4.8.5 Plan of Piaui River Basin

(1) Water Demand and Shortage

Water demand and shortage in Piaui River basin is estimated as shown in Table-4.35.

Table-4.35 Water Demand and Shortage in Piaui River Basin

River	Year	1997	1998	2000	2005	2010	2015	2020
Urban and Large Rural Area	Water Demand (m^3/day)	56,118	57,819	61,222	76,388	95,727	120,580	152,577
	Private Industrial Water (m^3/day)	20,789	22,008	24,446	30,902	38,006	45,167	52,327
	Necessary Supply Water (m^3/day)	47,198	47,933	49,403	62,282	78,936	101,493	131,329
	Industrial Water	104	109	118	6,116	15,637	30,502	51,771
	Municipal Water: Urban Area	41,368	41,664	42,256	47,178	52,520	58,542	65,526
	Municipal Water: Large Rural Area	5,727	6,161	7,029	8,988	10,780	12,449	14,032
	Current Water Supply Capacity (m^3/day)	24,752	24,752	24,752	24,752	24,752	24,752	24,752
	Supply Water Shortage (m^3/day)	22,447	23,181	24,651	37,530	54,185	76,741	106,577
	Supply Water Shortage Rate (%)	91	94	100	152	219	310	431
	Source Water Shortage (m^3/day)	26,936	27,818	29,581	45,036	65,022	92,090	127,893
Small Rural Area	Water Demand (m^3/day)	2,819	2,825	2,838	2,878	2,929	2,992	3,069
	Necessary Supply Water (m^3/day)	1,473	1,524	1,627	1,897	2,188	2,501	2,842
	Current Water Supply Capacity (m^3/day)	626	613	585	517	449	381	313
	Supply Water Shortage (m^3/day)	847	912	1,042	1,380	1,738	2,120	2,529
	Supply Water Shortage Rate (%)	135	149	178	267	387	556	808
	Source Water Shortage (m^3/day)	1,473	1,524	1,627	1,897	2,188	2,501	2,842

(2) Plan of Water Resources Development and Supply

Plan of water resources development and supply in Piaui River basin for the target year 2020 is shown in Figure-4.26. Source water to be developed within the basin and supply water to be consumed inside of the basin are explained in Table-4.36 and summarized as follows:

- As for urban and large rural water supply, 99.6 thousand m^3/day of water is newly developed within the basin. Of this source water, 70.8 thousand m^3/day (71 %) of water is supplied to the own basin and 28.9 thousand m^3/day (29 %) to other basins. Supply water into the basin is supplied with 66% from the own basin and 34 % from others.
- Surface water is main sources in the basin, accounting for 87 % in water supply for urban and large rural area and 85 % in total water resources.
- Irrigation water is supplied from the own basin by surface water, occupying 17 % of source water to the own basin.

Table-4.36 Source and Supply Water in Piaui River

Item	U/L Rural			S Rural	Irrigation	Total		
	S/W	G/W	Total	G/W	S/W	S/W	G/W	Total
Source water to inner basin	57,897	12,868	70,765	2,529	20,956	78,853	15,397	94,250
Source water to outer basin	28,414	437	28,851	-	-	28,414	437	28,851
Total inner source water	86,311	13,305	99,616	2,529	20,956	107,267	15,834	123,101
Supply water from inner source	57,897	12,868	70,765	2,529	20,956	78,853	15,397	94,250
Supply water from outer source	35,812	0	35,812	-	-	35,812	0	35,812
Total supply water	93,709	12,868	106,577	2,529	20,956	114,665	15,397	130,062

Note: Source water in U/L rural is expressed as supply water base.

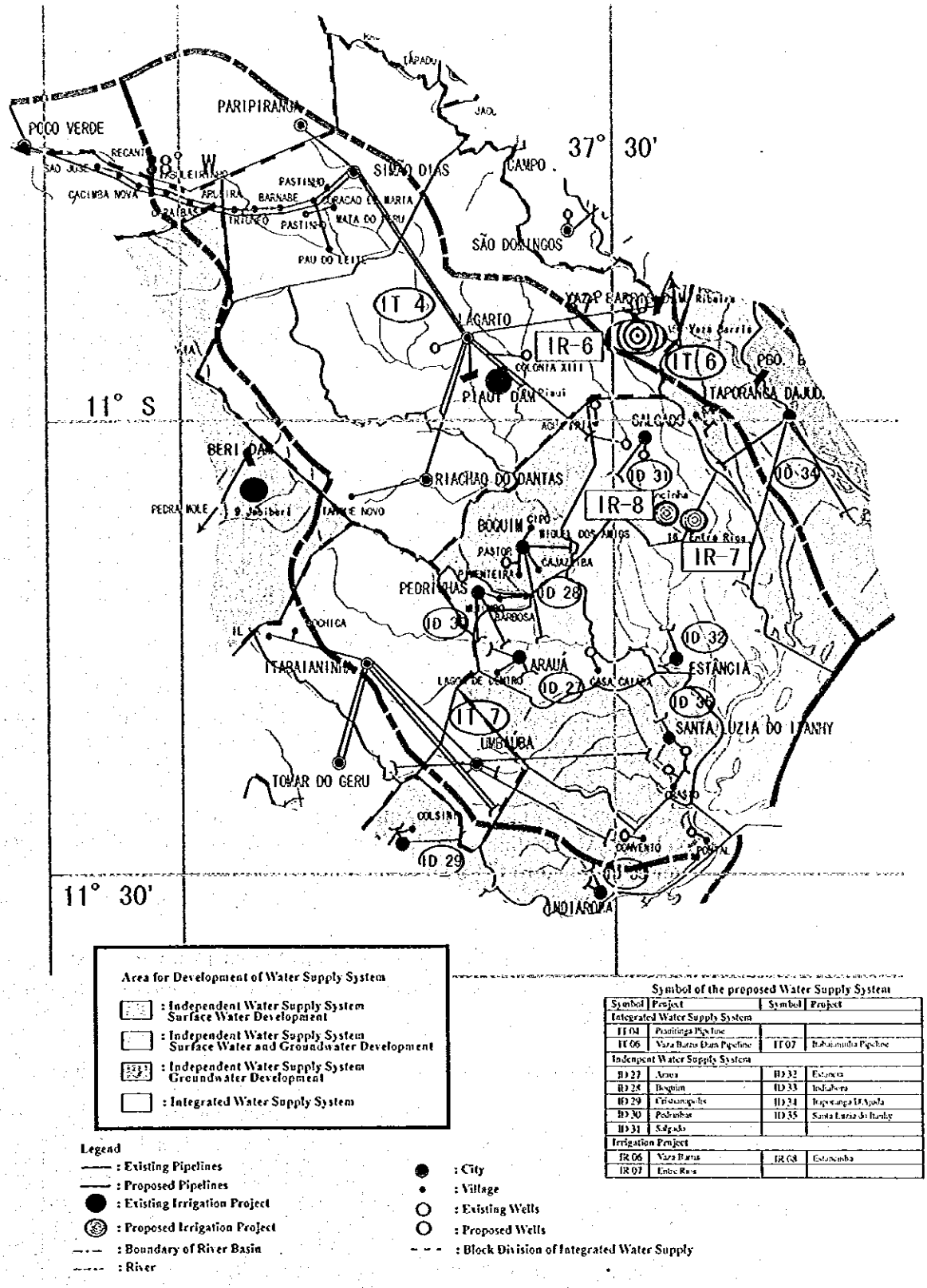


Figure-4.26 Water Resources Development Plan of Piaui River Basin

4.8.6 Plan of Real River Basin

(1) Water Demand and Shortage

Water demand and shortage in Real River basin is estimated as shown in Table-4.37.

Table-4.37 Water Demand and Shortage in Real Basin

River	Year	1997	1998	2000	2005	2010	2015	2020
Urban and Large Rural Area	Water Demand (m^3/day)	14,402	14,706	15,312	16,912	18,895	21,332	24,330
	Private Industrial Water (m^3/day)	679	718	798	900	999	1,060	1,068
	Necessary Supply Water (m^3/day)	16,535	16,995	17,916	20,202	22,868	26,044	29,860
	Industrial Water	36	38	41	268	577	1,032	1,665
	Municipal Water: Urban Area	15,279	15,496	15,929	16,812	17,978	19,444	21,258
	Municipal Water: Large Rural Area	1,220	1,462	1,946	3,123	4,314	5,568	6,937
	Current Water Supply Capacity (m^3/day)	9,888	9,888	9,888	9,888	9,888	9,888	9,888
	Supply Water Shortage (m^3/day)	6,648	7,108	8,028	10,315	12,981	16,156	19,972
	Supply Water Shortage Rate (%)	67	72	81	104	131	163	202
	Source Water Shortage (m^3/day)	7,977	8,529	9,634	12,378	15,577	19,387	23,967
Small Rural Area	Water Demand (m^3/day)	1,210	1,218	1,233	1,281	1,343	1,421	1,518
	Necessary Supply Water (m^3/day)	684	702	740	854	998	1,179	1,405
	Current Water Supply Capacity (m^3/day)	297	290	277	245	213	181	148
	Supply Water Shortage (m^3/day)	387	412	462	609	785	998	1,257
	Supply Water Shortage Rate (%)	131	143	167	248	369	553	848
	Source Water Shortage (m^3/day)	684	702	740	854	998	1,179	1,405

(2) Plan of Water Resources Development and Supply

Plan of water resources development and supply in Real River basin for the target year 2020 is shown in Figure-4.27. Source water to be developed within the basin and supply water to be consumed inside of the basin are explained in Table-4.38 and summarized as follows:

- As for urban and large rural water supply, 8.8 thousand m^3/day of water is newly developed within the basin. Of this source water, 8.5 thousand m^3/day (96 %) of water is supplied to the own basin and 0.4 thousand m^3/day (4 %) to other basins. Supply water into the basin is supplied with 42 % from the own basin and 58 % from others.
- Only surface water is the water source in the basin for water supply in urban and large rural area, and occupying 88 % of total water sources if including small rural water supply sources.

Table-4.38 Source and Supplied Water in Real River

Item	U/L Rural			S Rural	Irrigation	Total		
	S/W	G/W	Total	G/W	S/W	S/W	G/W	Total
Source water to inner basin	8,481	0	8,481	1,257	-	8,481	1,257	9,738
Source water to outer basin	351	0	351	-	-	351	0	351
Total inner source water	8,832	0	8,832	1,257	0	8,832	1,257	10,089
Supply water from inner source	8,481	0	8,481	1,257	-	8,481	1,257	9,738
Supply water from outer source	11,175	316	11,491	-	-	11,175	316	11,491
Total supply water	19,656	316	19,972	1,257	0	19,656	1,573	21,229

Note: Source water in U/L rural is expressed as supply water base.

