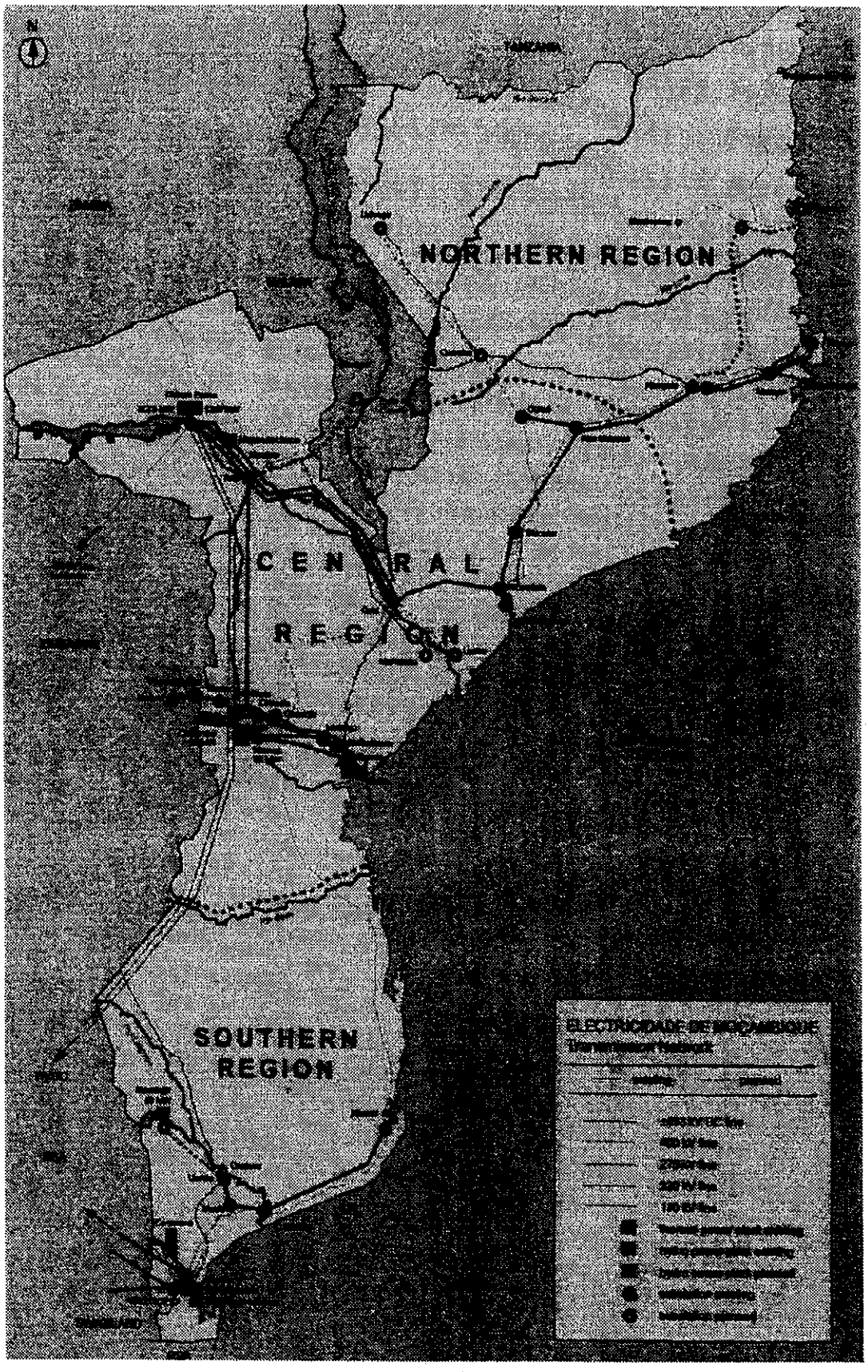
The total coal reserve in Mozambique is estimated at about 16 billion tons, most of which are in Moatize of Tete province. The estimated deposit is 10 billion tons and proven reserve stands at 1.8 billions. The quality of the coal is very high. While steam coal for power generation is available, the coking coal for industry process is extremely competitive both in price and quality. Maximum production of coal was 600,000 tons for domestic and export in the 1980's. The production was resumed after the Civil War. Presently, JC-Gold, a gold mining company in South Africa, is exporting about 15,000 to 20,000 tons to Malawi. JC-Gold group has envisioned a project to produce 2.8 million tons of coking coal for export and 3.2 million tons of steam coal for power generation.

Natural gas fields were found in Buzi Block, Sofala Province, and Pande, Inhambane Province. Feasibility studies are ongoing to explore both fields to supply gas or gas generated power to Beira, Maputo and, possibly, South Africa. The World Bank and the Norwegian Government have been supporting the exploration and feasibility operations in Pande. Proven reserve is about 40 billion cubic meters, according to the Ministry of Mineral Resources and Energy.

Mozambique's most important domestic energy source, however, is hydroelectricity, which, including Cahora Bassa Power Corporation (HCB), accounts for 97.3% of the total electric power generation and a major part of primary energy supply. The exploitable hydropower potential in Mozambique is estimated at 13,000MW, of which 2,184MW has been developed and another 2,600MW plus is under study for the near-future implementation.

Figure 3.1 presents the current power supply system in Mozambique.

Figure 3.1. Current Power Supply Situation in Mozambique



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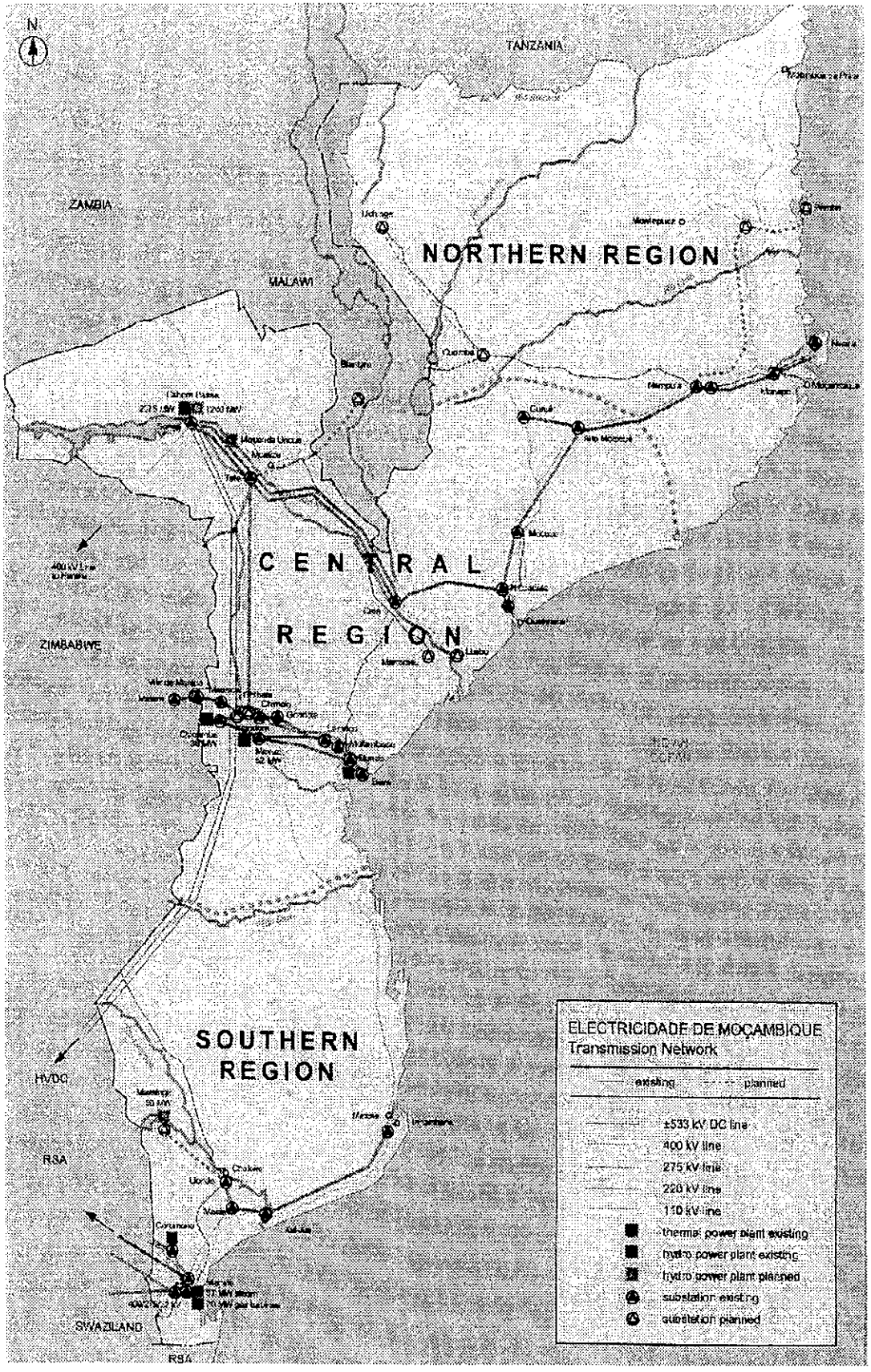


1.2. Institutions in the Energy Sector

While the Prime Minister's Office and the Council of Ministers oversee public investment, CPI coordinates private sector investment in the whole Mozambique, including energy sector development. National Directorate of Energy under the Ministry of Mineral Resources and Energy is in charge of rural electrification programs as well as middle and long-term energy demand forecast in Mozambique, based on projection of economic growth. The Ministry of Mineral Resources and Energy (MMRE) is responsible for the planning, coordination and development of energy resources in Mozambique. Under MMRE, the National Department of Coal and Carbonate is responsible for the coal and carbonate energy development and the National Directorate of Geology (DNG) is in charge of mapping and information process. The DNG offers exploration and mining companies access to the national geological database. The National Department of Mines has the responsibility for administration of the mining and exploration sector, through issuing licenses and supervising activities on the ground. It also supervises the collection of royalties, in addition to formulating and revising national mining policies, legislation proposals, and managing the country's database. The production, transport and marketing of petroleum products are undertaken by private sector.

Power development, generation, transmission, and distribution is under the responsibility of Electricidade de Mozambique (EDM). The EDM is responsible for hydropower surveys and implementation of the national electrification program.

The Southern African Power Pool was established on December 8th, 1995 when the representative of the power utilities from Mozambique, Botswana, Angola, Malawi, South Africa, Swaziland, Democratic Republic of Congo (then Zaire), Namibia, Tanzania and Zimbabwe signed the Inter-Utility Memorandum of Understanding. The objective of the pool was to provide reliable and economical electricity supply to the customers of each of the SAPP members. The present SAPP market structure has developed around the use of medium and long-term bilateral contracts for the provision of firm power supplies. Therefore, any power demand projection of a SAPP country will have to consider the demand situations in other member countries.

1.3. Per Capita Energy Consumption

Per capita electricity consumption (kWh) of Mozambique in 1997 was only 64kWh per year as shown below, according to the World Bank. This is smaller than those of Zimbabwe (975kWh), Zambia (736kWh), and Malawi (87kWh). In the region, South Africa is the leader, at 4,185kWh per capita.

International Comparison

Country	GDP growth (%/year, 90-97)	Power consumption (kWh/capita, 97)	GDP output (/kg US$)	Power production growth (%/year, 80-96)	T&D losses (%, 96)
USA	3.0	13,284	3.6	3.0	7
Japan	1.5	8,252	10.6	4.0	4
South Africa	1.5	4,185	1.5	3.9	8
Zambia	1.0	736	0.6	11.0	9
Zimbabwe	1.8	975	0.8	7.0	17
Malawi	3.6	87	--	--	--
Mozambique	4.9	64	0.4	-19.3	22 *

*1999 figure.
Source: World Development Indicator 1999.

1.4. Power Supply and Trade

The growth of energy consumption has been exhilarating as the economy sped up in the last three years. The number of customers served has also increased steadily. At the same time, the number of workers at EDM, the power company, declined slightly, reflecting EDM's productivity improvement. However, on the supply side, the installed capacity under EDM has not increased, and the growth of available capacity is in fact negative, reflecting a lack of demand and, therefore, new investment in the sector.

The economic growth is unbalanced, mostly coming from the South. This trend is also reflected in the demand for power. Power consumption increased by 14.3% in the South in 1999, 4.4% in the North, and 3.1% in the Central area where Tete province is located.

EDM is heavily reliant on HCB for the purchase of power. In 1999, EDM produced about 22.8%, or 302GWh of the total power consumed in the country, imported 5.5% (72.8GWh), and purchased the rest, about 72%, from HCB (952GWh). Presently, EDM is negotiating with the Government of Portugal for ways to increase long-term domestic power supply. The table below shows the characteristics of the power sector in Mozambique.

Power Sector in Brief

	1995	1996	1997	1998	1999	AAGR (%)
Total Energy (GWh)	965.3	1,023.3	1,112.2	1,202	1,328	8.3
Growth rate (%)	6.3	6.0	8.7	8.0	10.0	
No. of workers	2,895	2,895	2,728	2,799	2,860	-0.3
No. of clients	159,169	171,066	177,709	186,208	189,269	4.4
Installed capacity (MW)	312.8	312.8	313.2	313.2	313.2	0.0
Available capacity (MW)	219.3	219.3	183.7	183.7	183.7	-4.3
Total peak demand (MW)	177.3	190.5	208.2	245	233.4	7.1

(continued)	1995	1996	1997	1998	1999	AAGR (%)
Central	43.2	48	45.1	69.3	46	1.6
Central-North	24	24.4	31.5	34.1	33	8.3
Southern	103.5	111.9	125.2	133.8	145	8.8
Isolated system	6.6	6.2	6.4	7.8	9.4	9.2
Total length of transmission line (Km)	8,759	9,116	9,338	9,338	9,610.4	2.3
No. of Substations	54	54	55	55	65	4.7
Installed substation power (MVA)	1,580	1,580	2,245	2,245	2,429	11.4
Number of power stations	17	17	17	17	17	0.0
Thermal	12	12	12	13	13	2.0
Hydro	5	5	5	4	4	-5.4

Source: EDM.

Mozambique imports power from its neighboring countries, mostly to be consumed in the bordering cities. South Africa dominated the market, accounting for about 95% of the total imports or 70.9GWh in 1999. The country also imported from Zimbabwe by 1% or 8.1GWh, and Malawi 4% or 8.1GWh.

1.5. Government Policies Related to the Energy Sector

According to the latest Five Year Plan between 2000-2004, the economy is anticipated to achieve a sustainable economic growth at 7 to 8% per annum, while maintaining a balanced development between cities and rural areas. This growth rate, therefore, is used as guidance for planning power development in the Study Area.

The government policy in the energy sector is to give top priority to the sustainable use of the energy resources that provide a rhythmic increase of the country and promote development of the social and economic activities, particularly in the realization of investments in the industrial sector and the increase in the levels of exportation.

The government objectives for the field are as follows: expanding the access of energetic sources to the population, reducing the environmental impact caused by the use of non renewable energies, and increasing the outputs of the sector through the provision of incentives directed to the exportation of electrical power to the neighboring countries.

The actions to be taken include: 1) continue to rehabilitate the energy related infrastructures and reinforce the increment of energy distribution network at national, regional and international level; 2) improve the national transportation system of high voltage energy to urban centers identified in the program; 3) expand the national transmission network; 4) improve the medium and low voltage system as well as distribution systems in top priority areas; 5) reduce generation and distribution cost; 6) electrify the remaining district centers (about 53 of them) by the year 2004; 7) secure the connections of 60,000 new domestic consumers; 8) diversify energy sources, including bio-mass energy in the provinces; 9) establish an Electrical Network Dispatch Center; 10) continue regional power exchange with Malawi and Swaziland and construct a second line

from Zimbabwe and a third one from South Africa to Maputo; and 11) continue with the design of a liquid fuel distribution network.

In coal and hydrocarbons sub-sector, the government will give priority to the evaluation and sustainable use of coal and natural gas, including pursuing survey on hydrocarbons in several basins, concluding study for the construction of the oil refinery in Beira or Nacala, starting producing natural gas in the Pande, Sofala and Temane blocks, building pipeline to Maputo and South Africa and to steel projects in Beira and Maputo and other industrial centers. The government will also make viable the coal in Moatize, and consolidate the legal framework of the sub-sector, in particular the oil law.

EDM's commercial and strategic policies aim at 1) the rehabilitation of the infrastructures damaged during the war; 2) the increase in efficiency and service quality; 3) the reduction of the amount of technical and non-technical losses, and 4) extension of the electrical network to rural areas and the increase of number of consumers.

1.6. Load Forecast

Load forecast in Mozambique is both simple and complicated; simple because of its limited demand, complicated because of its power exchange relationship with the neighboring countries. A meaningful load forecast should include current power consumption situation and load forecasts in South Africa, Zimbabwe, and Malawi, which are expected to continue their import of Mozambique's hydro power. To have a rough picture of regional power demand, a preliminary study was carried out and the results are presented at the later part of this chapter.

1.7. Investment Program between 1999 and 2005

The budget for distribution system is US$80.1 million for current projects and US$30 million for planned projects. The total budget for transmission system is US$160.6 million including regional projects. Altogether, the whole investment plan would cost US$302 million, mostly financed by International donors, ASDI, AFD, BAD, BADEA, DANIDA, DBSA, IDB, KfW, Kuwait/OPEC, NORAD, and SIDA.

1.8. Tariff

Electricity tariff in Mozambique is not very high compared with those of OECD countries. According to CPI, the Investment Promotion Center, domestic electricity price to customers in August 2000 was US$0.0857 per kWh at 75kW level in Mozambique. However, the VAT is very high, at 62% per kWh. EDM's average selling price to consumers, including wheeling and other charges, was about US$0.068 in 1999.

Cost and Price per kWh

Price	Mt./kWh	US$/kWh
Average Price to Customers	810.0	0.063
Average Price to Customers*	873.9	0.068
Invoiced	939.0	0.074

*Including wheeling and other services. / US$1= Mt.12,760 (average in 1999).
Source: *Annual Statistical Report*, 1999.

1.9. Rural Electrification

The power development strategy in rural electrification are: supply, at least cost, the area with concentration of customers and economic activities, and, using main grid from HCB as a base, expand into the rural areas, mostly using 33kV distribution and low voltage networks to boost overall macro-economic development.

The following is a summary list of the projects:

Summary of Rural Electrification Projects

	US$10^6	Financiers
1. Ongoing Projects	46.0	Danida/ADB/KfW/Norad/Sida
2. New Projects Under Niassa Umbrella	13.4	
3. New Projects	68.1	
Total	127.5	

Source: EDM - Rural Electrification Projects.

According to the five-year plan, by the end of the year 2004, all 129 districts in the country will be electrified. 10 more districts will be electrified in 2000 (Chiuta and Zobue included), 13 in 2001, and 30 in the next three years. The year 2000 is also the first year that the government has ever allocated a budget for rural electrification under the umbrella of poverty alleviation program.

Chapter 2. Energy Sector in the Study Area

2.1. Study Area

The Study Area includes six districts, Angonia, Tsangano, Moatize, Macanga, Chiuta, Chifunde, and Tete city.

2.2. Constraints in Energy Sector in the Study Area

The Study Area can be summarized by five Ls: Low population density, Low access ratio, Low consumption, Low level of consumption pattern, and a Lack of transport and transmission.

1) Low population density: The most serious barrier to rural electrification in the region is a lack of population concentration and an inhospitable terrain for building transmission lines.

Population Density

District/Areas	Population	Area (km^2)	Density ($/km^2$)
Chifunde	48,498	9,326	5.2
Macanga	46,000	7,340	6.3
Chiuta	50,372	6,887	7.3
Moatize	109,103	8,879	12.3
Tsangano	106,557	3,439	31.0
Angonia	247,999	3,427	72.4
The Study Area	710,000	40,800	17.4
Tete Province	1,144,604	100,724	11.4
Mozambique	16,840,654	801,590	21.0

2) Lack of access: Low access ratio of 1.7% of the household compared with the national average at 4.1%, the third lowest in the provinces. In fact, two out of the six districts in the Study Area are not even served with any electricity.

Districts Served

District/Area	Town	KW (Current)	kW (Planned)
Chifunde		None	
Macanga	Furancungo	None	75
Chiuta		75	75
Moatize		Connect to the Grid	
Angonia	Ulongue	500 (From Malawi)	
Tsangano	Tsangano	75	
Tete City		Connect to the Grid (6 MVA)	

Source: EDM Tete.

3) Dependence on forest resources: The region is increasingly relying on forestry products as energy source. The estimated consumption of firewood increased by 35% in 1995 and 60% in 1996 and consumption of charcoal increased by a stunning 499.1% in 1995 and 121.9% in 1996, imposing great pressure on national forestry resources. A survey at the local market showed that a bag of charcoal cost about Mt.75,000 to 80,000 and four pieces of firewood Mt.5,000.

Consumption of Firewood and Charcoal in the Study Area

Description	Year	Quantity	Change (%)
Firewood (ton)	1995	92,088	
	1996	124,329	35.0
	1997	199,671	60.6
Charcoal (50-100kg bag)	1995	60,655	
	1996	363,393	499.1
	1997	806,498	121.9

Source: *Estatisticas de Resursos Minerals E Energia*, 1997.

4) Low consumption: Per capita energy consumption at mere 27.6kWh was lower than the national average (75kWh) per person in 1999. This is directly related to the low level of economic development. GDP per capita in Tete province is low, compared with that of the nation. There are no noticeable large industries, except JC Gold's operation in Moatize. Most businesses are operated in informal sector.

5) Lack of transportation and transmission lines: Energy products, coal in this case, cannot be delivered, in large quantity, to international market, because the railway is not functional and de-mining program has yet to be started. At the same time, lack of transmission capacity causes HCB to operate under 50% of its installed capacity.

Adding to the misery, the recent flood damaged the two DC transmission line to South Africa, causing economic losses to the country. Only one line was restored in August.

2.3. Potentials and Strength of the Study Area

Nationally, a low economic development base may provide opportunities to leapfrog old economies, taking advantages of the information technologies. At a lower level, the economy has space to grow fast and avoids the mistakes made by the advanced countries. Mozambique's recent robust growth rate shows sings of promise.

The rural area in the Study Area is expanding close to HCB's main grid lines, which helps speed up rural electrification program. Industry and agriculture sectors can exploit the cheap, abundant, and reliable hydro energy resources to their full benefits.

HCB is the most valuable asset in Mozambique today and, when the second phase finishes, along with several other hydro projects, it could be a regional power generation hub to

support economic growth in Malawi, South Africa, Zimbabwe, and, mostly, Tete province.

The coal reserve in the region could be exported to Japan and other industrialized countries, if the railway is rehabilitated. Coal products (briquettes) could also substitute firewood and charcoals in home cooking. With the opening of the railway, other minerals might become economical and competitive as well as agriculture might find new outlets for export. In the long run, the rich coal reserve could also be used for power generation, if there is a demand and if it is the least cost solution in the Southern Africa Power Pool.

With plenty of solar exposure in isolated, and sparsely populated highland of Chifunde district, which has no immediate plan for diesel generation, solar and wind energy might be an alternative for health clinics, basic home use, and water pumping, etc.

2.4. Potentials for Hydropower Development in the Study Area

About two-third of the national hydroelectric potential of 13,000MW is concentrated in the Zambezi river basin. HBC is one of the largest dams and power stations in Africa.

The hydro potential in the region could be as high as 9,000MW. The north bank has a potential for 550 to 1,240MW, in addition to the existing 2,075MW in HCB; Mpanda Uncua has a potential of 1,600MW, Boroma, 400MW; Lupata has 600MW, downstream from Lupata close to Muturata has 1,100MW. Other possibilities on its tributaries in Tete province include Luia (1,000MW), Revuboe River in Moatize (1000MW), Luenha (191MW), Lifidzi (2MW), Maue (15MW) and Mavuzi (88MW)

Moreover, a study has been launched to build a mine-mouth coal-fired power plant with a capacity of 1,050MW. The project envisions exporting power to Zimbabwe (400MW) and Malawi (100MW), and domestic market (500MW). Further study, however, is needed. For the project to be launched, three barriers will need to be overcome: 1) there should be a long term demand in the region which could guarantee a power price of above US$0.05-0.06 per kWh. Currently HCB's selling price to the Republic of South Africa and EDM might be below US$0.03 and US$0.02, respectively (confer the table below for an indirect calculation). A preliminary load forecast showed that 1) the coal-fired project will be needed some time in the next 25 years, 2) the thermal power project may also top the Least Cost Development Plan, after HCB second phase (North Bank) development, and 3) the only technical barrier may be the availability of transmission and distribution systems to load centers.

EDM Purchase Price from HCB in 1999

Total Purchased Energy (GWh)	753.4
Total Cost of Purchase (Mt.10^6)	92,931
Cost (Mt./kWh)	123.35
(US$/kWh)	0.010

Average exchange rate assumed at US$= Mt.12,760.

2.5. International Donors and NGO Activities in the Study Area

Because of its backwardness and landmine problems, international donors and NGOs have been active in the region. DANIDA works mainly in health and education, NPA works on de-mining in the region, and the World Vision is involved in all aspects of development and relief efforts.

Projects Related to Energy by International Donors and NGOs

Name	Activities	Districts
World Vision	Health facilities	Moatize, Angonia, Macanga
DANIDA	Support to water supply	Tete
UNDP (PROAREA)	Construction of health and education facilities	Chiuta, Tsangano, Macanga, and Angonia

2.6. Renewable Energy

There are about 27 solar vaccine refrigeration systems financed by DANIDA in Tete province, but most of them are not functioning properly and need repair, mainly due to the lack of spare parts and timely maintenance. Other organizations also face the same problems. There are also wind-power pumps in Angonia. Renewable energy could play a complementary role in the region, especially in places where grid connection would be too costly.

FUNAE, under the National Directorate of Energy, is in charge of promoting renewable energy in rural areas. It currently operates several solar energy projects in Maputo province. The current price for a two-panel system is about US$1,000. The users or users' sponsor pays a down-payment of 20% of the total cost and the remaining is paid biannually in three years. The users or users' sponsors have to sign a contract to guarantee the repayment of the cost and the maintenance of the solar panels. The pilot project was implemented in August 2000, starting with teachers' houses, a local shop, a village clinic, and a school. However, the financial structure might not be applicable to the Study Area, since farmers are poorer than those in Maputo Province. A village solar station where batteries can be collected and charged will be more economical and suitable for rural electrification in the Study Area.

2.7. Moatize Coalmines

According to the ministry of Mineral Resources and Energy, Mozambique has about 1% of the world's coal reserve, mostly in Moatize and Maravia districts of Tete province. Three international operators have current concessions to exploit the Moatize deposits. Export to Malawi have resumed and the Zambian market is being assessed. An estimate indicates that it would be feasible to export around 3.5 million tons per year, which will contribute towards improving Mozambique's trade balance.

Coal Deposit in Moatize and Maravia Districts

Mine/Deposit	District	Reserve (10^6t)
Moatize	Moatize	2,445
Mucanha-Vuzi	Moatize	3,633
Minjova	Moatize	450
Muaradzi-Mecondezi	Moatize	200
Chiroddeze		300
Total		7,028

Source: Ministry of Mineral Resources and Energy; Provincial Directorate for Mineral Resource and Energy.

The key issue for the development of the coal mines is the rehabilitation of the railway system and the price of the coal. According to Giersing Rose Report, Mozambique: Development Study of Moatize Coal Fields & Transport Infrastructure, the FOB price for steam coal in Beira could be around US$27, and for coking coal around US$43.

2.8. Hidroelectrica de Cahora Bassa (HBC)

The construction of HBC started in 1969, and in 1974 the first unit started to generate power. In 1976, the first phase of HBC was in full operation with 415MW for each of the five units (5 x 415) and an installed capacity of 2,075MW. At the time it was the second largest hydro power station in the world, and its Cahora Bassa-Apollo HVDC lines transmit the largest amount of power at the highest transmission voltage over the longest distance in the world, using the thyristor technique. The project was a joint venture between the South African government and Portuguese government. A supply contract was signed between Eskom and the Portuguese government. Following the independence of Mozambique, the previously signed contracts were re-negotiated to include Mozambique as a third party.

Operating less than 50% of its full capacity, currently HCB has only three units in operation because of lack of demand/customers and the bottlenecks in power transmission. Presently, South Africa is committed to take 900MW per year, Zimbabwe 320MW, and Mozambique, between 95-150MW. Total committed power is estimated at about

1,310-1,370MW.