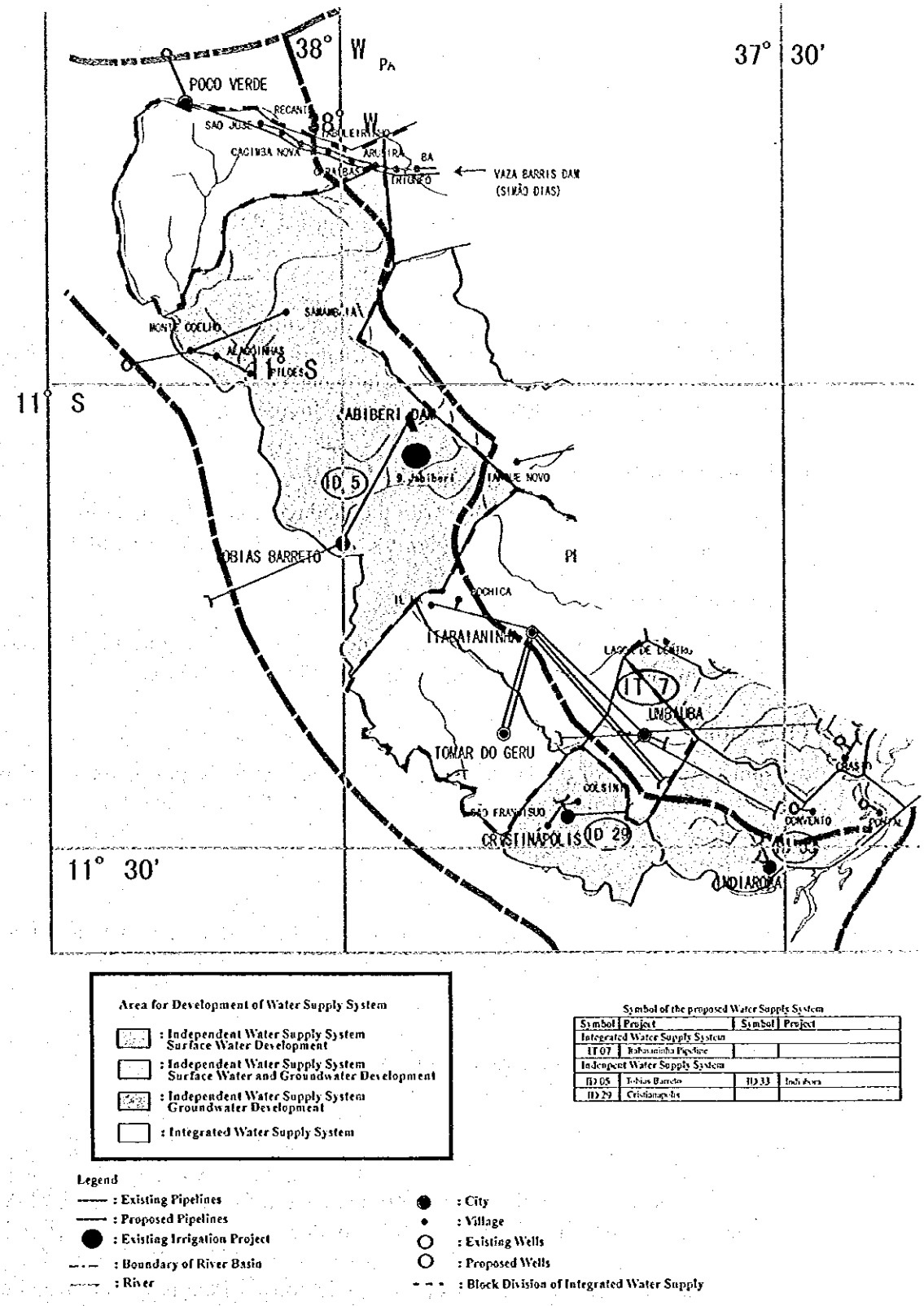


Figure-4.27 Water Resources Development Plan of Real River Basin

4.9 Cost Estimate

The cost estimation of the projects in the Master Plan Study has been conducted using the unit costs per representative capacity of facilities related to Water Resources Development proposed in the Study. The unit costs for each type of facilities have been established by compiling the costs for past and/or existing Projects or other equivalent data that the related organizations in the State of Sergipe have been presented.

4.9.1 Composition of Project Cost

Project cost in the implementation stage is composed of the following cost items:

(1) Construction Cost, CC

This is the cost required for the construction of facilities and other related works including the preparatory works. The cost includes material and equipment cost and labor cost including 1) installation and erection of equipment, etc. as a direct cost, DCC, and 2) direct and indirect benefit, BDI, 30% of DCC, as an indirect cost.

(2) Land Acquisition and Compensation Cost, LACC

This cost covers the cost associated with the land required for project implementation such as land acquisition, resettlement, temporary use of land and compensation for properties.

(3) Consulting Services Cost, CSC

The cost covers the cost for consulting engineering services required in the whole period of the project implementation and is taken as 10 % of CC and LACC.

(4) Administration Cost, AC

Administration cost of the Government covers the cost for supervision and management of the project implementation by the Government staff and is taken as 1% of CC, LACC, CSC and CT.

(5) Contingency, CT

Contingency includes the physical contingency of 5% of CC, LACC and CSC. No price escalation is considered.

(6) Government Tax

Government Tax is included in the unit costs for estimation.

4.9.2 Project Cost

Cost estimation for the Study is based on the costs and prices at the time of August 1998. Exchange rate of Brazilian "Real" to US$ as of August 1998 is US$ 1 = R$. 1.18

The estimated cost of the project proposed in the Master Plan is summarized in Table-4.39. The costs of each project are described in Table-4.45. The costs for Multi-Purpose projects and main projects are shown in Table-4.40 to Table-4.44.

Table-4.39 Summary of Project Cost Proposed in Master Plan

Unit: R$ million

Item	Domestic and Industrial Water Supply				Irrigation	Total
	Integrated W/S	Indepen-dent W/S	Small Rural W/S	Total		
1. Construction Cost	600.98	145.47	63.31	809.76	354.72	1,164.48
2. Land Acquisition and Compensation Cost	0.74	0.26	0.01	1.01	11.74	12.75
3. Consulting Services Cost	60.17	14.57	6.33	81.07	36.65	117.72
4. Administration Cost	6.95	1.68	0.73	9.36	4.23	13.59
5. Contingency	33.10	8.02	3.48	44.60	20.16	64.76
(1) Price Escalation	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
(2) Physical Contingency	*33.10*	*8.02*	*3.48*	*44.60*	*20.16*	*64.76*
6. Government Tax	-	-	-	-	-	-
Grand Total	701.94	170.00	73.86	945.80	427.50	1,373.30

Note: Government Tax is included in Construction Cost

Table-4.40 Cost of Xingo Dam Multi-Purpose Pipeline Project

Project Component	Cost (million R$)
(1) Xingo Dam Pipeline Project (Domestic and Industrial W/S Project)	145.66
Caninde Block	53.73
Nossa Senhora da Gloria Block	54.87
Frei Paulo Block	37.06
(2) Sao Francisco Irrigation Project	223.07
Total	368.73

Table-4.41 Cost of Vaza Barris Multi Purpose Dam Project

Project Component	Cost (million R$)
(1) Vaza Barris Dam Project (Domestic and Industrial W/S Project)	186.24
Dam Construction	63.25
Water Supply facilities (Itabaiana)	59.04
Water Supply facilities (Lagarto)	63.95
(2) Vaza Barris Irrigation Project	23.22
Total	209.46

Note: Irrigation project does not include dam construction cost. No allocation is done.

Table-4.42 Cost of Agreste Integrated Water Supply Projects

Project Component	Cost (million R$)
PROAGUA	14.56
Vaza Barris Pipeline	25.60
Vaza Barris Treatment and Distribution	33.45
Vaza Barris Dam (Allocated Cost)	15.81
Total	89.42

Table-4.43 Cost of Piauitinga Integrated Water Supply Projects

Project Component	Cost (million R$)
PROAGUA	9.29
Vaza Barris Pipeline	27.20
Vaza Barris Treatment and Distribution	36.75
Vaza Barris Dam (Allocated Cost)	15.81
Total	89.05

Table-4.44 Project Cost of Vaza Barris Dam

Item	Property	Cost (million R$)
Dam	Fill Dam w/ Dam height 36m	16.62
Spillway	Free Overflow Open Channel	35.55
Diversion Channel	Gravity Flow Open Channel	7.74
Check Dam	Concrete Dam w/ Dam Height 14m	2.21
Compensation	Land acquisition of 1,600 ha	1.14
Total	-	63.26

Table-4.45 Cost of the each Project Proposed in Master Plan

Project	Project Cost (1,000R$)	Project	Project Cost (1,000R$)
Domestic and Industrial Water Supply	**945,806**	Sao Francisco: Deep Well Development	503
Urban/Large Rural Area (Integrated Sys.)	**701,938**	*Carmopolis: Deep Well Development*	612
Project Expansion of Sao Francisco Pipeline Sys.	258,011	General Maynard: Deep Well Development	465
Aracaju Well Development Project	27,003	Maruim: Deep Well Development	1,511
Project Expansion of Agreste Pipeline System	14,562	Riachuelo: Jacarecica R. Development	1,793
Project Expansion of Piauitinga Pipeline System	9,293	: Deep Well Development	2,039
Xingo Dam Pipeline Project	145,662	Rosario do Catete: Siriri R. Development	2,042
1) Caninde Block	53,729	: Deep Well Development	3,454
2) Nossa Senhora da Gloria Block	54,872	S. Amaro das Brotas: Deep Well Development	552
3) Frei Paulo Block	37,061	Barra dos Coqueiros: Deep Well Development	2,925
Vaza Barris Dam Project	154,618	*Sao Cristovao: Deep Well Development*	2,732
(include dam cost allocated with irrigation project)		Araua: Camboata R. Development	1,195
1) Agreste System (Itabaiana)	74,854	: Deep Well Development	1,159
2) Piauitinga System (Lagarto)	79,764	Boquim: Gaiangal R. Development	3,748
Project Expansion of Itabaianinha Pipe. System	34,305	Cristinapolis: Itamirim R. Development	4,106
Project Expansion of Propria Pipeline System	4,814	Pedrinhas: Araua R. Development	2,193
Project Expansion of Alto Sertão Pipeline Sys.	20,518	: Deep Well Development	644
Project Expansion of Sertaneja Pipeline System	33,152	Salgado: Grilo R. Development	2,002
Urban/Large Rural Area (Independent Sys.)	**170,002**	: Deep Well Development	1,159
Gararu: SFR Direct Intake	635	*Estancia: Piauitinga R. Development*	6,825
Muribeca: Deep Well Development	846	*: Piaui R. Development*	4,061
Nossa Senhora das Dores: Pinol R. Development	2,870	*: Deep Well Development*	2,938
Malhador: Vermelho R. Development	2,113	Indiaroba: Paripe R. Development	1,184
: Deep Well Development	598	Itaporanga D'Ajuda: Fundo R. Development	5,851
Tobias Barreto: Jabiberi Dam Rasing Project	16,787	: Tejupeba R. Development	63,539
Brejo Grande: Deep Well Development	564	Santa Luzia do Itanhy: Ariquitiba R. Develop.	1,481
Ilha das Flores: Deep Well Development	594	**Small Rural Area (Residential W/S Only)**	73,866
Neopolis: SFR Direct Intake	8,310	Single Well System (Public Tap)	73,866
Santana do Sao Francisco: SFR Direct Intake	1,861	**Irrigation Water Supply**	427,497
Capela: Siriri R. Development	3,650	Quixabeira	35,051
: Adeira R. Development	3,301	Jacare-Curituba	37,852
Divina Pastora: Deep Well Development	523	Sao Francisco	223,070
Santa Rosa de Lima: Deep Well Development	457	Ladeirinhas	28,742
Siriri: Deep Well Development	628	Jacarecica II	44,545
Japaratuba: Deep Well Development	1,762	Vaza Barris	54,839
Japoata: Deep Well Development	540	(include dam cost allocated with W/S project)	
Pacatuba: Santo Antonio R. Development	1,922	Entre Rios	2,397
Pirambu: Deep Well Development	1,327	Estancinha	1,001

Note: Vaza Barris irrigation project does not include dam construction cost. No allocation is done.