Basic Data of HBC Dam

Max. height above foundation	171m	Crown length	303m
Dam crest altitude	331m	Volume of concrete	450,000m³
Excavation of foundation	210,000m³	Segmentary gates	8 x 1,650m³/sec.
Reservoir length	270km	Width	30km
Depth	140m	Capacity	63km³
Surface area	2,660km²	Turbines type	Francis
Capacity	415MW	Speed	107.1rpm
Effective head	103.5m	Consumption	452m³/sec.
Penstock length	170m-D.9.7m-45°		

Source: HCB.

Power Supply Commitment

Country	Power Demand (MW)	Estimated Energy (GWh)
South Africa	900	NA
Zimbabwe	320	NA
Mozambique	100	NA
Total	1,320	NA
Unused capacity	730	NA
Integrated peak in Mozambique*	235	NA

Note: Not simultaneous.
Source: HCB.

According to HBC, the sales prices to its customers are all very low. HBC sales price to South Africa is about R0.18 or US$0.024, but the average price in South Africa is currently at R0.56 or US$0.073 (at US$1=R7.635).

The project was financed by loans, mainly in the form of export credits, from France, West Germany, Italy, and South Africa. HCB is now mostly owned by the Portuguese government with 81.66% of share and Mozambique with 18.34%t. The Portuguese government is negotiating with the Mozambique government on the transfer of its full ownership to the GOM. The transfer is expected to happen in 2001.

The second phase of the project, building a power station with 60% of the existing capacity on the north bank was never started. However, since the dam has already been built with the tunnel available, the cost of the second power station should be very competitive against any other possible generation scheme. The second phase should be a priority in the long term economic development plan, given the continuous expansion of Mozambique's economy and, therefore, the increased demand for electricity.

Chapter 3. Energy Development Objectives and Demand Forecast

3.1. Objectives

In this section, a power demand forecast is made for Mozambique and Tete province in order to a) establish that three hydro power stations, plus some multi-purpose dams, are urgently needed, and b) a mine-mouth, coal-fired power plant will be required some time in the next 25 years for power export to the neighboring countries and to increase power supply security.

3.2. Demand Forecast for Mozambique and Tete

GDP growth and demand elasticity

Using the past GDP growth and the power demand trend, a simple power demand projection could be made. Historically, GDP grew at an average annual growth rate of 7.48% between 1991 and 1999. Power demand grew faster than GDP in five out of four years recorded as below.

Economic Growth and Power Supply in Mozambique

	1991	1992	1993	1994	1995	1996	1997	1998	1999	Ave.
GNP (%)	4.9	-0.8	18.8	4.5	1.4	6.2	11.3	12.0	9.0	--
Power supply (%)	8.1	0.9	5.9	6.5	6.3	6.0	8.7	8.1	10.5	--
Demand elasticity	1.6	1.2	0.3	1.5	4.5	1.0	0.8	0.7	1.2	1.4

Sources: Bank of Mozambique and EDM.

Based on the historical trend, a simple demand projection was made:

Demand Projection Based on Past Trend (Moderate Growth Scenario)

	2000	2005	2015	2020	2025
GNP Growth (%/year)	8.00	8.00	8.00	8.00	8.00
Demand Elasticity	1.4	1.4	1.4	1.4	1.4
Power Supply growth rate (%/year)	11.2	11.2	11.2	11.2	11.2
Power Demand (GWh)	1,060	1,805	5,235	8,913	15,176

Source: EDM.

According to EDM's 1997 projection, the energy demand would be 3,131GWh by 2020 and 3,388GWh by 2025, using the annual growth rate of 3.3%. This demand forecast could not even meet the demand of the recently finished Mozal Phase I, which imports around 4,000GWh per year.

Moreover, using the historical growth trend to project power demand in Mozambique, the power demand per capita would only reach 321kWh/person per year in 2025, less than half of that of Zambia's in 1997. This method may seriously underestimate the economic

growth, and therefore, power demand in Mozambique, for the following three reasons.

1) Mozambique economy is at a very primitive stage or is poised to taking off from a very low starting point. With a GDP per capita at around $100 per year, it would barely reach its neighbor, Zimbabwe's level of $270 (in 1997) by the end of the year 2025, even if it keeps a steady growth of 8% per year. On the positive side, this low level leaves room for a faster growth. The ten-percent economic growth in the last several years may prove to be a rule rather than an exception.
2) Presently, there are five large projects under various stages of development around Mozambique. Mozal Phase I was completed in the year 2000, and Phase II is expected to be finished in the year 2001. Other projects are under serious consideration and, if implemented, will be on board before the year 2015. These six large projects would jointly require a total of 19,500GWh per year with a peak demand of 2,670MW. On top of that, the expansion of Moatize coal mine to meet the energy demand in international market will surely require more electricity (illumination, pumping water, etc.).

Possible Large Projects in Mozambique

Project	Max. Demand (MW)	Annual Energy (GWh)
Mozal Phase 1	460	4,000
Mozal Phase 2	895	3,500
Maputo Iron & Steel (MISP)	850	5,000
Kaiser Aluminum Smelter, Beira	625	5,000
Titanium smelter, Nacala	150	1,000
Corridor Sands project, Chibuto	150	1,000
Total	2 670	19,500

Sources: UTIP, EDM-Mepanda Uncua and Cahora Bassa North Project Feasibility Study.

With such large infusion of foreign direct investment (FDI), the conventional historical method would severely underestimate the potential demand for power, and, therefore, the growth of GDP. And a power shortage could actually drag down economic growth as repeatedly experienced in other countries.

3) Any power demand projection in Mozambique should take into consideration South Africa's future demand. According to the same Project Feasibility Study, the Eskom system will experience a power deficit from 2007 onwards and will require some 3,000MW of new capacity by 2010. South Africa, Mozambique's traditional customer in power sector, will continue to rely on hydro projects from Mozambique.

Power Demand in South Africa

Year	Energy Demand (GWh)	Max. Demand (MW)	Max. Demand (MW) with DSM
1999	180,163	28,969	26,806
2000	186,147	29,927	27,764
2001	191,859	30,818	28,581
2002	198,390	32,389	30,077
2003	204,626	33,858	31,472
2004	210,160	34,874	32,413
2005	215,705	35,895	33,318
2006	221,570	36,977	34,284
2007	227,287	38,052	35,243
2008	233,121	39,140	36,215
2009	239,046	40,238	37,197
2010	244,939	41,335	38,178
2015	274,811	46,777	42,713
2020	307,004	52,457	48,345

Source: Eskom, *Integrated Electricity Plan 7*, 1998.

Separate projection for economic and non-economic sector

Since rural electrification is vital for social and economic development in Mozambique, it is a priority to set a moderate goal for rural electrification, as measured either by electrification of rural villages or by household access rate. Mozambique's electricity access rate is minimal, reflecting low level economic development. Nationally, only 4.4% of the households were estimated to be provided with electricity in 2000, so was 1.9% of households in Tete province. Believing that the current development strategies will benefit rural households, a goal of about 50% access rate for Mozambique, and 40% for Tete province by the end of the year 2025 is set . These rates are still low, compared with those of the other developing countries. To achieve these access rates, the domestic energy demand would have to reach 12,376GWh for Mozambique and 600GWh for Tete province, respectively in 2025.

The economic sector will continue to follow the GDP growth trend, using the historical demand elasticity of 1.4. Using this method, the combined power demand would be 9,035GWh for Mozambique and 205GWh for Tete. These figures are more compatible with the increased demand from the planned large projects.

Domestic Power Demand in Tete and Mozambique in 2000

	Domestic Customers	Population	Access Rate	Total Energy (GWh)	kWh per Customer
Tete	5,289	1,202,346	1.85%	11	2,027
Mozambique	166,179	15,894,428	4.39%	429	2,626

Note: Population figure is based on the estimates by the Study Team growing at 3.3 per year; kWh per Capita was estimated for 2000, based on figures in 1999. Average household size is considered as 4.2, using EDM's assumption. kWh per customer grew at an average annual growth rate of 5.5% between 1995 and 1999, reflecting the growth of disposable income in those electrified households, but in our projection, we used an AAGR of 1%, factoring in improvement in domestic energy consumption.

Sources: National Institute of Statistics and EDM.

Domestic Power Demand in Mozambique in 2025

	Domestic Customers	Population	Access Rate	Total Energy (GWh)	kWh per Customer
Tete	210,476	2,210,000	40.0%	600	2,851
Mozambique	3,351,190	28,150,000	50.0%	12,376	3 693

Domestic and Economic Sectors Combined Demand (Basic Scenario)

Unit: GWh

		2000	2005	2015	2025	Growth rate (%/year)
Domestic Sector	Tete	11	24	120	600	17.4
	Mozambique	429	840	3,225	12,376	14.4
Economic Sector	Tete	12	18	66	205	11.9
	Mozambique	631	1,075	3,116	9,035	11.2
Combined	Tete	23	42	186	805	15.3
	Mozambique	1060	1,915	6,342	21,412	12.8

Average annual growth rates of 15.3% and 12.8% seem very optimistic projections, but are based on a highly likely scenario. Even with such a growth rate, by the end of the year 2025, Mozambique's energy consumption (kWh) per capita would still be around 763kWh (21,412,000,000kWh/28,150,000—projected population in 2025). In comparison, kWh per capita was 975 in Zimbabwe in 1997, and 736 in Zambia in the same year.

High Growth Scenario is a fairly plausible scenario. If the projected domestic demand of 12,376GWh in 2025 is added to the projected demand of 19,500GWh from the six large projects, the total demand would be 31,876GWh. Mozal Phase I has already started to operate and is importing power from Eskom.

The three kinds of power demand projections presented so far are summarized as follows.

Summary of the Three Power Demand Scenarios

Item	2000	2005	2015	2025	Growth rate (%/year)
Moderate Growth scenario (GDP Trend)	1,060	1,805	5,235	15,176	11.2
Base Scenario (Domestic+Economic Sectors)	1,060	1,915	6,342	21,412	12.8
High Growth Scenario (Domestic+Large Projects)	1,060 (4,429)	8,340	16,725	31,876	14.6

3.3. Demand and Supply Balance

At this stage, three hydropower projects are under various stages of consideration. Their energy generation is assumed at an average plant utilization factor of 58%, plus 8% for line loss and auxiliary use. Moatize coal-fired power plants used a plant factor of 65% and a line loss rate of 8%.

HCB North	1,960MW,	9,201GWh
Mepanda Uncua	1,230MW,	5,774GWh
Boroma	360MW,	1,683GWh
Sub-Total	3,550MW,	16,657GWh

Moatize (not considered in base supply) 2400MW (4x600), 12572GWh.

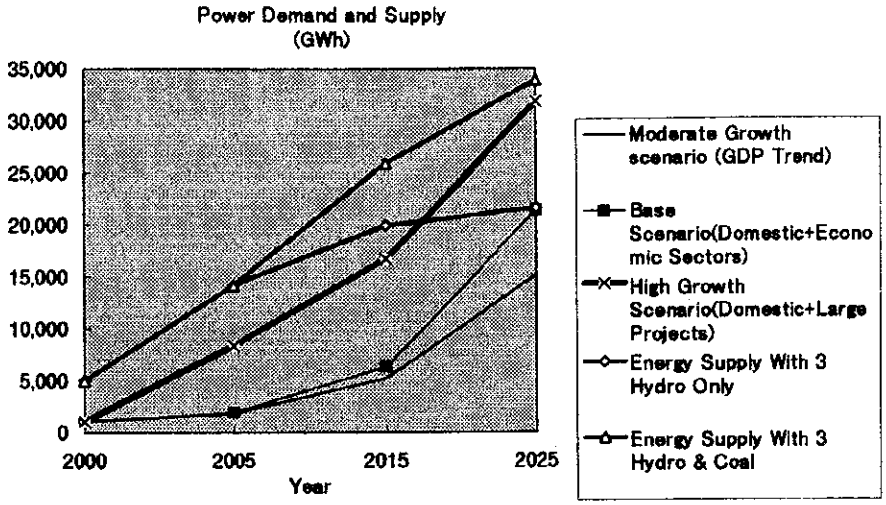
Table 3.1 compares the power supply capacity above with the power demand projected under the three cases for the years 2000,2005, 2015 and 2025. The balance is also shown in the following graph.

Table 3.1. Demand vs. Supply in Mozambican Power System

Unit: GWh

	2000	2005	2015	2025
With 3 Hydro Projects	303	9,503	15,277	16,960
Existing HCB	4,695	4,695	4,695	4,695
Total Supply in Mozambique	4,997	14,198	19,972	21,655
High Growth Scenario	4,429	8,340	16,725	31,876
Supply vs. Demand	568	5,858	3,247	-10,221
Moatize Coal Power Plant				*12,572*
Base Scenario	1,060	1,915	6,342	21,412
Moderate Growth Scenario	1,060	1,805	5,223	15,176
Supply vs. Demand	3,937	12,393	14,737	6,478

Power Demand and Supply



It seems that, with the help of the three new hydropower projects, the supply would be able to meet the demand in the base scenario. However, the supply figure includes HCB's 4,965GWh, which has mostly committed to exporting to South Africa and Zimbabwe. Worse, when the power shortage arises in South Africa starting from the year 2007, at 3,000MW peak demand (approximately 9,057GWh, at a plant factor of 58% and a line loss rate of 8%), Eskom will have to purchase more power from Mozambique, which needs large foreign currency to cover its trade deficit and international debt repayment.

Given the above supply-demand balance, with South Africa's possible increase in power importation from Mozambique, the mine-mouth, coal-fired power plant will be needed some time within the next 25 year. The power plant could be 2,400MW (4x600). The addition of a coal-fired power plant will also diversify Mozambique's power supply source and increase power supply reliability, in case of an unprecedented drought.

3.4. Development Objectives

3.4.1. Broad objectives

The broad development objectives are:

1) To strengthen the economic structure through enhancing agricultural productivity, accelerating industrialization, and promoting service linkages, in order to expand and diversify high earning employment opportunities and to alleviate poverty in association with such opportunities.
2) To improve levels and quality of various social services through selectively strengthening rural infrastructure and expanding human resources base with community participation as a means to promote regional integration or social cohesiveness, and

3) To restore and enhance the environmental capacity through establishing environmentally sound and sustainable production systems in rural and urban areas with proper management organizations based on private interests and community participation.

Basic strategies include strengthening the spatial structure, promoting outward-oriented production, and strengthening development administration at regional/local levels.

3.4.2. Sector objectives

Minimal infrastructure development and lack of linkage with outside world negatively affect further economic development. The development objectives in energy sector, therefore, are to speed up rural electrification and introduce sustainable and efficient energy use.

The preliminary demand forecast for national and regional power consumption was made for this study. This forecast is used as a reference for the implementation of development objectives in the Study Area.