CHAPTER 5 WATER RESOURCES MANAGEMENT PLAN

5.1 Institutional Plan

5.1.1 Grant of Water Rights

It has created to grant "water right" for water withdraw and for effluent drainage to every water users. Then, water users have to get water rights from the competent government. Thus, the grant system of water use rights is a legal action and also an effective tool for water resources management by the federal or state governments. The water code (Decree No.24643, July 1934) also stipulates that a water user obligatorily has to get a water right from the government. It also gives general stipulation on concession, authorization or permission of water use and obligation to titleholders. It classifies water rights into two types: (a) water for public utility as concession level and (b) water use other than public utility as authorization level.

In the drafts of the state decrees, the grant is also admitted as a legal tool for water resources management. Then, the grant should be set up in consideration of the following conditions. The proposed priority order is shown in Table-5.1

1) Priority of water use purposes.
2) Classification of waters under environmental legislation.
3) Preservation of multiple water use.
4) Maintenance of navigation system whenever necessary.

Table-5.1 Priority Order of Water Resources Use

Purposes	Priority Order	Categories of Water Use
Public Purposes	1) For support of human lives	Potable water, domestic water supply
	2) For keeping natural & social environment	Public hygiene, safety, natural animal lives, ecological balance
	3) For public utilities	Transportation (navigation)
Private Purposes	4) For economic activities*	Agricultural, livestock & fishery production, industrial production, commercial & service activities, tourism
	5) For amusement*	Recreation, sports

Note: * Priority order depends on the socio-economic situation in the river basin.

As mentioned in the law of state policy, the water resources are quite limited in the State of Sergipe. In addition, there are many existing water users in the state, who live relying on water and therefore who have to get rights of water uses. At the time of granting for water use applicants, thus, the competent agency should consider the following conditions to control water quality and quantity and to distribute water rights effectively and equally in the state.

1) In case of water intake, to maintain water balance taking into consideration of water availability, influence of downstream and existing water users.
2) To promote multiple-use system to utilize water resources effectively.
3) In case of effluent drainage, to effectuate the ecological balance without detriment to environment in the basin.
4) To take great care to grant water rights to pollutant charge dilution of effluent, because the dilution does not make the quantity of pollutant decrease and makes the treatment of effluent difficult technologically.

5.1.2 Charging to Use of Water Resources

(1) Charging to Water Resources Use

The charging system to users of water resources is a new administrative instrument in the state as well as in the country. Therefore, there are almost no examples of the charging system in the country. The study team collected some examples in foreign countries implementing the charging system.

The unit of pricing water resources is "per liter/sec per year". This is because the water resources potential is given in the form of discharge capacity, i.e., "liter/second". Even in reservoir and groundwater resources, their potential is given in the same form taking into account of rechargeable capacity. In areas of scarce water resources, thus, the pricing unit would rather be based on "per liter/sec per year". In Sergipe State, water resources are quite serious particularly during dry season, so a charging unit would rather be set as "per liter/sec per year".

The water charge to industrial use is summarized in Table-5.2. As shown in the table, the water price of industrial use varies considerably. The prices are set by the respective governments, which reflects the water policy of the respective countries except Chile. In Chile, the price depends on the relative value of water in a free market.

Table-5.2 Rate of Charging to Industrial Use in Foreign Countries

Country	Water Price (US$ per litter/sec)	GDP per Capita (US$)
Japan	27.60	28,500
Philippines	0.02	900
Zambia	8.20	450
Chile	96.00	2,700
Romania	80	1,500
Brazil, Ceara	320	2,800

Industrial and agricultural uses have separately determined sectoral water allocations in most countries. In many countries to date, the much higher value of industrial water, as compared with agricultural uses, is set a high economic cost in the existing allocation. In Japan in fact, the agricultural use is not charged to usage of water resources. In the Philippines, the small users (less than 5 litter/sec) of agricultural purpose are not charged, either. Although these allocations may have been appropriate historically, future developments might change their economic implications.

The GDP per capita in Sergipe State is estimated at R$2,400 (equivalent to US$2,600) in 1997. This value is close to Chile and Ceara in Brazil. It is also about six times higher than that in Zambia but one-tenth lower than that of Japan. Taking this observation into account, the unit charge for Sergipe is set at most between US$50 and US$100 per litter/sec.

The source water requirement of the respective sectors is estimated under the present conditions and in the target year 2020. Hence, the requirement means not actual peak water demand of consumers but water volume withdrawn from the competent river basin. Then, in case that the river basin has poor water resources and can not cover the water demand, the withdraw volume would be smaller than the peak demand because some source water has to be transferred from other river basins. Table-5.3 shows the results of the estimate of source water withdraw from the state domain, that is, three river basins of Japaratuba, Sergipe and Piaui. The table also shows two kinds of requirement estimates, i.e., five river basins except Sao Francisco River and all six river basins

Table-5.3 Water Withdraw: 1997 and 2020

Unit: litter/sec

Water Resources User	1997			2020		
	Surface Water	Ground Water	Total	Surface Water	Ground Water	Total
Three River Basins*1	1,287	2,278	3,565	4,522	3,147	7,669
Urban & Large Rural Water Supply	487	2,264	2,751	1,662	3,070	4,731
Small Rural Water Supply	0	14	14	0	77	77
Irrigation	800	0	800	2,860	0	2,860
Five River Basins*2	2,894	2,625	5,519	10,218	3,572	13,790
Urban & Large Rural Water Supply	894	2,602	3,496	3,245	3,460	6,705
Small Rural Water Supply	0	23	23	0	112	112
Irrigation	2,000	0	2,000	6,972	0	6,972
All River Basins*3	23,897	3,006	26,903	50,440	4,002	54,442
Urban & Large Rural Water Supply	3,597	2,979	6,576	8,718	3,866	12,585
Small Rural Water Supply	0	27	27	0	135	135
Irrigation	20,300	0	20,300	41,722	0	41,722

Note: *1 Three rivers under state domain are Japaratuba, Sergipe and Piaui.
*2 Five rivers include Vaza Barris and Real in addition to the three rivers above.
*3 Six rivers include Sao Francisco in addition to the five rivers above.

The revenue of the state government through the charging system is estimated as a product of water requirement and a unit rate of charging to water resources use. Table-5.4 shows the results of the total amount through water resources charge in terms of the three cases mentioned in Table-5.3. Hence, groundwater is under state domain, so charging revenues to groundwater of the respective cases are identical in all cases, as shown in the table. The annual revenue from the three river basins in the state domain is estimated approximately at US$215,000 in 1997 and US$426,000 in 2020, in case that the unit rate is set as US$50 per litter/sec. Furthermore, in case that the unit rate is set as US$100 per litter/sec, the annual revenue from the three river basins is estimated approximately at US$429,000 in 1997 and US$852,000 in 2020.

Table-5.4 State Revenue through Water Charge: 1997 and 2020

Water Resources User	1997			2020		
	Requirement	Water Resources Charge *1		Requirement	Water Resources Charge*1	
		US$50	US$100		US$50	US$100
	(litter/sec)	(US$ 1000/Year)		(litter/sec)	(US$ 1000/Year)	
Surface Water						
Three River Basins*2	1,287	65	129	4,522	226	452
Five River Basins*3	2,894	145	289	10,208	510	1,021
All River Basins*4	23,897	1,195	2,390	50,440	2,522	5,044
Groundwater	3,006	150	300	4,002	200	400
Total						
Three River Basin Case*2	4,293	215	429	8,524	426	852
Five River Basins Case*3	5,900	295	589	14,210	710	1,421
All River Basins Case*4	26,903	1,345	2,690	54,442	2,722	5,444

Note: *1 Unit rates of charging are set in two alternatives: US$50 per litter/sec and US$100 per litter/sec.
*2 Three rivers under state domain are Japaratuba, Sergipe and Piaui.
*3 Five rivers include Vaza Barris and Real in addition to the three rivers above.
*4 Six rivers include Sao Francisco in addition to the five rivers above.

If the state government take over the authorization of water right granting to the three rivers under federal domain from the federal government, the state government could have a power on granting of water resources use right on the federal rivers, i.e., Vaza Barris, Real and Sao Francisco rivers. Table-5.4 shows two kinds of revenue estimates, i.e., five river basins except Sao Francisco River and all six river basins. Hence, the unit rates of water resources charge are assumed to be the same as those in the above. The revenue from five river basins is estimated approximately at US$589,000 in 1997 and US$1,421,000 in 2020. In the case of six river basins, the revenue is estimated approximately at US$2,690,000 in 1997 and US$5,444,000 in 2020. The total revenue from the six river basins is 6.3 times larger than that from the three river basins in the state domain in 1997 and also 6.4 times in 2020.

A water agency in the state will be established in the future. The water agency will be managed on the basis of the charging revenue to water resources use. Furthermore, the appropriation to the water agency and river basin committees is limited to less than 7.5% of the total revenue from the charging to water resources uses (State Law No.3870, Art.27). Since this rate of 7.5% might be increased to 10% in the near future after the law amendment, the rate of 10% is used to estimate the budget for the water agency and committee expenses.

Supposing that the water agency has 12 full-time members at matured stage, the annual expenses for the agency and river basin committees are estimated as US$264,000 at 1999 price level.

The total annual expense of US$264,000 is larger than the total revenue in 1997 from the charging to water uses in three river basins under the unit rate of US$50 per litter/sec. Even in the case of the unit rate US$100 per litter/sec, the total annual expense accounts for 62% of the total revenue in 1997. That is far larger than 10%, the rate limited in the state law after amendment. The cases that exceed ten times of the total annual expense are only the following two cases: (1) the revenue in 1997 from the six river basins under the unit rate of US$100 per litter/sec; and (2) the revenue in 2020 from the six river basins under the unit rate of US$50 per litter/sec as well as US$100 per litter/sec. Since the rate of US$100 per litter/sec seems to be considerably high as compared with the foreign examples, the rate should be set at US$50 for the starting point. Anyhow, the water agency could be established in accordance with the progress of water resources charging system.

(2) Charging to Effluent Discharge

The charging system to effluent discharge is also found here and there in the foreign countries mainly in Europe, although the examples of the system are not many even in Europe. According to Romanian charging system to effluent discharge, the basic units are based on the weight of pollutants. They are suspended solids and BOD_5. In Romanian case, the charging rates are as follows: (1) 32,298 lei/ton (US$0.0020 per ton) of suspended solids; and (2) 130,578 lei/ton (US$0.0082 per ton) of BOD_5. In Sergipe State, the charging system to effluent discharge would better be introduced after the establishment of the charging system to withdrawal of water resources in the future.

5.1.3 Organization Plan

(1) First Stage Plan of Water Resources Management

In the state policy, the organizations for water resources management are composed of CONERH, RBCs, WA, FUNERH and SRH. The structure of these organs is figured out as shown in Figure-1.24 of Chapter 1. However, most of organs are still under preparation and do not exist at present except SRH and CONERH/SE in the state level.