To achieve the sector objectives, efforts should be made in installing diesel generation units in district town centers and large communities, where power grid line is far away. In isolated places where population density is low, solar energy should be used to power community facilities at first (schools, clinic, teacher's houses, etc.). A pilot communal solar energy project will be launched in Chifunde where farmers will be able to get their batteries charged at the local solar center with a reasonable fee. In places where grid system and proposed multi-purpose dams are accessible, a gradual expansion of electricity line will be introduced.

Renewable energy shall play an important role in the area. A Renewable Energy Center will be established to coordinate renewable energy development in the Study Area as well as in the Zambezi River Basin Area. The center will promote development of bio-mass, bio-gas, wind, solar, and small hydro projects.

Middle and large size hydro and thermal power projects will be pursued in the region, taking advantage of the rich natural resources. The region is expected to be a power export center, as a component of the greater regional cooperation. All of the future power projects will be in Tete province and at least one in the Study Area.

To complement environmental efforts, projects will also be recommended to promote making use of coal briquettes in place of charcoal and firewood. Energy saving cooking stoves will also be introduced to reduce the consumption of firewood.

Among the six districts, only Tete City, Tsangano, Ulongue, and Moatize are electrified. There are plans for Macanga and Furancungo, but are not implemented because of lack of fund. The next step is to electrify the remaining three districts, including Chifunde. At

the same time, a 500kW small hydro station in Ulongue needs to be rehabilitated in substitute for, or in addition to, the imported power from Malawi. A District Center Electrification Project is proposed.

The priority will be given to set up diesel generators in Furancungo, which is planned to install a 75kW diesel generation system in 2002. There are small diesel generators operating in Furancungo by a tobacco company (15kW), the district administration (10kW), PROAGRI and two NGOs (solar energy), but not enough to supply the whole residential areas, projected at 300 households.

A diesel system started to operate on June 22, 2001 in Chiuta. The capacity is 75kW, and the cost is US$30,963 for diesel generator and US 67,328.54 for distribution system. The tariff is set by National Directorate of Energy and FUNAE in consultation with local people. The project is a part of the World Bank lending program to electrify local district. The project was started in 1997 and is now in its second phase. The temporary tariff, which has been used in Tsangano is very low, not enough to cover the operation cost. A brief calculation of tariff and operation cost in Chiuta shows that the current tariff structure cannot even cover diesel and lubricant oil. The tariff, however, is expected to increase when farmers started to benefit from the electrification. Sustainable operation of the system, therefore, should be the priority.

Tariff, Revenue and Operation Cost of Diesel Generation System in Chiuta

Customers	Tariff (Mt./Month)	US$/month	Number of Customers*	Revenue Mt./month	US$/month	Operation Cost† (Mt./m.)
Residential	150,000	6.82	18	2,700,000	122.73	-
Small business	250,000	11.36	8	2,000,000	90.91	-
Commercial	350,000	15.91	2	700,000	31.82	-
Hospital	800,000	36.36	1	800,000	36.36	-
School	400,000	18.18	1	400,000	18.18	-
			Total	6,600,000	300.0	9,150,000

*Residential customers includes one for Administrator's Office and one for residence. †Operation cost includes Mt.9,000,000 of diesel cost and Mt.150,000 of lubricant oil. Labor and spare parts cost are not included. Exchange rate assumed: US$= Mt.22,000
Sources: Directorate of Mineral Resources and Energy, Tete.

In Chifunde, a solar charging center will be established, in the form of rural cooperative. In Ulongue, a 500kW station will be rehabilitated in substitute for, or in addition to, the power imported from Malawi.

The electrification project will benefit local farmers and their children. The communal facilities, clinics, mills, schools, will be further strengthened with the electricity.

Two 6.3 MVAs served Tete City with a peak demand of 5.4MW in 1999 and a new 6.3 MVA substation served Moatize. The distribution project is divided into two phases.

During the first phase, efforts will be made to improve the existing capacity and extend services to Matundo.

The second phase of the distribution project is expected to establish distribution infrastructure for Tete Moatize Core Urban Development Zone. Although it is hard to estimate the potential energy demand in the Zone, a rough estimate was made, based on the past trend and assumption of one kW for one household. The total energy demand in the Tete-Moatize area in the year 2025 is expected to be 730GWh, with a per capita consumption at 1,251kWh. For reference, in 1997 per capita consumption in South Africa was 3,800kWh, 563kWh in Zambia, and 919kWh in Zimbabwe. This demand forecast, however, does not consider possible large industry investments and back-up generators for Moatize coalmine operations. The additional distribution capacity is expected to be 119 MVA, which could cost US$44.8 million.

The development costs of the afore-mentioned mine-mouth, coal fired, power plant, and the urban distribution project in Tete-Moatize are estimated to be US$2,691.8 million by 2025 as shown below.

Development Costs for Thermal Power Plant and Power Distribution System

(Unit: US$ million)

Component	Phase-I	Phase-II	Total
Power plant	0.0	2,640.0	2,640.0
Distribution-I	7.0	0.0	7.0
Distribution-II	0.0	44.8	44.8
Total	7.0	2,684.8	2,691.8

A detail of the proposed electricity projects is presented in a separate volume VIII "Project Report".

Appendix

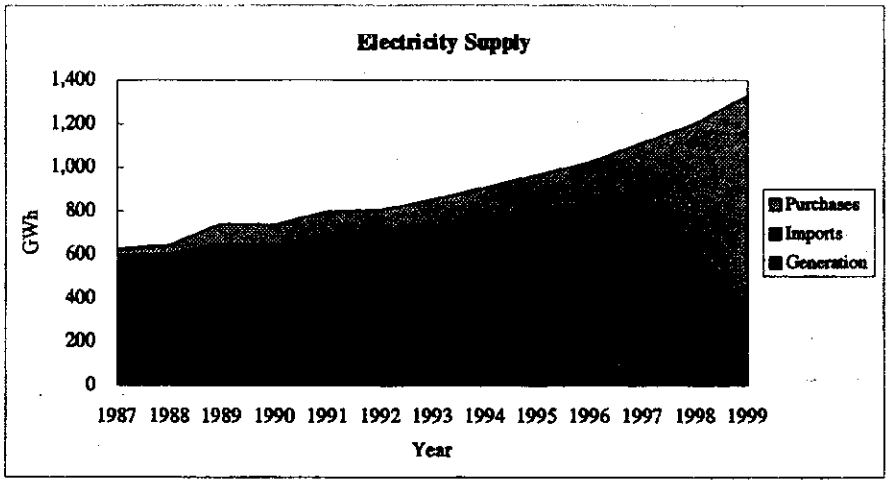
Sector Report 4
Infrastructure
Part 3: Energy

1. Electricity Supply over Last 11 Years

Unit: GWh

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	AAGR
Generation	268.6	263.0	342.3	322.1	325.7	273.8	223.6	200.4	212.1	238.8	219.0	243.8	302.8	1%
Imports	330.2	340.6	307.0	321.8	373.2	436.3	510.9	566.9	601.4	598.6	686.0	343.0	72.8	-12%
Purchases	25.7	40.5	92.6	94.2	98.7	95.0	118.1	141.0	151.7	185.5	207.1	615.3	952.5	35%
Total EDM	624.5	644.1	741.9	738.1	797.6	805.1	852.6	908.3	965.2	1,022.9	1,112.1	1,202.1	1,328.1	6%

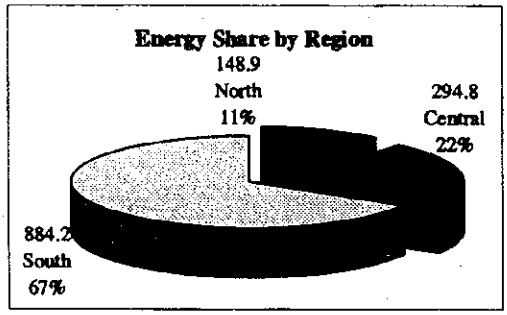
Source: EDM, *Annual Statistical Report 1999*.



2. Total Energy by Region, 1999

Unit: GWh

Region	1999	1998	%
North	148.9	142.6	4.4
Central	294.8	286.0	3.1
South	884.2	773.4	14.3
Total	1,327.9	1,202.0	10.5



3. Rural Electrification Project in Tete Province

Magoe and Chicoa Unit: US$

Activities	Qty	Unit Price	Total
33kV OH line leopard (km)	205	20,000	4,100,000
0.4kV Alus 4x50 mm^2 (km)	13	15,000	195,000
Pole Mounted Substations	21	11,000	231,000
		Total	4,526,000

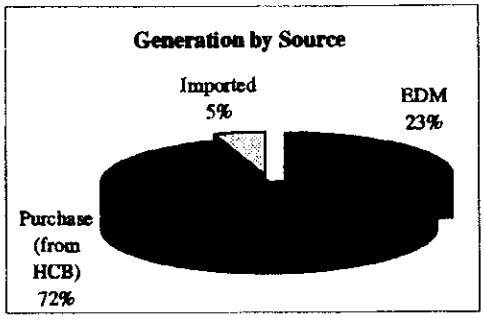
Ulongue and Furancungo

Activities	Qty	Unit Price	Total
33kV OH line leopard (km)	137	20,000	2,740,000
0.4kV Alus 4x50 mm^2 (km)	4	15,000	60,000
Pole Mounted Substations 33/0.4	4	11,000	44,000
		Total	2,844,000
Source: EDM.		Total	7,370,000

4. Generation Source

Generation Source	1999
EDM	23%
Purchase (from HCB)	72%
Imported	5%

Soure: EDM.



5. Electricity Supply of All Regions

Unit: GWh

	1999	Share	1998	Share	Change
Generation	302.8	22.8%	243.8	20.3%	24%
Purchase	952.5	71.7%	615.3	51.2%	55%
Import	72.8	5.5%	343.0	28.5%	-79%
Total energy	1,328.1	100.0%	1,202.1	100.0%	10%
Exports	0.1	0.0%	2.6	0.2%	-96%
Transmision losses	55.8	4.2%	65.5	5.4%	-15%
Gross available	1,272.3	95.8%	1,136.6	94.6%	12%
Power station losses & aux. con	86.7	6.5%	60.9	5.1%	42%
Distribution	1,185.6	89.3%	1,075.7	89.5%	10%
Distribution Losses	155.8	11.7%	158.4	13.2%	-2%
Invoices	1,029.8	77.5%	917.3	76.3%	12%
Total Losses & Aux. Cons.	298.3	22.5%	284.8	23.7%	5%

Source: *Annual Statistical Report 1999*.

6. EDM Forecast on Power and Energy Demand

Year	Energy out (GWh)	Growth (% p.a.)	Max. demand (MW)
1998	1,266	13.9	223
1999	1,399	10.5	257
2000	1,522	8.8	279
2001	1,613	6.0	296
2002	1,704	5.6	313
2003	1,792	5.2	330
2004	1,871	4.4	345
2005	1,952	4.3	360
2006	2,011	3.1	371
2007	2,073	3.1	382
2008	2,137	3.1	394
2009	2,202	3.1	407
2010	2,270	3.1	420
2011	2,343	3.2	434
2012	2,419	3.2	448
2013	2,498	3.2	463
2014	2,579	3.2	478
2015	2,662	3.2	493
2016	2,750	3.3	510
2017	2,841	3.3	526
2018	2,934	3.3	544
2019	3,031	3.3	562
2020	3,131	3.3	580

Source: Part of the study of a 275 kV interconnector between Mozmbique and Swaziland, 1997.

7. Transmission and Substations

kV	Overhead lines (km)	Substation voltage (kV)	No. of transformers	Total capacity (MVA)
400-330	252	330	1	665
275	102	275	3	252
220	1,316	220	7	560
110	1,164	110	32	657
60/66	348	66	22	300
Total	3,181	Total	65	2,434

Source: *Annual Statistical Report 1999*.

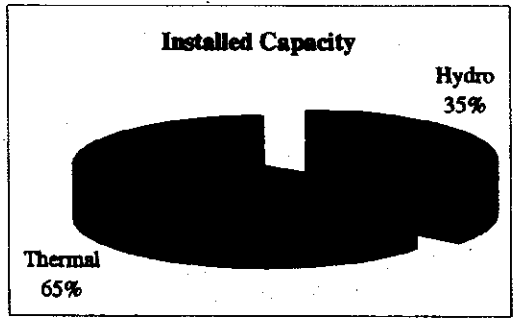
8. Installed Capacity in Mozambique

Operative generators only

Gen. type/Location	Year/Fuel	Existing (MW)
Hydro		
Chicamba	1968	38.4
Mavuzi	1955-57	38.0
Corumana	1990	16.6
Cuamba	1984-89	1.8
Sub-total		94.8
Thermal		
Angoche	1962-79	1
Beira	1988 (Gas)	12
Inhambane	1969-87	2.88
Lichinga	1970-80	1.87
Lionde	1970-79	2.97
Maputo	1968-91(Gas)	78.5
Tete	1991	0.41
Mocuba	1979	0.42
Nacala	1966-1987	4.292
Nampula	1965-87	6.536
Pemba	1964-85	7.04
Quelimane	1980 (F.O &D)	7.15
Xai-Xai	1963-72	1.43
Sub-total		126.5
EDM Total		221.3
HCB	1976	2,075.0
Total in Mozambique		2,296.3

Non-operative generators included

Installed Capacity	MW	%
Hydro	108.9	35.4%
Thermal	198.8	64.6%
Total	307.7	100.0%



9. Generation by Energy Source

	1999	Change	1998	Change	1997	Change	1996	Change	1995
Diesel	36.3	0.28%	36.2	9.04%	33.2	10.30%	30.1	4.51%	28.8
Fossil fuel	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0
Coal	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0
Jet fuel	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0
Thermal	36.3	0.28%	36.2	9.04%	33.2	10.30%	30.1	4.51%	28.8
Hydro	266.4	28.70%	207	11.41%	185.8	-10.97%	208.7	13.86%	183.3
Total	302.7	24.47%	243.2	11.05%	219	-8.29%	238.8	12.59%	212.1

Source: EDM.

10. Energy Consumption per Customer

Unit: kWh

Area	Domestic	Commer	LV	LV Total	MV/HV	Total
Tete (no. of customers)	5,289	1,250	48	6,587	8	6,595
National (no. of customers, $x10^3$)	162,604	24,559	1,012	188,175	1,094	189,269
Tete (invoiced energy)	10,164	4,617	3,725	18,506	3,158	21,664
National (invoiced energy)	404,775	123,668	58,171	586,614	409,547	996,161
Tete (kWh/customer)	1,922	3,694	77,604	2,809	394,750	3,285
National (kWh/customer)	2,489	5,036	57,481	3,117	374,357	5,263

Source: EDM.

11. Growth of Domestic Customer Power Consumption

Unit: GWh

Category	1993	1994	1995	1996	1997	1998	1999	AAGR
LV-commercial	133.2	125.2	146.5	126.3	90.7	104.4	123.7	-1.2%
LV-big consumer						48.2	58.2	20.7%
LV-domestic (DM)	285.4	259.1	271.6	268.9	305.6	348.6	404.8	6.0%
MV-HV	265.6	244.1	260.6	262.4	334.6	375.1	409.2	7.5%
Total Invoiced	684.2	628.4	678.7	657.6	730.9	876.3	995.9	6.5%
- Excluding DM	398.8	369.3	407.1	388.7	425.3	527.7	591.1	6.8%
Annual Change		-8.2%	8.0%	-3.1%	11.1%	19.9%	13.6%	6.9%

Domestic (GWh)	271.6	268.9	305.6	348.6	404.8	10.5%
No. of domestic customer	135,112	146,839	153,109	160,938	162,604	4.7%
kWh/domestic customer	2,010.2	1,831.3	1,996.0	2,166.1	2,489.5	5.5%

Source: EDM.

12. Access to Electricity by Province

Province	Consumers (1999)	Population	Access	Consumers (1998)	Population	Access
Cabo Delgado	5,134	1,436,496	1.5%	4,901	1,373,627	1.5%
Gaza	10,409	1,173,337	3.7%	9,823	1,081,843	3.8%
Inhambane	3,391	1,222,219	1.2%	3,250	1,156,462	1.2%
Manica	3,877	1,103,857	1.5%	2,939	1,094,465	1.1%
Maputo	87,201	1,906,913	19.2%	84,798	1,882,767	18.9%
Nampula	23,931	3,196,472	3.1%	25,686	3,280,289	3.3%
Niassa	3,327	848,889	1.6%	3,228	822,179	1.6%
Sofala	14,774	1,424,378	4.4%	11,878	1,478,587	3.4%
Tete	5,289	1,287,517	1.7%	6,035	1,294,361	2.0%
Zambezia	8,846	3,240,576	1.1%	8,400	3,452,059	1.0%
Total	166,179	16,840,654	4.1%	160,938	16,916,639	4.0%

Note: Average household size=4.2
Source: INE.

13. Regional Share of Electricity Consumption

Unit: GWh

Invoiced energy	Domestic	Commerical	LV.B.C.	MV/HV	Total
North	38.8	13.3	8.6	31.1	91.8
Central	67.9	27.1	11.9	105.5	212.4
South	298.1	83.3	37.3	272.9	691.6
Total	404.8	123.7	57.8	409.5	995.8
% of Total					
North	42.3%	14.5%	9.4%	33.9%	100.0%
Central	32.0%	12.8%	5.6%	49.7%	100.0%
South	43.1%	12.0%	5.4%	39.5%	100.0%
Total	40.7%	12.4%	5.8%	41.1%	100.0%

Source: EDM.

14. Number of Customers by Tariff, 1999

Area	Domestic	Commerical	High-volume	LV.B.C.	MV/HV	Total
Tete	5,289	1,250	48	6,587	8	6,595
North	32,392	3,406	218	36,016	91	36,107
Central	29,211	6,829	213	36,253	363	36,616
South	101,001	14,324	581	115,906	640	116,546
Total	162,604	24,559	1,012	188,175	1,094	189,269

Source: EDM.

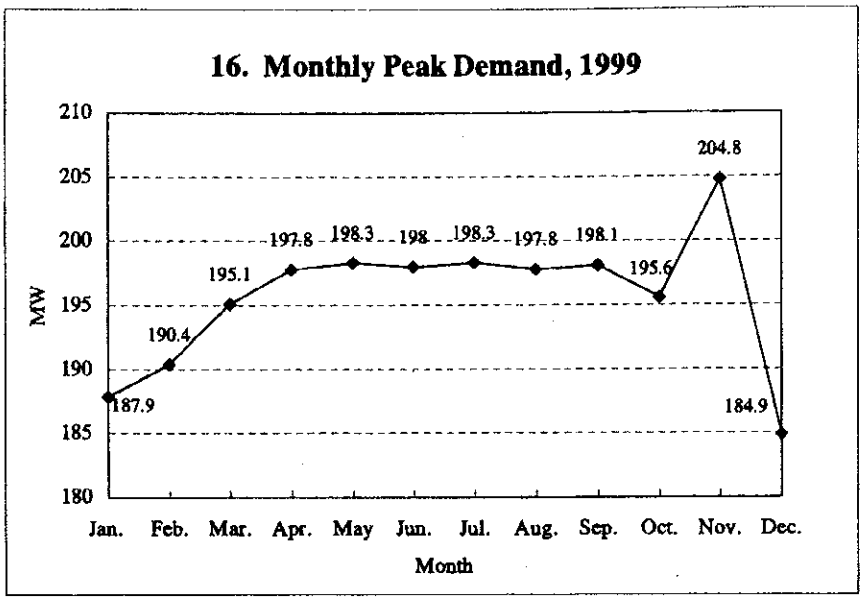
15. Average Energy Consumption by Customer, 1999

Unit: kWh

Area	Domestic	Commerical	LVBC	Low voltage	MV/HV
Tete	1,922	3,694	77,604	2,809	394,750
Central	2,323	3,975	55,803	2,949	290,639
North	1,200	3,894	39,445	1,686	341,323
South	3,244	6,770	65,307	3,962	438,284
National ave.	2,489	5,036	57,481	3,117	374,358

Source: EDM.

16. Monthly Peak Demand, 1999



17a. Tariff Table for Diesel Generator

Customers	Mt./mo.	US$/mo.
Residential	150,000	76.37
Small Business	250,000	127.29
Commercial	350,000	178.21
Hospital	800,000	407.33
School	400,000	203.67

Note: Exchange raate @ US$1=Mt.22,000.

17b. Tariff Table, VAT

Consumption level (kWh)	Residental (Mt./kWh)	Business (Mt./kWh)	Fixed Tax (Mt.)	Derivated (US$/kWh)
0 - 85	652	848	38.62	0.048
86 - 165	1,196	1,555	38.62	0.064
166 - 330	1,401	1,821	38.62	0.068
331 - 495	1,534	1,994	38.62	0.073
496 - 990	1,547	2,011	38.62	0.072
991 - 1,485	1,623	2,109	38.62	0.075
1,486 - 1,980	1,669	2,169	38.62	0.077
1,981 - 2,475	1,684	2,189	38.62	0.077
Above 2,476	1,739	2,261	38.62	0.080

Note: In addition, customers pay a montnly charge of Mt.34,000.

17c. Basic Need Tariff

Consumption level (KWh)	Price (Mt./kWh)	Fixed tax
0-50	602	0

17d. Tariff for High-volume Users

Voltage level	Short use	Medium use	Long use
Low			
Mt./kW	56,317	68,599	81,137
Mt./kWh	712	481	371
Medium			
Mt./kW	64,364	78,395	92,736
Mt./kWh	830	569	418
Avove 19.8kVa			
Mt./kW	67,042	81,652	96,598
Mt./kWh	835	582	436

The Study on the Integrated Development Master Plan of the Angonia Region

Sector Report 4: Infrastructure

Part 4: Water Resources

Contents

List of Tables

List of Figures

Sector Report 4: Infrastructure

Part 4: Water Resources

Chapter 1. Introduction

The water resources sector covers mainly: i) water resources development and management, ii) urban and rural water supply iii) irrigation, and iv) hydropower. Irrigation and hydropower are covered in more detail under the agriculture and the energy sectors, respectively. Watershed management is covered also under the environment sector.

Chapter 2. Existing Conditions

2.1. Overview of Water Availability and Use in Mozambique

Surface water is the main source of fresh water in Mozambique, with rainfall generally restricted to the warm season between October and April, decreasing generally from the north to the south, and from the coast to the inlands. The average annual rainfall in the country is 970mm. The total mean annual runoff is 214km3, of which only 88km3 (41%) is generated within the Country due to the fact that Mozambique is the downstream country of its nine major river basins. Almost 50% of the Country's surface water resources are concentrated in the Zambezi river basin, which is shared by eight other countries. This puts Mozambique in a vulnerable position of dependence on the quantity and quality of the imported flows.

Irrigation is the largest user of water sharing 80% of the total consumption nationally. Urban use accounts for 12%, rural for 5%, and the industrial sector the remaining 3%.

2.2. Water Related Policies and Institutions

(1) Water policies

The Water Law

The principal legal document related to the development and management of water resources in Mozambique is the Water Law, enacted in 1991. This law has established among others:

- the management and allocation of water resources as a public domain,
- the Government empowered to manage public water resources,
- the basis for protection of water quality and pollution control,
- the general guidance of water use, and
- the rights and obligations of water users.

National Water Policy

The National Water Policy of Mozambique, drawn up in August 1995, consists of sector-wide principles, sub-sector specific policies, proposed targets, and first key steps to be taken. The policy recognizes the importance of integrated water resources management. It states:

> *The collection of raw water through integrated river basin management should optimize the benefits to the community, balancing the interests of both present and future users. It should take into account environmental impacts, and conserve water resources for the future. ... actions required are inter-related and their implementation will need to be coordinated*

through a well directed sector policy which is integrated with those being prepared for local administration, health, agriculture and finance.

The policy places great emphasis on water supply and sanitation as part of basic human needs. It recognizes correctly that "despite the advances made in the water sector since the independence, the level of services and the degree of coverage are still far from adequate." The policy stipulates the immediate targets for water supply as follows.

Water supply	Target coverage	Target year
Urban and peri-urban	50-80% of the population	by 2002
Rural	40% of the rural population	by 2000

According to the new policy, the role of the Government will be shifted from direct implementation to policy and regulatory functions. The latter includes setting priorities, defining minimum levels of services, collecting and providing adequate information, and providing incentives to and regulating service providers. Related specifically to the Study Area, the issue of transferring water-related functions of various agencies to GPZ has been on agenda recently.

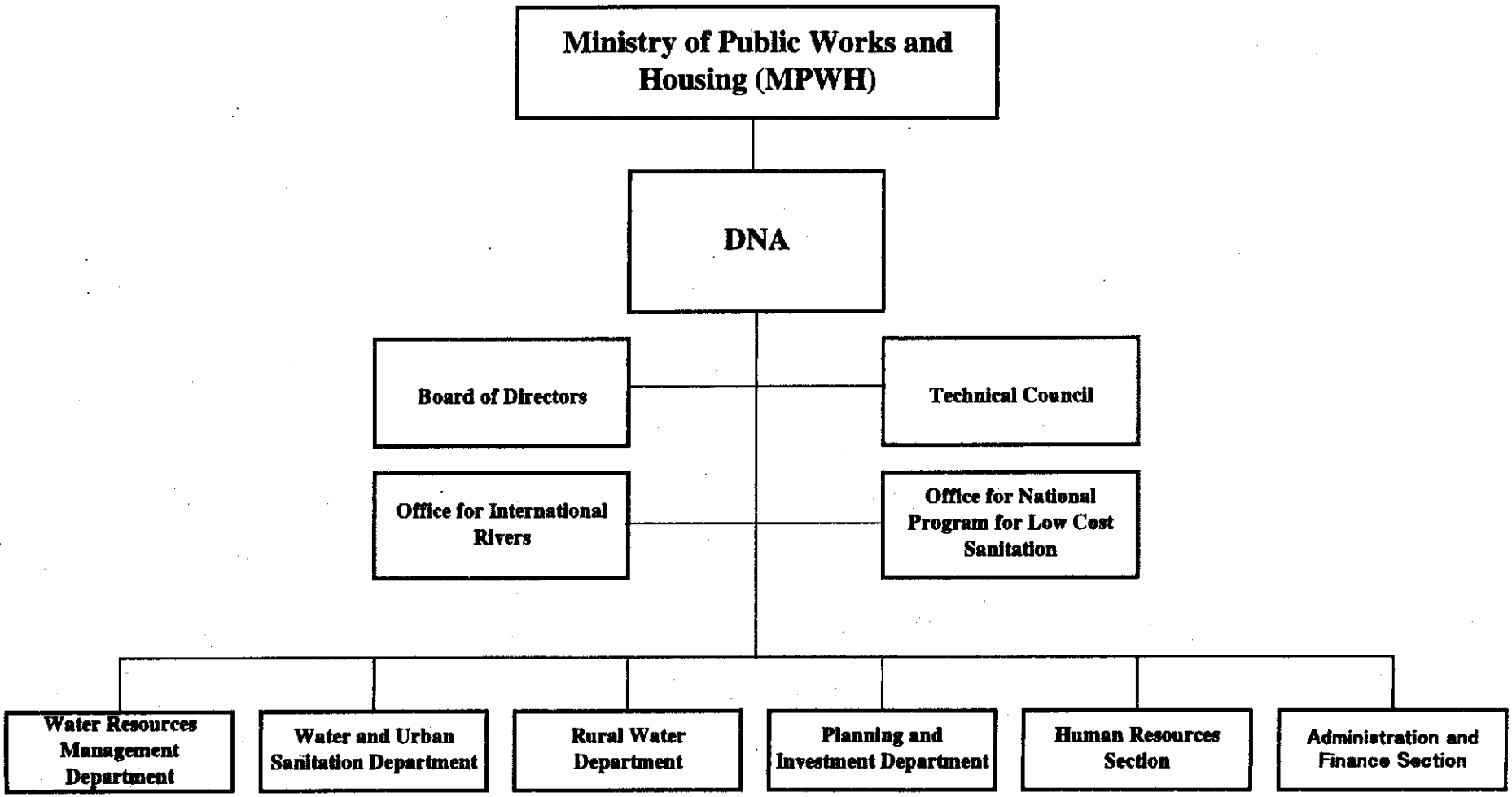
(2) Water related institutions

The Ministry of Public Works and Housing (MPWH) is responsible for establishing policies and strategy for development and management of nation's water resources, coordinating activities of other related agencies and planning for major water resources development projects. It is also responsible for controlling major water quality monitoring stations.