The SRH has to promote the following major works for the beginning period:

1) To form River Basin Committees in the state domain.
2) To establish a draft of grant system of water resources use
3) To create a draft of charging systems to water resources users and effluent discharge
4) To formulate a master plan of water resources for the respective river basins
5) To promote some multiple-use water resources projects in the master plan
6) To set up and to operate an information system of water resources
7) To get hold of present situation of water resources in the respective basins
8) To establish an observation network of hydrology and aquifer

Moreover, the state revenue from the charging system is expected for supporting the new organizations. The expected amount through the charging system might be not enough to support the new organizations and their works, if the charging rates were smaller than the expected. In order to promote the works above, thus, the SRH has to be financially supported by the general fund of the state government for the time being. Besides, the SRH has to be strengthened to promote the works as a leading organization in the state government. Then, the SRH must be strengthened in accordance with the progress of requirement to water resources management. A draft plan of the new SRH for the first stage is illustrated in Figure-5.1.

In the future, a lot of works in water resources management would make headway along with the economic growth in the state. At the time when the SRH will not be able to do works effectively, the water agency (WA) could be separated as an independent organization, that is, the second stage for water resources management.

Finally, the FUNERH could be established for managing the fund from the charging system, after the water market takes a firm hold in the state and also in the country. This is the final stage for the institutional frame of water resources management. The structure of the frame shown in Figure-1.24 of Chapter 1 is carried out in the third stage.

(2) Training Plan

The vocational training is essential to improve the employee's capability and eventually the performance of the organization. The ways having been applied in the water sectors were an on-the-job training. Although the on-the-job training is still one of the considerably efficient methods and therefore it has been applied in every field widely, it will be necessary that the training be carried out with more systematic and premeditated planning. In addition to the on-the-job training, workshops and seminar programs might be useful for new workers in the field of water resources management to get necessary technical knowledge for the time being.

Furthermore, the SEPLANTEC/SRH has to create a training program for new workers and agencies concerned. The SRH in the MMARHAL must have enough capability of staff training owing to cooperation with the World Bank's training program. Upon deliberation with the MMARHAL/SRH, the senior members of the SEPLANTEC/SRH should formulate an optimum training program for new workers.

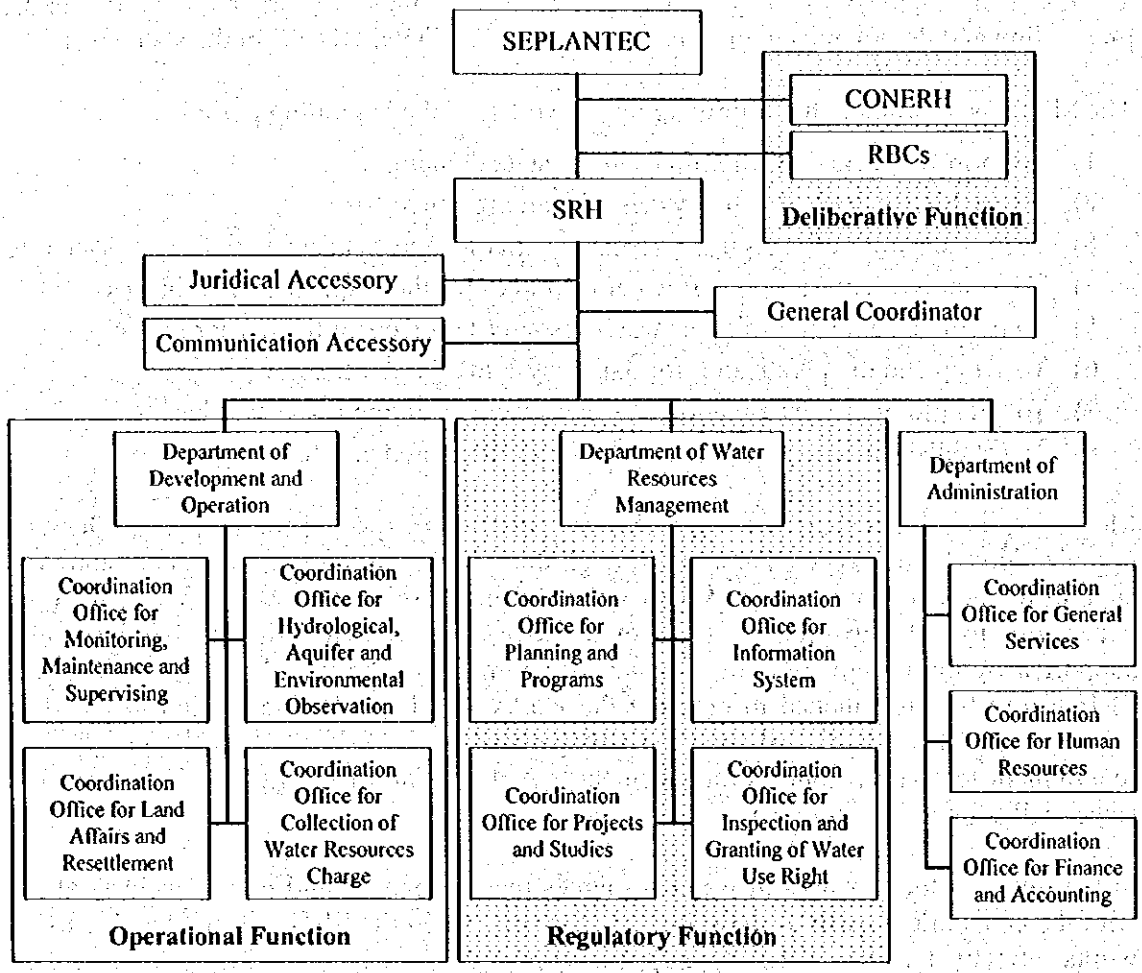


Figure- 5.1 Organization Plan of SRH at First Stage

5.1.4 Participation of Civil Organizations

Public participation and decentralization are the key concepts of water resources management. In the laws, civil organizations are expected to attend to river basin committees, members of which are selected from the local associations and organizations interested in water resources. Thus, the stakeholders influence policy formulation of water system, alternative design, investment choice and management decisions. Then, they will take the responsibility for their water system. In fact, the stronger the participation and interest to water system the users have, the more successful the project will be in achieving its associations as the primary agents for water resources management.

The participation of civil organization is put into practice through CONERH/SE and River Basin Committees (RBCs). According to the state decree No.18099 disposed on 26th of May 1999, the eight members are expected to attend CONERH as representatives of the water users and civil societies related to water resources.

According to the draft of the water resources management, the ten members are expected to attend each RBC as representatives of the respective water users and civil societies related to water resources. However, the names or statuses of the members are not identified so far. Only a representative of Indian communities is expected to attend the competent committee. Other members are selected among the economic fields such as agriculture and manufacturing industry. In addition to those, some members of professional or academic standing should be added to the respective committees in compliance with the situation of the river basins.

5.1.5 Cost Allocation of Multi-Purpose Facilities

In development of multiple use facilities, the costs for their construction are allocated to users taking part in their works. The method of this cost sharing is called as cost allocation. Although there are several methods for cost allocation, the "separable cost remaining benefit method" is generally in many countries adopted at present. It is recommendable for Brazil to adopt this method to allocate the costs of multiple-use facilities. The simplified procedure of the method is illustrated in Figure-5.2.

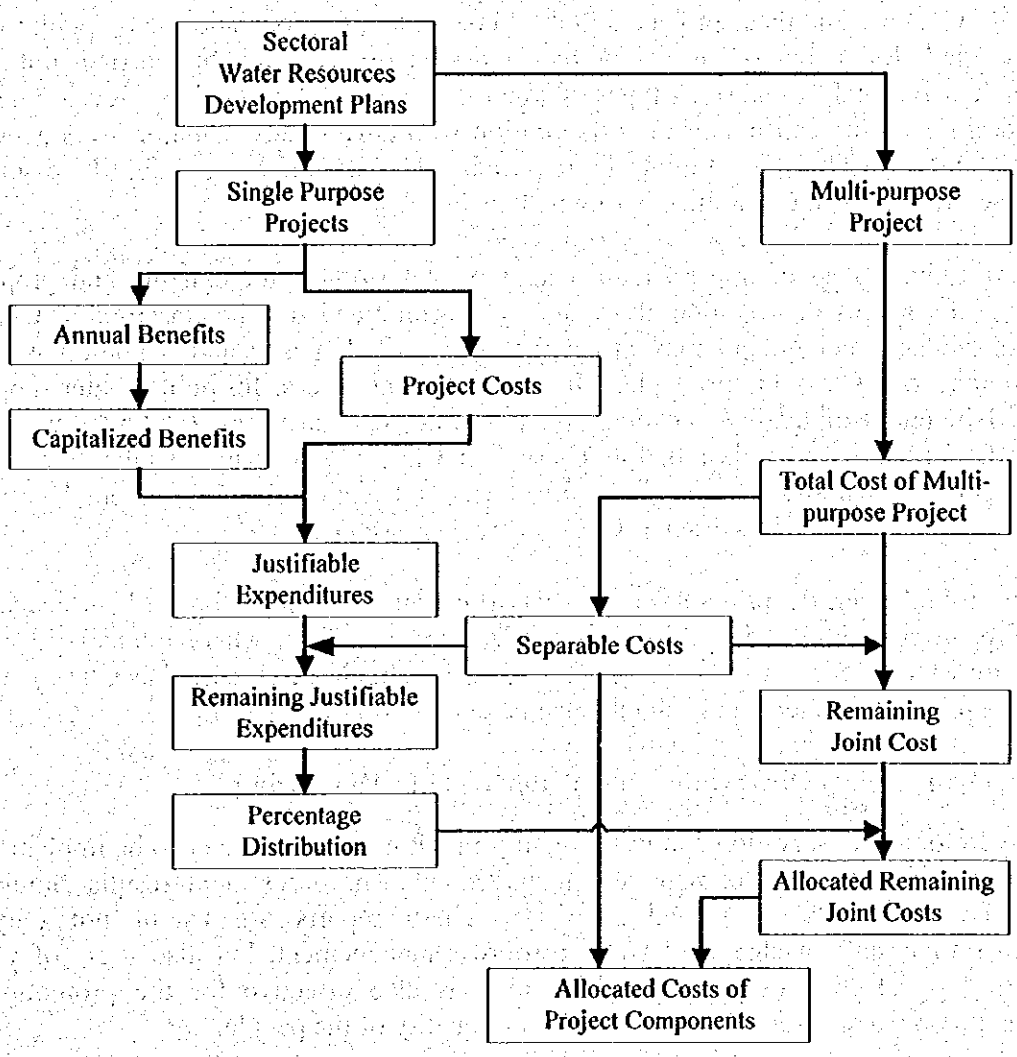


Figure- 5.2 Cost Allocation Procedure of Multi-purpose Facilities

5.2 Water Resources Management and Conservation Plan

5.2.1 Classification of Waters According to the Predominant Use

As mentioned previously, classification of waters according to their predominant use provided in CONAMA Resolution No. 20, 1986 is still to be conducted in the State. The Resolution classifies water as follows (Art. 1):

1) Fresh Water: Special Class, Class 1, Class 2, Class, 3, Class 4
   From Special Class: domestic water supply without previous disinfecting or with simple disinfecting, to Class 4: navigation, landscape harmony and insignificant use
2) Brackish Water: Class 7 and Class 8
   From Class 7: recreation of primary contact, to Class 8: commercial navigation, landscape harmony and recreation of secondary contact

The following recommendation for classification of waters is made for six river basins, except main stream of the Sao Francisco River, which is of federal domain, based on the existing water use and those projected in the Master Plan, for domestic use by public water supply, and for irrigation use. Actual classification should be carried out after comprehensive analyses on other types of water use and on future land use development in each basin. Hiring consultants or collaboration with universities or major users of water, such as DESO or COHIDRO might be required. The classification should be discussed with each River Basin Committee before its legislation.