MPWH exercises its main functions through the National Directorate of Water (DNA). The organization chart of DNA is presented in Figure 4.1. Recently, by virtue of the National Water Law (1991), five Regional Water Administrations (ARAs) have been created. They consist of south, central, north-central, north, and a separate ARA for the Zambezi river basin. Until now, ARA-southern has been established and the ARA-the Zambezi is under development. ARAs are autonomous public corporations, managed through beneficiary participation and supervised by MOHP. They are responsible for water resource management, including data collection, flood damage prevention and licensing of water usage. They constitute part of the national water resource management system, which includes DNA and the National Water Council.

The Provincial governments are responsible for promoting and monitoring the provision of rural water supply and sanitation services. MPWH is represented by DAS to undertake these functions. The provinces where there are no DASs, national programs are still operated and managed by Provincial Physical Planning Services (SPPF). The state rural

Figure 4.1. Organizational Chart of DNA



water supply company, Água Rural, has been involved in construction and repair works for boreholes and wells, often supported by NGOs and aid organizations. Água de Tete is another state company, currently run by MPWH, in charge of piped water supply for Tete city. It will be waived from state ownership soon.

Within the Central Government, the principal stakeholders are the Water Resource Management Department, the Rural Water Department (DAR) and Low-cost Sanitation Program (GPNSBC) in DNA. Within the Zambezi river basin, government interests are represented by the Zambezi Valley Development Authority (GPZ) and the DPOPHs.

Since the restoration period from the civil war, many NGOs and international aid organizations have been involved particularly in the water sector. NGOs involved in water works in the Study Area include ADPP, ARC, CVM, SDR, LWF and several others. Several private firms undertook construction works.

2.3. Existing Conditions of Water Resources and Use in the Study Area

(1) River system

Zambezi river basin

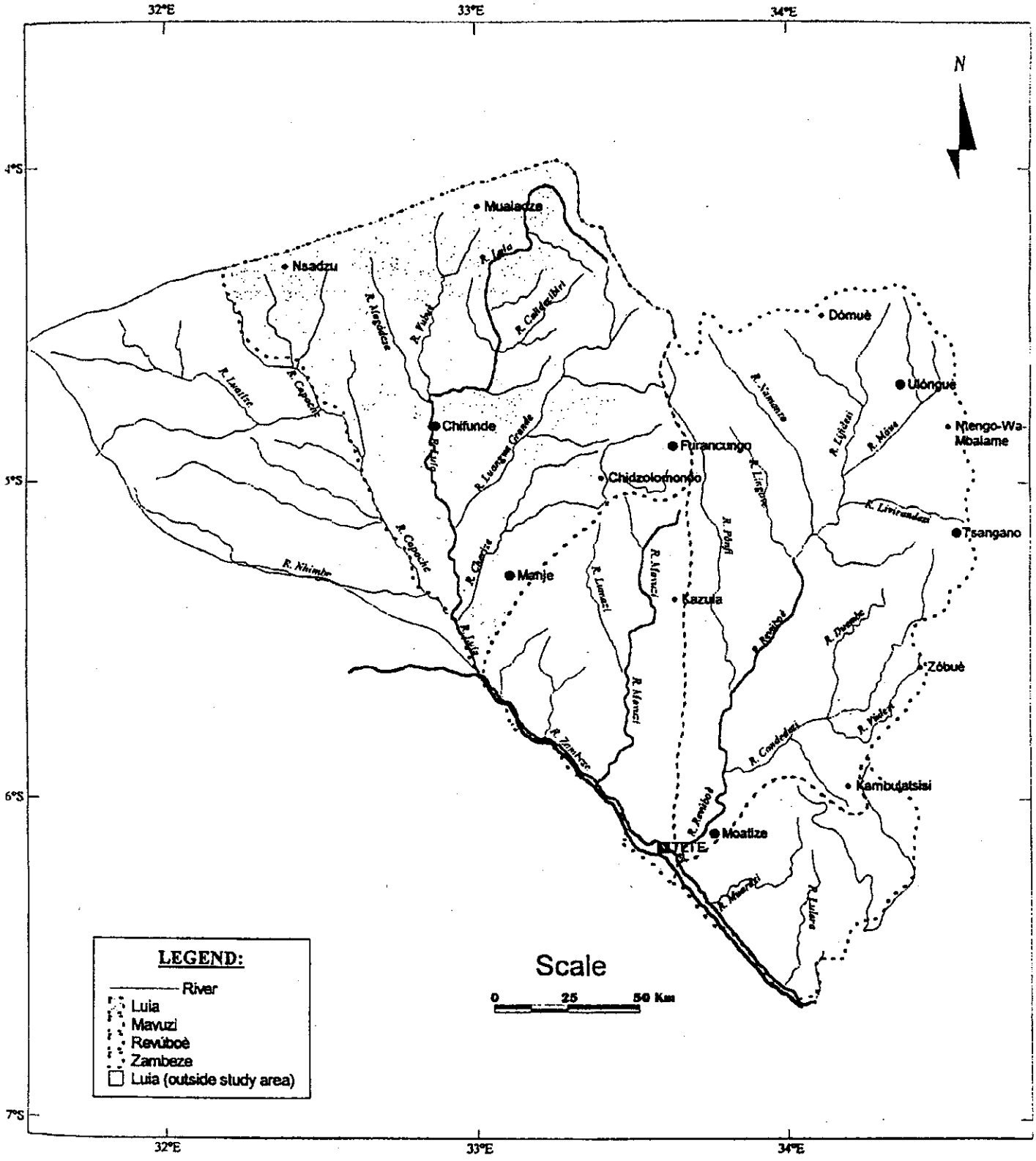
The Zambezi river originates in a marshy area near the Kalene hill on the southern end of the Democratic Republic of Congo (Zaire) at an elevation of 1,460m. The river flows through Angola and Zambia and constitutes boundaries between Namibia and Zambia first and then Zambia and Zimbabwe before it enters the territory of Mozambique at Zumbo. Within Mozambique, the Cahora Bassa reservoir extends some 270 km from Zumbo at the western end of Tete province. The river then flows through the Tete basin and the Mozambique plains, forming a broad valley. The Zambezi river drains in the Indian Ocean forming a wide delta in Chinde of Zambezia province. The total length of the Zambezi river is 2,800 km, the fourth longest in the African continent, of which a stretch of 831 km is within Mozambique.

The Zambezi river basin in Mozambique has an area of 223,000km^2, accounting for 28% of the national territory. It comprises the whole of Tete province, and parts of Zambezia, Sofala and Manica provinces. The Study Area, occupying the eastern half of Tete province, falls entirely in the Zambezi river basin, constituting 18% of the basin area.

River system in the Study Area

The Study Area may be subdivided hydrologically into four separate basins. They are, from the north, the Luia, the Mavuzi, the Revobue and the Zambezi basins, the last one consisting of small rivers draining directly into the Zambezi river. The river system in the Study Area is shown in Figure 4.2. A brief description of the four sub-basins follows.

Figure 4.2. River System in the Study Area



1) Luia Basin

The Luia river originates from the northern part of Macanga district at an elevation of 1,450m. At first, it flows towards the north along the Malawian border and enters the Chifunde district from its north-eastern part. It flows further towards north to the Zambian border and then makes a left turn, and continues to flow towards the south and then to the west for a distance of about 40km before it makes another left turn. It flows in a southern direction until it reaches the Zambezi at a point before the boundary between Chifunde and Chiuta districts.

The main tributaries are Calidezibiri, Vuboe, Luanga, Grende, Capoche and Cherisse. There are some tributaries with catchment areas extending beyond the Mozambican territory. Some tributaries maintain some flow even towards the end of the dry season, and the Luia river itself has presumably a large amount of underflow in the dry season. The total catchment area of the Luia river is 23,490km², of which 15,250km² lies within the Study Area and the rest mostly in the Maravia district, to the west of the Chifunde district.

2) Mavuzi Basin

The Mavuzi river originates from the mountainous range of southeastern side of Chidzolomondo, an administrative post of Macanga district, at an elevation of 1,400m. As it flows, the Mangazi river joins from the east, the Lumazi and the Metenze rivers from the west. The Mavuzi river makes the eastern boundary of Chiuta district with Moatize district. The river maintains a reasonable flow during the dry season. The catchment area is 5,886km².

3) Revobue Basin

The Revobue river is the second largest river in the Study Area. It originates from an elevation of about 1,500m in the extreme northern part of Angonia district. The upper part of the Revobue with the district is called the Lifdzi river, which is joined by the Licange, the Chivomoze and the Mafifi rivers. It flows southerly and forms the district boundaries in sequence between Tsangano and Macanga, Tsangano and Chiuta, and Chiuta and Moatize. The main tributaries along the mid-streams are Nomanzi, Pomfi, Livirandeze, Condedzi and Moatize. The catchment area is 15,650km².

4) Zambezi Basin

This basin with an area of about 3,390km² within Moatize district consists of the Muarazi and the Lulra rivers draining directly to the Zambezi river.

(2) Hydro-meteorological Conditions

Hydro-meteorological network and data

The number of hydro-meteorological stations decreased drastically after 1973, and the hydro-meteorological network of the Zambezi river basin has been degraded by the

prolonged war. DNA and INAM are trying to rehabilitate some stations and willing to establish new ones, but constrained by the lack of human resources and capital.

According to INAM in Maputo, only four functioning meteorological stations exist in the Study Area at Tete, Moatize, Chiuta and Angonia. Hydrological data in the Study Area are collected by Hydrological Services of the Provincial Directorates of DPOH only at two stations in Chingodzi on the Revobue river and in Tete city on the Zambezi river. The Luia and the Mavuzi rivers have no gauging stations functioning at present.

Hydro-meteorological data for the Study Area have been collected as summarized in the table below.

Hydro-meteorological Data Available for the Study Area

	Parameter	Station	Period (year)
1.	Rainfall	Tete, Ulongue, Chiuta and Moatize	20, 20, 9 and 7
2.	Temperature	Tete	20
3.	Evaporation	Tete	20
4.	Humidity	Tete	20
5.	Wind speed	Tete	20
6.	Sunshine	Tete	20
7.	River flow	Chingodzi on Revobue	12
		Tete on Zambezi	20

The quality of some data collected at this time is dubious. Main causes of unreliable data are faulty measurements and errors at input into computers.

Meteorological conditions

Meteorological conditions of the Study Area are outlined by parameter.

1) Rainfall

Monthly data from the four stations were collected and analyzed. A review of old data has revealed that annual rainfall of Tete province ranges from 600mm to over 1,000mm (Figure 4.3). The north and northeastern parts of the Study Area, i.e., Manje, Furancungo, Ulongue and Tsangano, have higher rainfall than the southern part. Most of the rainfall occurs during the rainy season from October-November to March-April as shown in the figure.

2) Temperature

Tete province is known for its hot climate. Temperature generally goes up above 40°C at the beginning of the rainy season. June and July are cooler with the average temperature in Tete city being 16°C. In the northeastern districts, temperatures could go very low in some months.

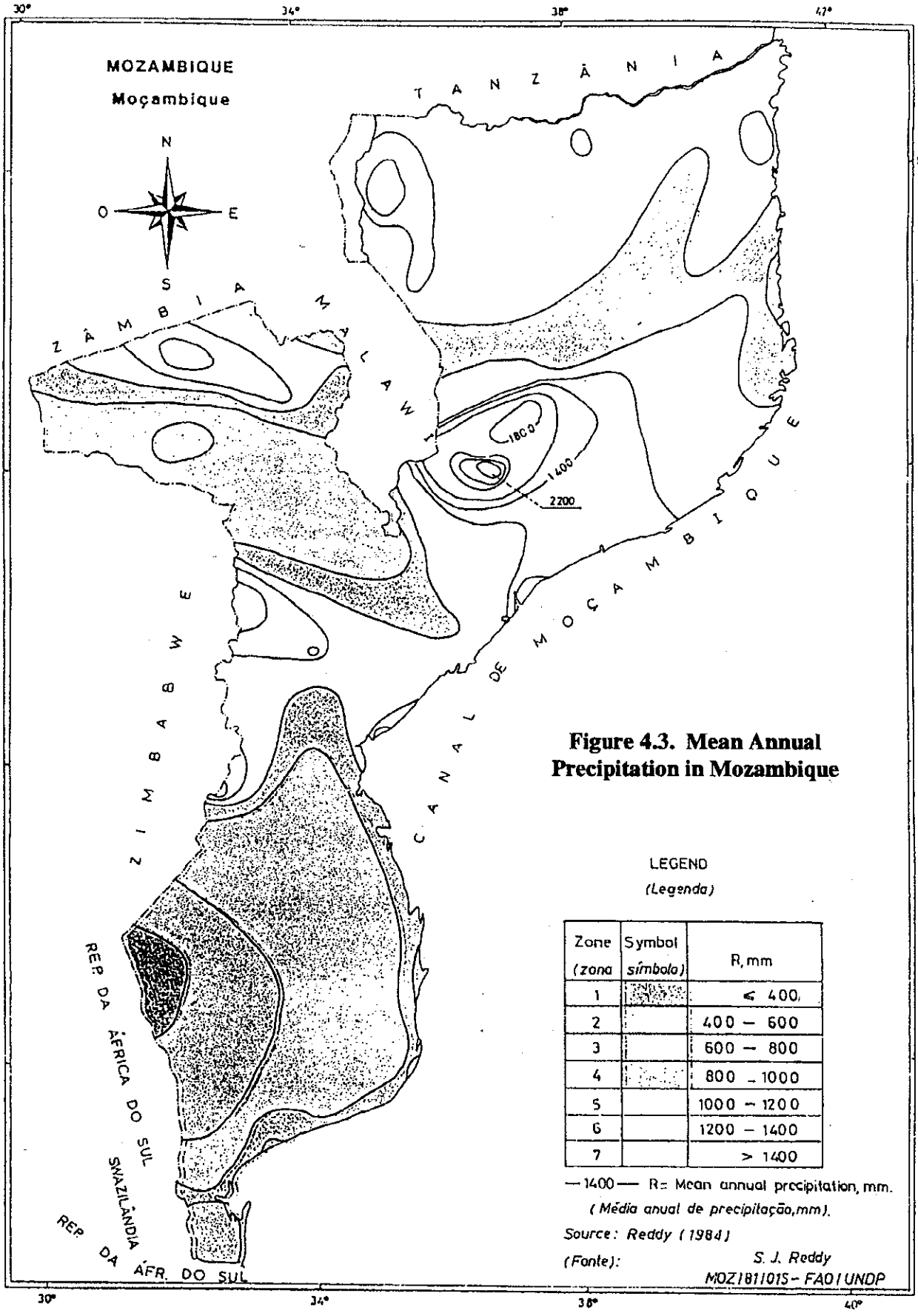


Figure 4.3. Mean Annual Precipitation in Mozambique

LEGEND

(Legenda)

Zone *(zona)*	Symbol *(símbolo)*	R, mm
1		≤ 400
2		400 – 600
3		600 – 800
4		800 – 1000
5		1000 – 1200
6		1200 – 1400
7		> 1400

—1400— R= Mean annual precipitation, mm.