In this Study, waters of upper stream near the intake points for existing and projected public water supply or irrigation, the waters are recommended to be classified as Class 1. Waters whose water quality may affect the source of domestic and irrigation water is recommended as Class 2 in principle. In case treatment process for public water supply is assured in terms of quality and quantity, the water can be Class 2. Other waters of insignificant use may be classified as Class 3 or Class 4. Special consideration can be recommended near the estuary of the Vaza Barris River from environmental concern, where waters should be classified as Class 7 (brackish water).

As for groundwater, the principles of the classification are same as those of surface water. Aquifers in Alluvium and Sergipe Basin have high potential, where intensive uses for domestic water occur or would occur. Those basins should be classified as Class 1, while aquifers for public water supply should also be classified as Class 1.

5.2.2 Hydrological Observation and Water Quality Monitoring

The hydrological observation and water quality monitoring is necessary to be implemented for water resources development and management. The assessment results should be published, preferably as annual reports. These reports are useful not only to administrative staff in charge of water resources management, but also users of water, including prospective users. The publication is also effective for the promotion of awareness on water resources in quantity and in quality of the people.

The plan of hydrological observation and water quality monitoring is proposed as follows:

(1) Meteorological Observation Network

The meteorological observation network in Sergipe could be considerably improved by a more integrated approach to the collection, storage and analysis of data. In particular, the data collected by the federal agency INMET should be made available to the state organizations, as should the historical data for the observation stations at Propria, Aracaju and Itabaianinha. The data collected by COHIDRO and CODEVASF at their respective irrigation projects should also be incorporated into a statewide observation network.

In terms of coverage, the Agreste region of Sergipe is quite well represented with three COHIDRO stations and two INMET meteorological observation stations. However, the coastal Leste region and the Semi-Arido region of the interior have insufficient stations for the effective monitoring of the meteorological parameters necessary for water resources assessment. In addition, long term meteorological data is essential for all aspects of planning and development across Sergipe and therefore the following recommendations can be made.

- **Sub-Umido (Leste) Region:** Currently, the only meteorological stations in the coastal Leste region are those in Aracaju (INMET and Aeronautica at the airport) and the CODEVASF irrigation project at Betume. Additional stations are recommended at Japaratuba and at Estancia.
- **Agreste Region:** The existing COHIDRO and INMET stations provide adequate coverage of the Agreste region. There is also an existing SEPLANTEC station at Nossa Senhora das Dores which is no longer operational (since 1996) but for which some historical data is available. It is recommended that this station be fully rehabilitated and returned to operation.
- **Semi-Arido (Sertao) Region:** The Semi-Arido region is particularly poorly represented with only the COHIDRO station at the California irrigation project near Caninde do Sao Francisco providing meteorological data for this region. Additional stations are recommended at Nossa Senhora de Gloria, Porto da Folha and Poco Verde in order to provide reasonable data collection across the region.

Table-5.5 Additional Meteorological Stations Necessary

Region	No.	Location	Comments
Sub-Umido (Leste)	1	Japaratuba	
	2	Estancia	
Agreste	3	N. Sra das Dores	Rehabilitation
Semi-Arido (Sertao)	4	Porto da Folha	
	5	N. Sra de Gloria	
	6	Poco Verde	

The following data should be collected on a daily basis – rainfall, temperature (maximum, minimum and mean), relative humidity, evaporation, wind speed and solar radiation. Readings should be taken at least twice per day.

(2) Rainfall Observation Network

Prior to 1991, SUDENE was responsible for the operation of most of the rainfall gauges in Sergipe as part of the Northeast Basic Hydro-Meteorological Network. Daily data from 59 stations is available on database for the period until 1984 and monthly data was also published in book format as "Monthly Rainfall Data in the Northeast – Sergipe" by

SUDENE in 1990. However, since 1991, SUDENE has not collected the daily rainfall data. The main agency responsible for the collection of rainfall data is now EMDAGRO which operates or collects data from 44 rainfall stations across the state. EMDAGRO has already made an assessment of the current situation regarding rainfall stations across Sergipe and the work required to bring the existing network to a satisfactory condition. This assessment of work required can be summarized as follows:

1) Re-evaluate and survey the co-ordinates and condition of all EMDAGRO rainfall stations and ensure that all are fully operational.
2) Re-evaluate and survey the co-ordinates and condition of all rainfall stations operated by other agencies.
3) Purchase of 35 complete rainfall gauges for installation at locations identified as necessary in the assessment.
4) Purchase of 5 complete rainfall gauges as spares.
5) Transfer of remaining SUDENE rainfall stations to EMDAGRO responsibility.

The above findings can be endorse by this Study, in particular the necessity to undertake a thorough survey of all existing rainfall stations including the determination of GPS co-ordinates. At a minimum, the main recommendation would be to re-establish the 59 stations included in the SUDENE database and ideally there should be one rainfall station in each of 75 municipalities in Sergipe.

WMO recommends a minimum density of 1 rainfall station per 600-900 km^2 for flat areas of tropical mediterranean/temperate climate regions, rising to 1 station per 100-250 km^2 for mountainous areas. Assuming a network of 75 rainfall stations, the average density in Sergipe would be 1 station per 300 km^2, which is deemed acceptable within the WMO guidelines.

The current system of data collection operated by EMDAGRO needs to be improved and expanded to include the input to computer of daily rainfall data. At the moment, only monthly totals are input to computer at the EMDAGRO headquarters in Aracaju. It is essential that the daily data is also input to computer and the original paper forms should also be archived as a back up.

(3) Surface Water

(a) Hydrometric Observation Network

The current hydrometric observation network is not adequate for the monitoring and analysis of surface water resources of the State. The existing hydrometric observation network in Sergipe comprises the 12 flow gauging stations operated by ANEEL on the six main river basins and the 89 flow measurement points monitored by DESO on smaller rivers, mainly in the Leste coastal region. River discharge is measured at the ANEEL stations for long-term monitoring of surface water resources whereas DESO is principally interested in available discharge for water supply. In addition, CHESF operate four flow-gauging stations on Sao Francisco River for the monitoring of flows for hydropower purposes.

In order to improve the observation network, it is necessary to increase the number of flow gauging stations as well as improve the frequency of discharge measurement. Currently, river water levels are monitored on a daily basis by gauge readers employed to read staff

gauges. It is recommended that automatic water level recorders (AWLR) be installed in order to provide continuous monitoring of variations in river water level. AWLRs should be provided at all the existing ANEEL and CHESF flow gauging stations. In addition, new flow gauging stations should be established to supplement the existing network. In particular, there is currently no gauging station on the main stream of Piaui river – a suitable location would be at the existing weir upstream of the main BR-101 road bridge in Estancia. Monitoring of the main tributaries is also recommended, preferably by AWLR. The proposed automatic water level recorder stations are listed in Table-5.6.

There is currently no water level monitoring at the DESO flow measurement points and discharge measurement is only carried out on an intermittent basis. It is recommended that staff gauges are installed at all flow measurement points and that gauge readers are employed to read the staff gauges on a daily basis. This comment also applies to the flow measurement points previously monitored by COHIDRO.

Table-5.6 Proposed Automatic Water Level Recorders (AWLR)

River Basin	No. of AWLR	Station Names	Comments
Sao Francisco	4	Piranhas, Pao de Acucar, Traipu, Propria	Existing CHESF stations
Japaratuba	5	Japaratuba, Faz. Cajueiro, Faz. Pao de Acucar, Siriri, Rosario do Catete	Existing ANEEL stations
Sergipe	3	Santa Rosa de Lima, Jacarecica, Poxim	Existing ANEEL station (1) Proposed new stations (2)
Vaza Barris	4	Ponte SE-302, Faz. Belem, Salgado, Rch. Das Trairas	Existing ANEEL stations (2) Proposed new stations (2)
Piaui	3	Piauitinga, Piaui - Estancia, Araua	Existing ANEEL station (1) Proposed new stations (2)
Real	4	Faz. Tourao, Itabi, Jabiberi, Itamirim	Existing ANEEL stations (2) Proposed new stations (2)
Total	23	-	-

(b) River Flow Measurement

In addition to the water level monitoring described above, a program of regular flow measurement is necessary in order to establish discharge-rating curves for each of the flow gauging stations. For newly established stations, it is recommended that flow measurement be carried out on a monthly basis for the first two years in order to quickly gather data in both the dry and rainy seasons. Thereafter, flow measurement on average twice per year is sufficient to check the discharge-rating curve. If possible, flow measurement should also be undertaken during flood flows in order to verify the rating curve at high discharges. Water quality sampling and sediment sampling should also be undertaken at the same time as the flow measurement.

Survey of the river cross section at the flow gauging station is also necessary on a regular basis, preferably at least once every five years. Checking of staff gauges and AWLR levels relative to a fixed reference datum should be undertaken on an annual basis.

With the data collected in the measurement of the above, the following basic analyses is necessary by SRH/WA, namely 1) Preparation of discharge rating curve, 2) Calculation of discharge by station, and 3) Calculation of annual flow regime by station.

(4) Groundwater Monitoring

Over pumping must be regulated to prevent the groundwater disasters, such as 1) Groundwater table draw-down and drying up of wells, 2) Yield decrease and drying up of springs, 3) Water quality problem, 4) Sea water intrusion into aquifer in the coastal area, and 5) Land subsidence in the coastal area.

More than 1,000 wells are now being operated in Sergipe State. However, the actual situation is not clear. Therefore, current situation of wells/springs now in use must be surveyed to obtain information, such as locations, current yields, etc., and the survey results should be stored in a database. Then, the representative wells/springs should be selected as monitoring wells/springs referring to the well database, and the groundwater monitoring should be started. For this purpose, SRH should make the well database and select monitoring wells/springs, and users of wells/springs should carry out the groundwater monitoring. Groundwater monitoring should be carried out step by step as described below:

- **First Stage:** Database of wells/spring should be established. Wells/springs now in use should be surveyed to obtain basic information of wells/springs such as locations, current yields, etc., and the survey results should be stored in the database.
- **Second Stage:** Representative wells/springs should be selected as monitoring wells/springs referring to the well database. Users of the monitoring wells/springs should carry out the groundwater monitoring once a month as a rule and should report the results to SRH. The groundwater monitoring items are 1) Yield of wells/springs, 2) Groundwater level of wells, 3) Groundwater quality, and 4) Unusual deformation of buildings/facilities caused by differential ground settlement.
- **Third Stage:** In case of the groundwater disasters, adequate countermeasures should be formulated by SRH based on the analysis of the groundwater monitoring results. The procedure of this stage is; Area of the groundwater disaster should be specified at first, then more accurate and detailed data should be collected by strengthened monitoring network system in the area. Yield of individual well must be regulated considering the allowable yield, which should be decided based on the analysis of the groundwater monitoring results. The effect of the regulation should be examined by the groundwater monitoring.

(5) Water Quality Monitoring

Currently no regular water quality monitoring is conducted in Sergipe. A system of regular monitoring of water quality coupled with quantity assessment should be established and implemented to assure present and future availability of water resources. Remedial or improving actions should be taken when water quality deterioration is detected by the regular monitoring.

As a first step, locations for the monitoring should be identified. In principle, all waters classified as Class 1 at around location of 56 sources of surface water (exclusive main stream of the Sao Francisco River) and 80 sources of groundwater should be monitored.

As a second step, items of regular monitoring should be determined. Initially, monitoring of all items (11 items of basic conditions, such as floating materials, oil/grease, substances of taste/odor, artificial dyers, subject of objective deposit, coliforms, BOD, DO, and

Turbidity, Color, pH, and 66 items of harmful substances) should be carried out. In addition, some items such as Electric Conductivity (EC), Suspended Solid (SS), Ca or K or other items should be examined, considering the present and future uses, conveniences for monitoring, as well as the industrial process or household chemicals used along the waters. After initial monitoring, items for regular monitoring should be selected based on the results of the initial monitoring. Candidate items for regular monitoring are shown in Table-5.7 below.

Thirdly, monitoring organization should be established. For regular monitoring, collaboration with DESO and major industrial and commercial users is inevitable for efficient monitoring. A contract or an agreement with DESO with explicit payment is necessary, except the cases that DESO carries out the same monitoring for their own requirement or responsibility. Conditions of monitoring should be included in the grant of water rights especially for major industrial and commercial users of ground water. As for monitoring at the sources of irrigation water, collaboration of entities in charge of dam operation, such as WA, is required since most of the sources are dam reservoirs.

Analyses and database management should be conducted by ADEMA and SRH. Establishment of a laboratory in ADEMA is necessary. Analyses on items for basic conditions (11 items in the CONAMA Resolution), can be made by handy analyzers distributed to branch offices of DESO. Analysis of other items should be made in the laboratory in ADEMA.

Table-5.7 Required Items for Regular Water Quality Monitoring

Items	CONAMA	Once a month	Twice a year	Items	CONAMA	Once a month	Twice a year
pH	6.00 - 9.00	*		Ba (mg/L)	1.0		*
DO (mg/L)	(1) > 6.0 (2) > 5.0	*		B (mg/L)	0.75		*
BOD (mg/L)	(1) < 3.0 (2) < 5.0	*		Cd (mg/L)	0.001		*
Turbidity (UNT)	1) 40 UNT 2) 100 UNT	*		Pb (mg/L)	0.03		*
Conductivity (µS/cm)	NO LIMIT	*		Zn (mg/L)	5.0		*
Alkalinity Met. (mg/L)	NO LIMIT		*	Cu (mg/L)	0.02		*
Hardness ($CaCo_3$ mg/L)	NO LIMIT		*	Cr (mg/L)	Cr^6 0.05 Cr^3 0.5		*
Cl. (mg/L)	250		*	Sn (mg/L)	2.0		*
Na (mg/L)	NO LIMIT		*	SO_3 (mg/L)	NO LIMIT		*
Fe (mg/L)	0.3 (sol.)		*	F (mg/L)	1.4		*
Mn (mg/L)	0.1		*	Hg (mg/L)	0.0002		*
SO_4 (mg/L)	250		*	Ni (mg/L)	0.025		*
Tot. diss. solids (mg/L)	500	*		PO_4 (mg/L)	0.25 (P)		*
Fecal coli (NMP/100mL)	1000		*	Ar (mg/L)	0.05		*
Total coli (NMP/100mL)	5000	*		CN (mg/L)	0.01		*
NO_3 (mg/L)	10.0 (N)		*	HCO_3 (mg/L)	NO LIMIT		*
Al (mg/L)	0.1		*				

5.2.3 Control of Effluent Discharge

Obligation of monitoring quality and quantity of effluent can be attributed to factories or industries. Legislative arrangement should be started with an initiative of SEMA and State Environmental Council. Conditions of the monitoring can be attached to the grants of water rights. For the enforcement of the obligation, items of regular monitoring by type of industry first, then by each of major factories should be carefully discussed taking account of the follows: 1) Amount of effluents, 2) Class of the waters which accept effluent, 3) Process used in the industry, 4) Possibility of regular monitoring, such as scale of the factories, costs for monitoring, availability of equipment and specialists or technician, etc.

For the industries up to medium-scale, especially, it is almost impossible to have a specialist for effluent monitoring. A system, by ADEMA or a federal organ, should be examined for licensing environmental auditors. A licensed auditor supervises the monitoring by the factory or monitor by himself/herself with a contract with the factory, and report to ADEMA or SRH. The contents of the reports should be included in the water resources database.

As for pollution control caused by agricultural activities, close cooperation with entities in charge of agricultural extension services not only for environmentally sound use of agricultural chemicals, such as fertilizers or toxic materials, but also economical use of them. Control of toxic agricultural chemicals, through strict obedience of the Federal Law No. 7803, would be a priority.

5.2.4 Regulation of Land Use for Water Resources Conservation

Change in land use may cause effects on availability of water resources in quality and in quantity, resulting changes in regional hydrological cycle as well as contamination caused by settlers or land users. Land use should be regulated, considering water resources conservation in quality and in quantity. Legal provisions should be prepared to regulate land use and development in terms of the followings.

(1) Forest Development, Preservation and Management

Although large scale forest development or preservation for water resources conservation might not be feasible in some areas in Sergipe mainly because of climatological conditions of the state, forest development and preservation after zoning of the areas for water resources conservation would be effective in the following two aspects.

< Areas for Groundwater Recharging >

Forest areas hold water, after rainfall in a while, and promote recharging water to aquifers near by. Recharging areas for aquifers of intensive use and of importance, such as those located near Aracaju, should be identified. In the identified areas, afforestation should be promoted and present forests should be preserved and well managed. Although devastating cutting and extensive use of fuel trees or charcoal production should be prohibited, all forestry activities in the identified areas are not necessarily restricted, since impacts on recharging capability of well managed forestry might be little. In the identified forest, fire protection is important. Burning vegetation in the identified forest as well as the area near the forests should be prohibited or strictly controlled. Compensation for restricted land use or forestry activities can be funded from collected fees in water rights granting. Fees for ground water use in the identified areas can be set to cover the compensation.

< Forest Belt along Reservoirs and Rivers >

Forest belts along courses of water, as provided in the Forest Code, should be developed and preserved as far as possible, to preserve the water quality and to prevent sedimentation in reservoirs and rivers. Slopes along reservoirs should be afforested, while width of forest belts along rivers can be determined according to the topological and climatological conditions.

(2) Restriction of Contaminating Activities near Water Sources

< Control of Solid Waste >

Illegal dumping along waters, especially near Class 1 and Class 7 waters, should be strictly prohibited. Inspection should be conducted by ADEMA or SRH. Waste disposal sites, of both domestic waste and industrial waste, should be located with sufficient distance from the areas of groundwater recharging and on the valleys of rivers classified as Class 1 and dam reservoirs, due to the possibility of contamination caused by leachate.

< Prohibiting Effluent to the Ground >

Special concern for groundwater contamination should be paid, because, once contaminated, remedial or recovery is almost impossible or highly costly. In the recharging areas for aquifers of importance, especially, all discharging of effluent to the ground should be prohibited. Even in other areas, some regulation specific to effluent discharge to the ground should be prepared with strict punishment against infracting activities. The infraction can be detected by regular monitoring.

5.2.5 Costs for Water Resources Management Programs

The programs proposed above will require the initial and operation costs as shown in Table-5.8. In the following estimation, operation costs of regulatory organs of direct administration, such as SRH, and those of autarchies, such as ADEMA, were not included.

Table-5.8 Costs for Water Resources Management Programs

Programs	Cost	Note
Classification of Waters	R$ 160,000	All of the five basins and sub-basins of the Sao Francisco River
Meteorological Stations	R$ 72,000	Construction of five (5) meteorological stations and rehabilitation of one (1) station
Rainfall Gauges	R$ 24,000	Purchase of 40 sets of complete rainfall gauges
River Flow Measurement	R$ 24,000	Cost for installment of AWLR system at an existing station
	R$ 30,000	Construction of a new station
	R$ 600,000	Improvement of river flow measurement network
	R$ 24,000	Annual cost for stations in total
Water Quality Monitoring	R$ 60,000	Establishment of a laboratory in ADEMA
	R$ 220,000	Water quality analysis
	R$ 36,000	Procurement of 10 sets of handy quality analyzers to DESO branch offices and dam operation offices
	R$ 210,000 per year	Operation of monthly monitoring and reporting, and sending samples twice a year

5.3 Operation and Maintenance Plan for Water Supply

5.3.1 Issues in Management for Water Supply

(1) Efficiency in Urban and Large Rural Water Supply

DESO employed 1,066 persons as of September 1998. Compared to water suppliers in Japan, it seems to be over staffed. Although covered population for an employee varies according to conditions, such as population density of the area for the service, there might be some room for rationalization, especially of administrative staff.

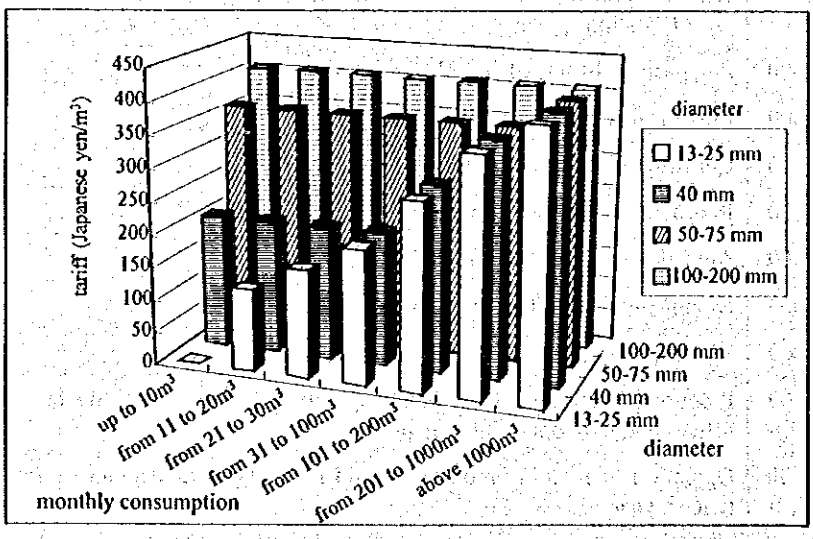
Besides costs in administrative divisions of DESO account for 36% of the operating expense and increase 2% annually, the administrative cost of Japanese suppliers remain near 10% of the total cost. Although there may be a difference in accounting methods, the gap between them seems to be very large.

(2) Tariff of Water Supply in Urban and Large Rural Areas

Current water tariff of DESO is mainly determined to cover the expense. Escalation of the tariff in the period between 1994 and 1997 was much faster than that of consumer price in Sergipe. Comparison of water tariff by DESO with that in Japan for small users shows that the tariff level by DESO seems to be high, considering the difference in purchasing power of the customers in the two countries, despite the difference in the service level (most of water through public supply is potable in Japan).