(Média anual de precipitação, mm).

Source: Reddy (1984)

(Fonte): *S. J. Reddy*

MOZ/81/015 – FAO/UNDP

3) Evaporation

Evaporation data measured at the Tete station show that the province has an annual rate of about 2,000mm. The highest rate is observed in the month of October, with 253mm, followed by November with 243mm and September with 227mm.

4) Humidity

Analysis of 20 years of humidity data collected at the Tete station reveals that the average humidity varies within the range of 50-70% with the highest in February at 71% and lowest in September at 49%. Monthly average humidity is shown below.

Monthly Average Humidity in Tete City

(Unit: %)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
69	71	67	63	61	61	60	53	49	50	52	64

5) Wind speed

Wind velocities during the months of August through November are generally higher than the rest of the months. Data of the Tete stations show that October has the highest velocity, at 10.5 km per hour. Average monthly wind velocity is shown below.

Average Monthly Wind Velocity in Tete City

(Unit: km/hour)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.7	4.4	5.6	5.8	5.2	5.0	5.9	8.7	9.9	10.5	9.2	6.4

6) Sunshine

Tete province enjoys an average of 7.5 to 9.0 hours of sunshine per day. October and November have the longest hours of sunshine, about 9.0 hours per day. Daily sunshine hours observed at the Tete station is as follows.

Daily Sunshine Hours in Tete City

(Unit: hours/day)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7.5	7.8	8.4	8.6	8.6	8.3	8.0	8.8	8.9	9.0	9.1	7.6

7) River Flow

As mentioned earlier, the hydrological services in Mozambique have deteriorated over the last decades affected by the civil war and also devastating floods in the recent years. Therefore, except for one station on the Revobue river, located at Chingodzi in Moatize district, no river flow data are available. The catchment area of this station is 15,540km², which is almost equal to the whole catchment area. Data from the period 1981 to 1999 were collected and analyzed. The analysis has revealed that annual average discharge is

3,448 million m^3. This corresponds to a specific discharge of 14,276mm/km^2. The runoff co-efficient is calculated to be 0.22.

2.4. Existing Water Use and Facilities in the Study Area

Existing water use – overview

In general, there are four kinds of direct usage of water resources: irrigation, power generation, and industrial and domestic uses. As the Study Area is predominantly rural, and its economy is based on agriculture, the industrial water use is minimal. There exists no hydropower generating capacity in the Study Area, although Angonia district produced 250kW electricity on the Mace river during 1972-90.

The Study Area is blessed with relatively large amount of rainfall, and crops are cultivated mostly under rain-fed conditions by the dominant family sector. There exist no irrigation schemes of commercial scale. Small farmers do not have any strong motivation to increase their produce beyond their self-consumption, as marketing opportunities are limited except for maize, wheat and few other crops. Micro-scale irrigation schemes exist only along small rivers to cultivate vegetables and other high value crops under gravity irrigation. In Angonia district, there used to be a commercial irrigation scheme by the defunct Angonia Agro-Industrial Complex (CAIA). It has been de-capitalized and its facilities, including a small dam, degraded through neglect during the civil war.

The main source of domestic water is groundwater, extracted by boreholes or wells using diesel or hand pumps. River water is used for Tete city and Moatize from the Revobue river, and for Ulongue from the Mace river.

Water supply facilities

Existing water supply facilities in the Study Area are summarized by district/city in Table 4.1. Main characteristics are outlined.

1) Angonia District

Only Ulongue is served by an old piped system established in 1972. Water is pumped from the diversion channel on the right bank of the Maoe river to an overhead tank and supplied to 300 customers in the city itself and also to five public fountains. The quality of water is not adequate especially during the rainy season, but water is treated only by chlorine. Other areas rely on shallow groundwater. Main institutions like, teachers training institute, motels, prison, and hospital are solely dependent on this old system.

Table 4.1. Existing Water Supply Facilities in Angonia Region

District/Sub-district	Population	No. of systems/ hand pumps	Notes
Angonia district			
Ulongue	127,378	1 system	300 connections
		5 public fountains	2 operational
		116 hand pumps	Conditions unknown
Domue	120,621	139 hand pumps	Conditions unknown
Chifunde district			
Tembue	6,612	16 hand pumps	2 operational
Mwaladze	15,729	20 hand pumps	3 operational
N'sadzu	6,246	25 hand pumps	Conditions unknown
Chiuta district			
Manje	34,977	2 systems	1 system non-operational
		4 public fountains	None operational
		52 hand pumps	10 non-operational
Cazula	15,395	1 system	Run by gravity
		17 hand pumps	4 non-operational
Macanga district			
Furancungo	29, 067	3 systems	1 owned by MTLC
		75 hand pumps	5 non-operational
Chidzolomondo	4,610	65 hand pumps	1 non-operational
Moatize district			
Moatize town	53,764	3 systems	900 connections
		3 hand pumps	
Zobue	41,520	1 system	Run by windmill
		11 hand pumps	3 operational
Cambulatsitsi	13,819	1 system	Only for a mosque
		7 hand pumps	1 non-operational
Tsangano district			
Tsangano town	37,866	1 system	Non-operational
		9 hand pumps	7 non-operational
Ntengo-wa-Mblame	68,691	1 system	Run by windmill
		5 hand pumps	3 non-operational
Tete city/Degue area			
M'Padue area	9,048	Hand pumps	
		Independent system	
Matundo-Chingdozi area	5,706	Independent system	
		With 2 hand pumps, 2 overhead tanks and 30 public fountains	
City main area	24,860	5 boreholes with pumps,	
		3,500 customers	
		4 overhead tanks and 30 public fountains	

Source: District and City Administration Offices.

2) Chifunde District

There is no piped water supply system in Chifunde district, although the district capital used to have one during the colonial period. People use groundwater by hand pumps or river water for drinking, bathing and washing. A hospital in Nsadzu has its own supply system. Chifunde district has the worst performance record of hand pumps with 80% pumps out of order.

3) Chiuta District

Manje has a system run by solar power to serve 3,000 people with house connections and four public fountains, but it is out of order at present due to theft of some solar panels. Another system serves a hospital newly built in Manje with DANIDA assistance. Cazula has a system run by gravity flow. It is reported that Lumadzi in Manje and Matenge in Cazula do not have access to safe drinking water.

4) Macanga District

Furancungo has three water supply systems: two old systems owned by the administration and a new one owned by the Mozambique Tobacco Leaf Company (MTLC) strictly for their own consumption. The two old systems serve 2,748 people with house connections and four public fountains. Other people rely on groundwater with hand pumps and river water. The number of pumps that are operational in the district is comparatively larger than in other districts.

5) Moatize District

Moatize town has three water supply systems owned by the administration, the railway company (CFM) and the coal company, all taking water from the Revobue river, except one groundwater source used by the administration. The total number of connections provided by these systems is 800. There are also 12 public fountains supplied by them. There are some localities that do not have access to safe drinking water, and Msungo has a salinity problem.

Cambulatsitsi used to have a piped water supply system by CFM, currently broken down, and is served now by wells with hand pumps. A small system run by windmill also exists. Many settlements in this sub-district do not have access to safe drinking water. Zobue has an old system run by a windmill since the colonial period to serve only major establishments such as a hospital and a motel.

6) Tsangano District

The district's capital used to be served by a piped system until 1995, when the only diesel pump for the system broke down. The system had 20 connections. People now use open wells or hand pumps. The quality is a concern in case of open/dug well's water. Ntengo-wa-Mblame has a system run by windmill with a public fountain.

7) Tete City

In comparison with other districts, Tete city has a good water supply system at present, especially after the completion of DANIDA's assisted project phase 1. The City is supplied by Água de Tete for four separate areas. The Degue area is served well with hand pumps. The M'Padue, the Matundo-Chingodzi and the city main areas have individual systems, respectively. The City main area (Tete Antiga, as it is called) is served by a fairly good supply system run by five boreholes equipped with pumps and four overhead tanks of 500m³ capacity each. The system supplies to 3,500 house connections and 48 public fountains. It should be noted that Mutemba area (supposed to be a part of the main system) which is located on the other side of the Nharthanda Valley and shares 25% of the city population does not have any system. Outbreaks of waterborne diseases are reported occasionally.

Water use and service coverage

Based on the data on the existing water supply facilities and some assumptions, existing water use and service coverage have been estimated as shown in Table 4.2. Population coverage for safe drinking water in the Study Area is estimated to be 42%, ranging from 26% in Angonia district to 79% in Macanga district.

Table 4.2. Estimated Water Use and Service Coverage in the Study Area

District	Population	No. of systems	Pop. covered by system	No. of BH/wells	Functional	Pop. covered by BH/well	Total coverage	% covered
Angonia	247,999	1	1,800	255	128	63,750	65,550	26
Chifunde	48,498	0	0	61	31	15,250	15,250	31
Chiuta	50,372	2	3,300	69	35	17,250	20,550	41
Macanga	46,515	2	2,748	136	68	34,000	36,748	79
Moatize	109,103	3	4,450	217	109	54,250	58,700	54
Tsangano	106,557	1	300	154	77	38,500	38,800	36
Tete City	101,984	3	27,410	134	67	33,500	60,910	60
Total	711,028		40,008			256,500	296,508	42

Source: JICA Study Team.

2.5. Planned and Ongoing Projects

(1) Past studies

The only comprehensive study that has been carried out related to water resources in the Zambezi river basin is the one conducted by the Portuguese in the early 1960's. The study covered practically all the sectors including water resources, agriculture, and power and energy. The study proposed areas suitable for crop cultivation and livestock development, recommended sites for hydropower generation, and presented many project proposals at varying levels of sophistication.

GPZ contracted out consultancy services to prepare "Zambezi Valley Development

Proposal" (final report in October 1999). Potential areas of development have been identified in agriculture, livestock and forestry, energy, and mining, infrastructure needs clarified, and promising agricultural activities clarified. Specific project proposals, however, have not been formulated.

Another study was carried out recently to provide input to the ZMM-GT cooperation supported by UNDP (April 2000). The study has identified promising areas for public and private investments in Tete province as well as other areas within the ZMM-GT. Again, no specific projects have been formulated, following the study.

(2) On-going projects and programs

A pre-feasibility study has been completed of a hydropower dam at Mpanda Uncua, on the Zambezi mainstream, downstream of Cahora Bassa, to produce 1,200MW. The study has proposed also to construct another dam at Boroma further downstream to produce 200 MW. The Boroma reservoir would serve as an afterbay to regulate discharges from the Mpanda Uncua, which then can produce 2,400MW. The study endorses the north bank development at Cahora Bassa to produce 600-900MW initially and 1,600 MW eventually after the completion of the Boroma dam. These projects are expected to be implemented by BOT schemes.

Hydropower development on tributaries of the Zambezi river, proposed during the 1960's, has not been sustained. No major irrigation projects have been planned, either.

Rural water supply projects have been continuously implemented, supported by NGOs and aid organizations, either by themselves or as components of other rural development programs. Expansion of water supply for Tete city phase 1 has been completed, but phase 2 implementation has been delayed.

At the national level, within the First National Water Development Project, a framework for Comprehensive Water Management Strategy has been prepared with the objectives to identify and prioritize the requirements for information, institutional arrangements, policy reforms, studies and investments needed to keep current and future water needs of the population and to protect environment, while stimulating the growth of the national economy, through a rational and sustainable development of Mozambique's water resources enforcing also its ability to face floods and droughts.

Chapter 3. Development Issues for Water Resources Development and Management

3.1. Characteristics of Water Resources in the Study Area

Characteristics – overview

The Study Area is relatively well endowed with water resources. The annual average rainfall ranges in 600-1000mm, sufficient for rain-fed agriculture. Tributary basins on the left bank of the Zambezi river are covered predominantly by sedimentary rocks to make the Study Area rich in groundwater. This condition is also accountable for perennial flow in most tributaries in the Study Area. This is in contrast with tributaries on the Zambezi right bank which has dried up completely toward the end of the dry season. The practice of water resources development and management, however, is still at a very early stage in the Study Area. Reflecting partly less developed economic conditions, there exist practically no substantive irrigation nor industrial water use. Hydropower has not been exploited even in a small scale. Service coverage by water supply is still very low, especially in dominant rural areas.

3.2. Identification of Development Issues

Given the existing conditions outlined above, six main development issues may be identified related to water resources development and management. The first issue is, as part of basic human needs, how to expand the coverage of rural water supply and promote rural sanitation. The second issue is, given the lack of experience in irrigated agriculture, how to introduce irrigation in a step-wise manner. The third issue is fundamental: how to effect watershed management to prevent further degradation of watershed areas and retain or enhance land productivity.

The fourth and fifth issues are more directly related to economic development. The fourth issue is, given the envisional urbanization in general and rapid development of Tete city and its surroundings, how to expand urban water supply effectively to support the high economic growth. The fifth issue is how to promote multi-purpose dam projects, possibly reformulating the existing hydropower dam projects, as a means for cost-effective water resources development. In order to support all of these, the sixth and the last issue is how to improve planning and coordinating functions for water resources development and management in order to promote environmentally sound and socially accepted practices.

3.3. Development Issues

(1) Rural water supply

Population coverage of rural water supply is still quite low. Even under the optimistic assumption that each well or borehole covers 500 people, the overall service coverage in

the six districts is calculated to be 39%. Excluding piped water systems serving urban areas, the coverage of rural water supply may be more or less one-third of the rural population, short of the national target of 40% coverage by the year 2000.

What is more disturbing is that many hand pumps installed on wells and boreholes are not working. For the hand pumps for which conditions have been identified at this time, 70 out 280 hand pumps are not operational. This situation makes the rural population especially the women and children to travel long distance to fetch water. Thus, not only installation but also operation and management of wells and boreholes need to be improved. A key may be to encourage community involvement in the identification of needs and sites for wells and boreholes as well as their installation.