DESO's water tariff is set by purpose of use, such as residential, industrial, commercial and public use. Tariff for commercial, industrial and public users are comparatively high. There might be no clear reasons for the difference except higher affordability of those users or political pressures not to raise the residential tariff.

Currently, most of water suppliers in Japan have abolished the tariff setting by type of users and introduce tariff by diameter of connection pipes as shown below. The diameters show peak demand of the users and intention of their load to water supply capacity. There, allocation of facility costs or capacity costs could be more reasonable. Even in Japan, some municipalities take a dual tariff system, where tariff are set by diameter and by purpose of the use.



Note:
Actually, charge collections are made once in two months. The left figure is adjusted to monthly ones. (Source: Dep. of Water Works, Chofu Municipal Government)

Figure- 5.3 Tariff Structure of Chofu, City, Japan

(3) Small Rural Water Services

(a) Responsibility Allocation and Operating Entities

COHIDRO's services in small rural areas include construction of water facilities, operation and maintenance of irrigation, actions on agricultural lands, and mechanization. Actually in management of irrigated perimeters, not only operation and maintenance of irrigation facilities but also extension services are necessary and are carried out.

A merger of COHIDRO with EMDAGRO is discussed at present. Although the merger may contribute to integrated and efficient management and administration in agricultural development, it might not solve fundamental problems of the two companies. COHIDRO and EMDAGRO are so called companies of mixed-economy, having characteristics of both public entities and private companies. In the administration and management of public services, separation of regulatory and operational functions and succeeding responsibility allocation is required. Operational entities would better be corporatized only if the functions of the entities are suitable for *commercialization*. Generally, in pursuing efficiency of the public service, *corporatization* and *privatization* proceeds. However, most of the functions of EMDAGRO and COHIDRO seem not to have a nature of commercialization. Agricultural and rural extension services and researches are normally carries out at the level of "direct administration" or "autarchies".

(b) Cost Recovery of Small Rural Water Services

The COHIDRO hands over small rural domestic water supply facilities to local communities without monetary payment from the communities or users. In some cases, users pay some part of the salary of the person in charge for operation, and municipalities pay other operational costs. Although users' payment may vary, full cost recovery by tariff collection could not be found in Sergipe.

According to the data provided by COHIDRO on O&M expenses and tariff collection, only, 10% of the O&M costs exclusive of depreciation are covered by tariff collection. An old data shows that the tariff collection rate varied from 32% to 78%. Even in case the tariff is collected 100%, the collected tariff does not cover the operation expenses. It seems that COHIDRO does not intend to cover the costs by tariff collection, while CODEVASF actually achieve the cost recovery in many perimeters. It would be necessary for COHIDRO to change the management of irrigation projects, applying the cost recovery methods used by CODEVASF.

5.3.2 Proposal for Improvement of Management for Water Supply

(1) Improvement of Management Efficiency in DESO

Target of the efficiency improvement in the management of DESO would be to reduce the share of administrative expense to 20% by 2020 or not to increase the real value of administrative costs up to 2020 and to keep the total number of employee as current level or around 1,000 up to 2020. To achieve the above target, following measures can be proposed.

(a) Streamlining of Staff Allocation in DESO with Higher Motivation of Employees

To achieve targeted efficiency, cost consciousness of every employee is inevitable. Streamlining of the staff allocation and raising motivation of employees are common in the management of private business. DESO should introduce the management prevailing in the private companies.

DESO has to make annual objectives of sales, profits and tasks to achieve the objectives. Each directorate, department and section should have allocated tasks to achieve the norms and objectives with indicators to measure the attainment. Salaries and promotion of each member of the staff would preferably be determined by degree of contribution to the achievement of the norms or objectives. Although DESO has started management reform, and the reform will raise the motivation of employee, the necessity of the introduction of the above objective management seems to remain or the current management reform and the introduction will complement each other.

In response to the expansion of the operation of DESO, the staff in the administrative sections should move to the operational sections with enhanced efficiency in administrative sections, thus the total number of employees remains stable.

Reduction of times of tariff collection should be examined. Many of Japanese water suppliers collect the tariff once in two months. If financing cost of working capital for a month is less than the cost of tariff collection in a month, tariff collection once in two month will serve for improved efficiency, by reducing the personnel for tariff collection.

(b) Outsourcing and Restructuring

Outsourcing of some parts of its business done, is an effective measure to introduce competition in a monopolized sector like DESO, if its tender is open to all private sectors. To obtain the benefit of the competition, restructuring of the sections which currently carry out the tasks should follow.

Potential parts for outsourcing in addition to the present, would be metering and tariff collection, especially in large villages. Hiring part-time workers might also be an option. In urban areas, collaborated agreement with banks for tariff collection will help in improvement of efficiency. Specialized services, such as calculation of salaries to the employees, in addition to the security and office cleaning services contracted at present, can be contracted with private company if available.

Outsourcing of parts of operation in DESO's professional fields, such as operation of a treatment plant, may also promote efficiency by introducing competition in the monopolized business. However, introduction of this type of outsourcing has to be carefully examined, considering the following points. In case these points are cleared, outsourcing can be recommendable.

1) Possibility of succeeding restructuring: the outsourcing should be followed by restructuring, which may include firing or re-training some employees.
2) Capability of own efforts for efficiency: DESO, by itself, have and should have characteristics of a private company. DESO is an expertise for the services and could be a best competitor with experiences when incentives for efficient operation are properly given, such as yardstick tariff setting proposed below.
3) Costs of quality control: contracted private companies may operate with less cost with tendencies of less quality of the service that may cause serious affects to the society. Cost for inspection or quality control will increase.

Concession of water supply service in Aracaju is not simply recommendable because of the following consideration:

1) Aracaju is the most profitable area and if the concession of only this area is given to other entities, financial conditions of DESO may be worsened
2) In the metropolitan area, many of the large users may be located. Cross-subsidy between small and large users cannot work after the concession.

(c) Tariff Control

Meter installation at all or most of connections is a fatal prerequisite for equitable tariff charging and control. DESO is currently implementing meter installation program. The implementation of the program and further installation is very important in sense of proper tariff charging. Proper tariff setting requires the following procedure as shown in Figure-5.4. Strengthening the accounting system with enhanced cost analysis capability should firstly take place. Investigation on water use, such as peak demands or seasonal variation, should accompany. In some part of the formulation of the basic policy, such as extension plan and improvement plan, the roles of the regulatory organ, such as SESP or SEPLANTEC is important.

Basic principle of tariff setting is "long-term marginal cost pricing", where customers should pay the cost for their marginal use. The tariff for additional use of water should be set to cover additional cost for investment and O&M.

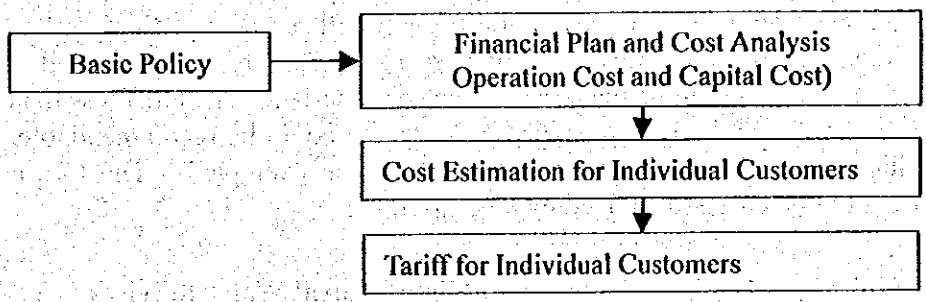


Figure- 5.4 Recommended Calculation of Tariff

Current tariff structure by purpose of water use is preferably changed to that by diameter, where reasonable allocation of capital or capacity costs is possible. Since diameter of connection pipes to residences are unified to 20 mm, the introduction of diameter tariff should start with large commercial and industrial users. Some period of preparation for the change is necessary to confirm that the diameter of current connections corresponds to the peak demand of users.

Basically, additional charge by volume can be set corresponding to the variable costs (flat tariff). However, small users, such as families with low income and small-scale industries should be provided the service with less charge, while large users should cover the incremental cost (marginal cost) and financial requirement for cross-subsidy. Higher tariff to the customers of large user can be effective for demand control, promoting recycle use and suppressing soaring capacity costs.
For the equitable tariff control, a deliberative committee should be organized to check and evaluate tariff proposals by DESO. A deliberative committee was established in late 1998, whose members consists of representatives from several secretariats of the State Government, and functions of checking DESO' tariff proposal can be fulfilled by the committee. It would necessary to analyze social and economic implication of the proposal by DESO and to give policies and guidelines on tariff setting to DESO. Adding members of representatives from customers to the committee is also recommendable.

It would be recommendable to establish a subcommittee for the remaining functions. Members of the sub-committee should be selected among professors or persons with knowledge of economic policy and management of water supply companies and representatives from associations of expertise. The sub-committee should submit evaluation report on DESO's proposal to the committee and issue drafts of policies and guidelines on the tariff setting.

Yard-stick tariff setting (theoretical competition) should be discussed in the committee. Introduction of yard-stick tariff setting can give norms and incentives to DESO for efficient provision of the service. Theoretical competition can be made with comparison with other state water supply companies. Although DESO has achieved medium level of efficiency in all state water supply companies in terms of efficiency, detail comparison will help improvement of the DESO's efficiency through yard-stick competition. Other state companies may also have the same inefficiency, international comparison would also help.

Social interests sometimes conflict with commercial interests which DESO may have during the course of its commercialization and privatization. Water supply for human consumption is one of the basic human needs. Social tariff might be necessary for the people in poverty. Generally affordability to pay for water is said to be 3-5% of family income. Social tariff should be set for the minimum use of volume to meet the basic requirements according to this affordability. Small users up to 5 m^3/month (30 liter/day/person x 5 person/family x 30 days = 4.5 m^3/month/family as civil minimum) with the least diameter could be the target of the social tariff. The tariff less than R$ 2 for a family in a month can be recommended. A system could be recommendable, where if some families can prove no income, the tariff may be exempted. The loss caused by social tariff could be cross-subsidized by large users.

(2) Establishing Management System of Small Rural Water Services

(a) Responsibility Re-allocation in Agricultural and Small Rural Management

The following functions of COHIRO and EMDARO should be attributed to *an autarchy*, while SAGRI should be strengthened to take the regulatory functions for formulation of agricultural development policy, supervising the following activities by the autarchy and carrying out actions for agricultural land by itself in coordination with Office of the State Prosecutor.

1) Agricultural research and development
2) Technical assistance and extension services to farmers
3) Assistance for agricultural crediting
4) Vegetable and animal sanitation
5) Technical and financial support to rural communities for operation of irrigation and rural water supply
6) Marketing information (not all marketing service)

Functions for water resources development of COHIDRO, excluding those for small rural water supply, should be transferred to SRH/WA as proposed in section 5.1. Drilling section of COHIDRO could be reformed as a private company or state-owned company with private participation. Mechanization should be transferred to private sector.

(b) Operating and Supporting Entities for Small Rural Water Supply

Basically, local communities, hiring one person in charge of operation, should operate water supply in small villages. However, local communities do not have enough knowledge and skills for establishing management system, and sustainable operation and maintenance. Technical assistance, including training of operating persons, periodical facility inspection, repair and replacement, is inevitable, and should be discharged by the autarchy proposed above.

(c) Tariff Collection and Financial Arrangement for Small Rural Water Supply

Operation and maintenance cost such as electricity, chemical, and salary of operating persons, excluding depreciation, at least, should be covered by tariff collection from the beginning. Gradually, the tariff collection should be enhanced in order to cover the depreciation cost, as reserve for replacement, and interest payment or other financing costs.

Operation costs should be paid by local community directly with instructions on book keeping by the autarchy, and the rest is preferably raised as reserve fund for repair and replacement. The fund should be managed by the autarchy for repair and replacement. In case that unexpected disorder occurs, repair or replacement can be paid from the fund. Even in that case, some part of repair or replacement cost should be charged to the community or operator, because full payment from the funds may spoil the intention for careful operation and maintenance.

From water use survey of this study, willingness to pay for safe and stable water supply for a person can be estimated as R$ 1.4/person/month. Although per capita charging is recommendable, charging by floor or residential area could be another option, if these indicators show the affordability to pay.

Unified tariff setting, despite the variation in operating cost, with cross-subsidy system should be examined by SAGRI because the per capita operation cost of water supply in some small villages or villages with desalination may exceed the affordability. Introduction of unified tariff may increase duties of the autarchy.

(d) Establishing Management System of Irrigation

Farmer's community or users association in each perimeter should manage operation and maintenance of irrigation facilities, in principle, with technical assistance by the autarchy through its extension network. The tariff should be set in order to fully cover operating costs and investment costs, except the cost for technical assistance by the autarchy. To attain the full cost recovery by tariff collection in irrigation projects, careful agronomic, economic and financial analysis is necessary in feasibility studies, which should be conducted by regulatory organ, i.e., SAGRI. Strengthening of SAGRI is necessary in this sense as well.

Water tariff for irrigation should be charged by volume of water used, from the viewpoint of water resources management. Payment to bulk water supplier, i.e., SRH or WA should be determined by volume. For the equitable demand control and proper water resources development, tariff setting and charging to individual farmers would preferably be charged by volume as much as possible where metering is feasible.

5.3.3 Cost Estimation of Operation and Maintenance of Water Supply Projects

Operation and maintenance cost (O&M cost) is estimated using unit costs per capacity or other equivalent parameter established based on the information presented by the related organizations. O&M cost for water supply and irrigation is estimated based on the data presented by DESO and CODEVASF.

The O&M cost consists of 1) Operation and maintenance expenses, 2) Commercial expenses, and 3) Administrative expense. The O&M cost at this stage of the Study does not include depreciation for the purpose of economic and financial examinations of this phase. O&M cost is divided into the three expenses for 1) personnel, 2) materials and others, and 3) energy.

(1) O&M Costs for Water Supply in Urban and Large Rural Area

< Pumping Station >

Correlation between O&M cost (R$/month) and capacity of pump station P (m^3/day) is obtained based on the data presented by DESO as follows:

- Personnel expenses: $OCP = 5{,}851.92 \times e^{2.1088E\text{-}5xP}$
- Other expenses: $OCP = 4{,}369.60 \times e^{2.1703E\text{-}5xP}$
- Expenses for energy: $OCP = 6{,}773.65 \times e^{2.7816E\text{-}5xP}$

< Water Treatment and Distribution >

Correlation between O & M cost (R$/month) and capacity of treatment plant P (m^3/day) is given by the analysis of the data presented by DESO as follows:

- Personnel expenses: $OCP = 8{,}061.51 \times e^{2.9264E\text{-}5xP}$
- Other expenses: $OCP = 15{,}114.3 \times e^{2.64575E\text{-}5xP}$
- Expenses for energy: $OCP = 0.0487672P + 1{,}253.88$

< Administration Cost >

The increment "with the projects" in the cost for general administration is estimated as the cost for general administration of the projects. Considering management improvement of DESO proposed in the previous section, no incremental cost is estimated. As for small rural water supply, administrative activities by the autarchy proposed in the previous section are assumed to be conducted with resources of current extension networks of COHIDRO and EMDAGRO. No increment is also estimated for the projects.

(2) O&M Costs for Small Rural Water Supply

Power of pump for standard design of well water supply system is given by the following expression by analyzing the correlation between the power of pump, P_P, and water supply volume per day, P, in the existing design for villages by DESO:

$$P_P = 0.0027919 \times P^{1.2631} \text{ (kW)}$$

Personnel expense is for one operator and is estimated to be 200US$ per month. Cost for desalinizer is 0.3 US$/$m^3$, which is presented by the Manufacturer, Perenne.

(3) O&M Costs for Irrigation Projects

O&M cost for irrigation is estimated at 4% of the investment cost, based on the results of estimation by a mission of FAO/World Bank to Brazil for similar type of irrigation projects to the proposed ones in the Study, referring "Projectos de Irrigacao: O Custo da Transformaca Social" by Ministry of Agriculture of Brazil.

5.4 Operation against Drought

(1) Conditions of Droughts

Drought potential in Sergipe is high in inland areas. Drought conditions or water shortage can be summarized as follows:

- At present, 65% of the rural population does not have public water supply schemes, depending their water supply on unstable and vulnerable rainfall collecting system. Water tank trucks of Civil Defense are dispatched frequently.
- In urban and large rural areas, water shortage occurs due to insufficient capacity of the facilities and unstable sources, and the water supply is often restricted.
- In the Master Plan, even in 2020, 15% of the rural population will not have public water supply schemes and water distribution by Civil Defense will still be an important measure in case of droughts.
- Although water supply in most of urban and large rural areas will be stable after 2020, water saving and restriction in water supply will be necessary in case of more severe droughts than the designed one except the areas whose water source depends on the Sao Francisco river or groundwater.
- Livestock breeding whose watering source depends on "aguadas" (watering ponds) is seriously affected by droughts, especially in inland areas.
- Rain fed agriculture is directly affected by droughts.
- Public water supply schemes whose water sources are boreholes will have a little damage by droughts.

(2) Proposed Measures against Droughts

In the following section, measures against droughts regarding domestic and agricultural water are proposed in order to make effective and efficient use of limited water for the period until stable water supply proposed in the Master plan are realized.

(a) Domestic Water

Against droughts, 1) water saving would be necessary first of all. In case further severe water shortage, 2) restriction of water supply should be conducted. Finally, when minimum requirement cannot be met, emergent water distribution should be carried out.

< Promotion of Water Saving >

For the promotion of water saving, information on the present and prospective available water volumes as well as on effective manner of water saving should be provided concretely and understandably to users. Campaigns for water saving should be conducted through the network of Civil Defense, while SRH and DESO should provide the information for the effective campaigns.

Introduction of seasonal tariff in public water supply will enable efficient use of limited water in dry seasons, giving incentives for economically feasible water saving. Increment of the tariff in dry seasons should be set as the saving in damages by re-allocation of a unit volume of water to more economic types of water use. The seasonal tariff increment should not be applied to the basic charge (up to $10m^3$/month for residential use).

< Restriction of Water Supply >

There is an example of uneven restriction of water supply by areas within an integrated water supply system, such as that occurs in Aracaju. In order to reduce overall social and economic loss caused by water supply restriction, aerial difference in the restriction should be avoided within an integrated water supply system.

Besides, bottlenecks in public water supply schemes at times of droughts should be analyzed. The parts to be improved or enhanced in the processes of the system should be clarified to minimize the restriction of water supply at times of limited flow of the river in terms of quantity and quality. The measures for the improvement should be examined whether the measure is feasible for the period up to the project implementation proposed in the Master Plan and whether the measure is effective even after the project implementation of the Master Plan.

< Emergency Water Distribution >

Although planning for efficient emergency water distribution would be difficult, further efforts should be placed for the planning. Information should be collected and accumulated by analyzing the data on distribution of villages and rural population, available volume of water at times of droughts or in dry seasons in the rural areas through current water facilities, and past and prospected damages caused by droughts. All of the sectors related to water resources management and water supply in small rural areas, such as SRH/WA, the autarchy (COHIDRO and EMDAGRO) should collaborate with Civil Defense for the planning of efficient emergency water supply.

Corresponding to development of public water supply schemes in the areas neighboring to the areas where the water supply is seriously affected by droughts, the emergency water distribution can be more efficient, especially in case the developed scheme has water source from boreholes. Water can be distributed from the developed schemes to neighboring areas. In case of some severe droughts, the water supply in the developed schemes can be restricted for the emergent distribution. Collaboration for better distribution programs should be conducted by Civil Defense, and the related entities mentioned above. When the cost recovery is achieved in the developed water supply schemes, compensation financial arrangement is required.

(b) Agricultural Water

Like domestic water, water saving in irrigation should be promoted for the purposes other than anti-drought measures. In the following section, measures against droughts in water supply for livestock breeding and rain fed agriculture, which are vulnerable to droughts, are discussed.

< Livestock Breeding >

Livestock breeding is a kind of economic activity. However, livestock is inevitable to sustain lives of people and is the important asset of the farmers. Livestock breeding should not be discussed only in economic terms. Water use for livestock watering has been given a higher priority than other economic activities since the Water Code of 1934. Livestock water should be positioned in water allocation policy at a place between those for human consumption and for economic activities, such as other agricultural activities.

DESO has installed taps on the pipelines of some integrated water supply system, and supplied water in emergent cases to livestock farmers with some fee collection. The emergent tap installation should be applied as far as technically possible on the water pipelines to be constructed in the future. It might be difficult for small-scale livestock farmers to take these services with payments for them. Fund raising by groups of small-scale farmers should be promoted for them to apply this service.

Besides, technical assistance for anti-drought measures or drought resisting livestock breeding should be enhanced. Loan programs with low interests or partial subsidies for borehole drilling or other anti-drought measures by groups of small-scale farmers should be examined. However, in case the measures are not economically feasible, whose economic internal rate of return are less than 5%, these measure should not be conducted or encouraged, and it would be better to promote adequate scale or manner of livestock breeding suitable to the climatological conditions of the area.

< Rain fed Agriculture >

Agriculture is also a kind of economic activity. Farmers should take risks of droughts in principle. However, small-scale farmers do not have resources, especially those for capital investments. Supplements to the lack in technical and financial resources of the small-scale farmers would be good programs or projects. Loan programs for borehole drilling or other anti-drought measures by groups of small-scale farmers can be recommended. Technical assistance for provision of information and guidance is important for the farmers to examine the risk taking. Information on risks of droughts, drought resisting crops and methods of the cultivation should be given to the farmers. Collaboration with EMBRAPA is inevitable.

(3) Accumulation and Dissemination of Information on Droughts

Accumulation and dissemination of information on droughts is very important for effective and efficient operations against droughts. Data on i) distribution of villages and population, ii) current conditions of agriculture and its drought resisting capability, iii) water supply capacity of the existing water facilities at times of droughts, iv) records of past restriction of water supply and emergent water distribution, v) degrees or amounts of damages caused by past droughts, vi) available water resources in terms of quantity and quality at times of droughts should be collected, analyzed, assessed and disseminated. These data seems to scattered in DESO, COHIDRO, EMDAGRO, ADEMA, Civil Defense or some federal agencies. These data and information should be collected in the database of SRH/WA as a part of information system of water resources management. Studies on damages caused by droughts will be necessary.