(2) Irrigation

The first step to substantive introduction of irrigated agriculture in the Study Area may be to implement small scale irrigation schemes to allow small farmers to gain experiences and to convince them of the utility of the irrigation. Simple weirs may be constructed across small tributaries and streams to raise the level of water, which would be introduced into contour canals and gravity irrigation. One possibility is to utilize gabions, that can be produced by utilizing gravels and stones widely available in the Study Area and skillfulness of local people. Bamboo may be used instead of steel wire, if necessary to reduce costs. Alternatively, sand bags and/or logs may be used as already attempted in the Study Area. Local communities should better be involved in the identification of sites for weirs and suitable agricultural areas as well as construction works.

Small farmers should be supported not only for the construction works but also for operation and management of irrigation schemes. Short training courses may be effective on crop cycles, on-farm water management for irrigation scheduling and drainage, and soil and slope protection as well as weir design, canal alignment and land preparation.

Large scale, possibly commercialized irrigation development may follow the implementation of many small irrigation schemes. With the experiences to be gained through the small irrigation schemes, small farmers should be able to participate in the large scale development as active stakeholders rather than subordinate contract farmers. Simple weirs would not obstruct in any way the construction of large irrigation facilities.

(3) Watershed management

Slash and burn practice is widespread in the Study Area. Especially toward the end of the dry season, extensive areas undergo this practice, well beyond the level necessary for shifting cultivation. This practice needs to be controlled. Also upper catchment areas of main tributaries have been degraded by deforestation. Watershed management is essential to restore and maintain production and water retention capacities of the entire river basins.

Given the magnitude of the existing problem and the need for a broad-based approach, community-wide involvement is necessary under the leadership of traditional authorities, religious leaders and politicians.

(4) Urban water supply

Rapid urbanization in the Study Area in the coming decades is not only inevitable but in fact desirable. To improve the delivery of various social services for the majority of people cost-effectively, concentration of the population is the direction to pursue rather than dispersion. For the Study Area to serve some central functions in the context of the ZMM-GT cooperation, urban functions need to be strengthened selectively. Demand for urban water will expand rapidly along with the envisioned urbanization.

Urban water supply capacity needs to be expanded rapidly especially for Tete City and its surroundings. Still there are places like Mutemba, a densely populated area along the Nhartanda valley, which needs to be brought under city water supply system. Otherwise, possibility of further outbreak of water borne disease like cholera will always remain. However the main directions of expansion is clearly to the east, beyond the Zambezi river. According to the existing Urban Master Plan for Tete (Plano de Estrutura da Cidade de Tete, 1981), the expansion areas for building houses, industries and commerce will be in the Matudo-Chingodzi region. Use of surface water of the Revobue river with a dam in the upstream, would become an important option as well as direct use of the Zambezi river water by pumping. Comparative advantage of the dam option would depend on project formulation with multiple purposes, including irrigation, hydropower, and possibly flood control.

(5) Multi-purpose dam projects

There are several dam sites identified on the tributaries and the Zambezi main stream within the Study Area, but all of them have been formulated as single-purpose dams for hydropower. Following the government policy to double the energy production in the immediate future, a few dams are planned to be constructed on the Zambezi main stream. One of them is at an advanced stage with the pre-F/S completed. Therefore, smaller hydropower dams on the tributaries would not be a realistic option. Rather, multi-purpose dam projects may be formulated on the tributaries, possibly reformulating the existing hydropower dam projects. Irrigation, urban water supply, smaller hydropower and flood control are among the purposes to be considered, depending on the tributaries and dam sites. Improvement of upper watershed areas and a comprehensive study on the possible impacts due to the construction of the dam should also be the integral parts of any multi-purpose dam projects.

(6) Planning and coordination

Water resources development and management naturally involve various sectors such as agriculture, industry, energy, environment and social services. These sectors are usually under jurisdictions of different sector agencies, as is the case in Mozambique as well, to make coordinated actions difficult to take for effective development and management. Planning and coordinating functions for water resources development and management need to be much strengthened especially at the local level. GPZ may be in the best position to strengthen these functions in cooperation with local governments.

Effective development and management of water resources should be supported by proper information and accurate data. Among the most important data are hydro-meteorological data, data on existing water use facilities (e.g., location, dimension and capacity of wells and boreholes), and data on groundwater resources. For proper information on development needs and operational conditions of existing facilities, involvement of local communities would be essential. Local communities should also be involved in monitoring and evaluation activities related to natural environment including watershed management, and social environment such as change in social values and habits due to improved access to safe drinking water, irrigated agriculture, and dam projects.

(7) Reformulation of laws, policies and regulations

The existing Water Law of Mozambique forms a relatively modern framework for facilitating integrated water resources development. However, the Law was established before the Water Policy, which logically should have been the other-way-around. The law should be a translation of agreed policy principles into a legal context. Therefore, the Water Policy should be revised prior to amending the Water Law.

The duplications, gaps and contradictions between the different policies, and regulations, as exist for instance in land use rights related to water, should be carefully eliminated while demarcating the institutional responsibilities between the key organizations, local authorities, private and public entities, NGOs etc.

Chapter 4. Objectives and Strategy for Water Resources Development and Management

4.1. Objectives of Water Resources Development

As discussed in the previous sections, water utilization in the Study Area is very limited at present. Water is mainly used in the water supply and sanitation sector. Expansion of water usages will depend on the development of other sectors such as industry, tourism, hydroelectricity etc. in the future. Therefore, the objectives should be set in such a way that would satisfy the immediate necessity while considering long-term development opportunities.

The short term objectives are:

- to provide basic human needs through the expansion of coverage of water supply for both urban and rural areas, and
- to provide irrigation water for agriculture.

The long-term objectives are:

- to secure the future demand of water for hydropower generation, agriculture and industrial use, and
- to protect the degradation of watershed areas and capacity building of water related organization, in particular GPZ.

4.2. Strategy for Water Resources Development and Management

Strategy for water resources development and management in the Study Area is established with the goal to maximize social and economic well-beings of the regional people in an equitable manner. The strategy has following five components. Each is described below. Phasing strategy is also indicated.

(1) Accelerated expansion of urban water supply

Rapid urbanization is envisioned in the Study Area in the coming decades. Urban water supply capacity needs to be expanded rapidly to meet the growing demand. Especially for Tete city and its surroundings, urgent measures need to be taken to alleviate the existing stress. At the same time, existing projects and plans should be reviewed, and medium and long term measures formulated in accordance with the Urban Master Plan for Tete and Angonia regional development master plan.

In the short to medium term, existing water supply systems for district capitals should be improved with rehabilitation, restoration and expansion of service areas. These systems will be continually expanded as the urbanization proceeds.

(2) Step-wise introduction of irrigated agriculture

The first step to substantive introduction of irrigated agriculture in the Study Area may be

to implement small scale irrigation schemes to allow small farmers to gain experiences and to convince them of the utility of the irrigation. Simple weirs may be constructed across small tributaries and streams to raise the level of water, which would be introduced into contour canals and gravity irrigation. One possibility is to utilize gabions, that can be produced by utilizing gravels and stones widely available in the Study Area and skillfulness of local people. Bamboo may be used instead of steel wire, if necessary to reduce costs. Alternatively, sand bags and/or logs may be used as already attempted in the Study Area. Local communities should better be involved in the identification of sites for weirs and suitable agricultural areas as well as construction works.

Small farmers should be supported not only for the construction works but also for operation and management of irrigation schemes. Short training courses may be effective on crop cycles, on-farm water management for irrigation scheduling and drainage, and soil and slope protection as well as weir design, canal alignment and land preparation.

Large scale, possibly commercialized irrigation development may follow the implementation of many small irrigation schemes. With the experiences to be gained through the small irrigation schemes, small farmers should be able to participate in the large scale development as active stakeholders rather than subordinate contract farmers. Simple weirs would not obstruct in any way the construction of large irrigation facilities.

(3) Multi-purpose water resources development and management

The practice of water resources development and management is still at a very early stage in Mozambique. The Study Area should pioneer in the application of modern water resources technologies as it has high potentials for water resources development largely unutilized and management needs are high due to unique climatic, hydro-geometric and soil conditions. In particular, multi-purpose dam projects should be formulated on the tributaries of the Zambezi river for irrigation, hydropower, flood control and urban water supply.

The concept of multi-purpose water resources development and management should be recognized through a feasibility study on a multi-purpose dam project in the future, when various usage of water, especially use of water for irrigation is established. Technical capability for modern water resources development and management should develop in the medium to long term through continual implementation and operation of multi-purpose dam projects.

(4) Community participation in watershed management and rural water supply

Slash and burn practice is widespread in the Study Area. Especially toward the end of the dry season, extensive areas undergo this practice, well beyond the level necessary for shifting cultivation. This practice needs to be controlled. Also upper catchment areas of

main tributaries have been degraded by deforestation. Watershed management is essential to restore and maintain production and water retention capacities of the entire river basins.

Integrating conservation and development activities through people's participation and collaboration among different institutional and social actors is increasingly being recognized as the most promising approach to sustainable natural resources management. Given the magnitude of the existing problem and the need for a broad-based approach, community-wide involvement is necessary under the leadership of traditional authorities, religious leaders and politicians.

Holistic forest zoning may be recommended for apportioning watershed within a given planning area for specific purposes. It will divide forests into areas for different uses and establish clearly written rules, standards, and guidelines to regulate all human uses. In practice, zoning ought to be a participatory and open process aimed at reaching consensus among all key stakeholders with the theme *"conservation by use"*.

Population coverage of rural water supply is still quite low, more or less one third of the rural population. What is more disturbing is that many hand pumps installed on wells and boreholes are not working. A key for improving not only the service coverage by new installations but also operation and management of wells and boreholes may be to encourage community involvement in the identification of needs and sites for wells and boreholes as well as their installation. Establishment of Water Committees consisting of users of each hand pump and appropriate training for small repairing works could be a practical idea for the improvement of the present situation.

(5) Enhanced planning and coordinating capacities.

Water resources development and management naturally involve various sectors such as agriculture, industry, energy, environment and social services. These sectors are usually under jurisdictions of different sector agencies, as is the case in Mozambique as well, to make coordinated actions difficult to take for effective development and management. Planning and coordinating functions for water resources development and management need to be much strengthened especially at the local level. GPZ may be in the best position to strengthen these functions in cooperation with local governments.

Effective development and management of water resources should be supported by proper information and accurate data. Among the most important data are hydro-meteorological data, data on existing water use facilities (e.g., location, dimension and capacity of wells and boreholes), and data on groundwater resources. For proper information on development needs and operational conditions of existing facilities, involvement of local communities would be essential. Local communities should also be involved in monitoring and evaluation activities related to natural environment including watershed management, and social environment such as change in social values and habits due to

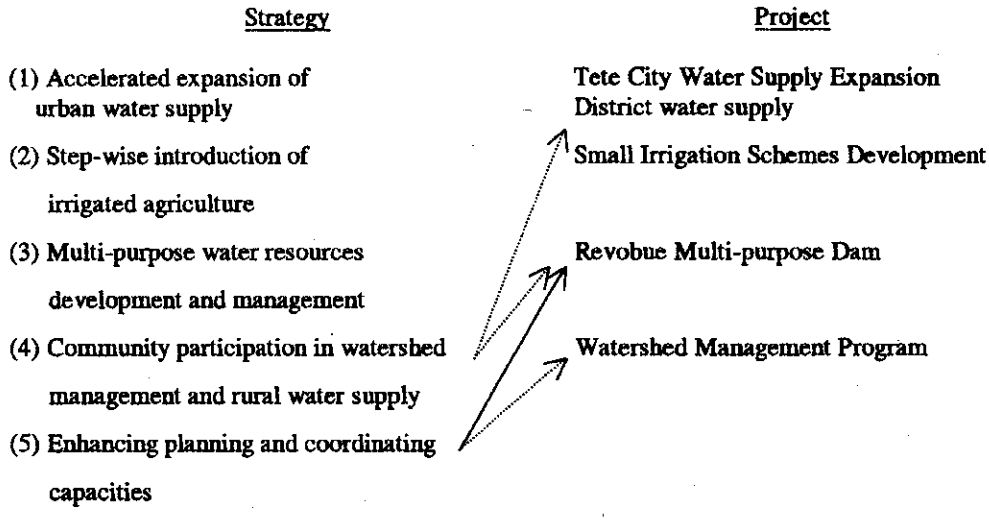
improved access to safe drinking water, irrigated agriculture, and dam projects.

As GPZ is committed to the development of the Zambezi Valley, a recent decision to govern its activities based in the central part of the Valley, i.e. Tete, is very appropriate. However, strengthening of its existing departments with resourceful persons and equipment should be the immediate target. For the time being, emphasis should be placed on the coordination with other agencies like DNA, ARAs, Agua de Rural, Department of Agriculture, Department of Energy, NGOs and so on. However, sooner or later GPZ should create its own database and network for data collection.

Chapter 5. Water Resources Development and Management Program

Projects and measures

A program for effective development and management of water resources in the Study Area has been formulated to attain the short and the long term objectives, under the strategy with the five components presented in the previous section. It consists of projects and related institutional measures. The policy reform and streamlining of related laws and regulations mentioned in Chapter 2 are national issues, and also included here. The program contains five main projects. Correspondence between the strategy and the projects is indicated below.



Profiles of the five projects are contained in the Propject Report (separate volume). To complement the project implementation, the following institutional/policy measures are recommended:

i) Reformulation of the Water Policy and amendment to the Water Law covering, among others:
   - clarification of functional divisions between water-related national institutions and agencies, local governments, the private sector, NGOs and local communities,
   - establishment of roles of traditional authorities with land related rights in relation to water use,
   - introduction of private sector involvement in water supply operation,
   - participation of local communities, and
   - clarification of principles for water charges; and

ii) Re-definition of roles of GPZ in water resources development and management in the Zambezi river basin, clarifying relationships with DNA/ARAs, related national institutes and agencies, and the Tete provincial government.

Action plan

It is recommended that the following actions be taken immediately following the completion of the Angonia Regional Master Planning:

1) Implement the Tete City Water Supply Expansion-phase 1 with a grant-aid assistance,
2) Prepare a plan for rehabilitation and expansion of district water supply systems with community participation, and draft an aid proposal to facilitate early implementation,
3) Identify about 20 sites (2-10 ha) each for small scale irrigation schemes that can be implemented by the local initiative supported by district agricultural offices and GPZ,
4) Prepare for a feasibility study of the Revobue multi-purpose Dam project,
5) Identify model sub-basins for watershed management through inviting proposals from local communities in cooperation with district offices, and
6) Complete the on-going re-organization of GPZ, and prepare a policy paper recommending expansion of its functions as the implementing agency in selected fields such as water resources development and management, social/livelihood development , and environmental management.