CHAPTER 1 MASTER PLAN OF WATER RESOURCES DEVELOPMENT

1.1 General

1.1.1 Objectives of the Master Plan

Toward the target year of 2020, a plan of water resources development and management, which is a state vision from the water sector, is proposed through sustainable water resources development for the purpose of securing stable life of the state people. The objectives of the plan are set as follows:

1) To supply clean and sufficient water for the state people through the public water supply system.
2) To supply industrial water through the public water supply system for the growth of manufacturing industries.
3) To supply irrigation water to agriculturally potential land for the achievement of high productivity.
4) To maintain environmental quality through sustainable water resources development.

1.1.2 Principal Policies for Preparation of Plan

(1) Plan Units and Composition of Plan

The Master Plan is to be formulated by river basins and consists of water resources development and supply for municipal/industrial water and irrigation water. Table-1.1 shows river basins and micro-regions in Sergipe State.

Table-1.1 River Basins and Micro-Regions in Sergipe State

River Basin / Micro Region	S. Francisco River Basin	Japaratuba River Basin	Sergipe River Basin	Vaza Barris River Basin	Piaui River Basin	Real River Basin	Total
Area (km^2)	7,276.3	1,722.0	3,673.0	2,559.0	4,262.0	2,558.0	22,050.3
Composition (%)	33.0	7.8	16.7	11.6	19.3	11.6	100.0
(01) S. do Sertao do S.F.	4,899.6	120.6	435.8	—	—	—	5,456
(02) Carira	—	—	974.7	908.5	—	—	1,883.2
(03) N. S. das Dores	320.4	376.7	571.7	—	—	—	1,268.8
(04) Agreste de Itabaiana	—	—	439.4	666.4	—	—	1,105.8
(05) Tobias Barreto	—	—	—	135.8	474.6	1,450.2	2,060.6
(06) Agreste de Lagarto	—	—	—	208.8	1,145.6	136.5	1,490.9
(07) Propria	1,014.9	—	—	—	—	—	1,014.9
(08) Cotinguiba	—	570.1	188.1	—	—	—	758.2
(09) Japaratuba	1,011.4	423.3	—	—	—	—	1,464.7
(10) Baixo Cotinguiba	—	220.1	516.9	—	—	—	737.0
(11) Aracaju	—	11.2	513.5	334.6	—	—	859.3
(12) Boquim	—	—	—	—	1,079.6	816.8	1,896.4
(13) Estancia	—	—	32.9	304.9	1,562.2	154.5	2,054.5

(2) Water Demand Projection

Concerning municipal water demand, the service level improvement demand refers to the demand made necessary by increase of per capita consumption and supply rate, resulting in improved living standards. The population increase demand is necessary to gauge demand for the possible cases where population movement from rural areas to the cities continues and urban population concentration reaches a peak.

Industrial water demand and agricultural water demand are strategic water demands concerned with economic vitalization. Since this is demand for water needed to achieve the correction of regional disparities in the state and the mitigation of poverty (important issues in water resources development projects), it is necessary to strike a balance with the long-term development plans and industrial development plans.

In this Study, the strategic scenario, in which population and industry was redistributed in consideration with decentralization, is adopted for the master plan.

(3) Water Resources Potential Projection

The water resources to be targeted are surface water and groundwater within Sergipe State. Surface water to be targeted for development refers to the waters of the six rivers that flow through Sergipe State, i.e. Sao Francisco River, Japaratuba River, Sergipe River, Vaza Barris River, Piaui River and Real River. Sao Francisco River, which is a major river flowing through seven states, is the most stable water resource of the said rivers. Water quality, especially saline contamination, shall be taken into account for water resources development.

Although groundwater can not be expected to provide as much water potential as surface water, it is a cheaper and more convenient water source. Groundwater sources could be made use as the domestic water for small and medium towns, and moreover it could complement surface water sources for urban and large rural cities.

(4) Development Facility Plan

Concerning surface water development facilities, examination shall first be carried out on the plan for water conveyance from Sao Francisco River, which possesses the most stable and abundant potential. Xingo Dam, located in the northern tip of the state, is a promising intake point that allows water to be supplied over the widest possible area. Regarding the other rivers, intake weirs, dams, reservoirs and other development facilities shall be examined.

In districts which cannot be covered by the above water conveyance plan or intake weir, dam and reservoir plans, the appropriateness of groundwater use shall be ascertained. Concerning groundwater that possesses high salt concentration, the feasibility of using desalination to improve water quality shall be examined.

(5) Water Resources Management Plan

An important factor in water resources development and management is the achievement of an appropriate distribution of limited water resources to each consumer sector and the proper operation of the distribution system. In view of this, the following measures are required:

- Setting up of a system for coordinating the interests of each consumer sector (public water supply, power generation, industry, tourism, environment, etc.)
- Cost recovery and demand control through pricing
- Participation of users and residents, and decentralization in the area of water resources management and development
- Institutional development for the implementation of multi-purpose projects

1.2 Future Water Demand Projection

1.2.1 Future Socio-economic Framework

In Sergipe State, the 1996 census population was 1.62 million or 1.03% of the national population. The average growth rate of the state population in 1990's was 1.7% with higher average 2.6% in the urban area. Meanwhile, the population in the rural area was decreasing. The state GRDP in 1995 (in 1998 market prices level) was 4.4 billion or 0.55% of the GDP in Brazil. This GRDP is composed of 1st industry:12.4%, 2nd industry: 30.2% and 3rd industry: 57.4%. GRDP in Sergipe State grew at a rate of 1.0% per annum on average for six years (1990 - 1995), while the annual average GRDP growth rate of 3rd industry in the urban area was higher (3.5%) due to the high population growth. GRDP per capita (in 1998 market prices level) was R$2,770 which was only 54% of the national GDP per capita (R$5,160).

The Sergipe State is composed of 75 municipalities. These municipalities are divided into 13 MRH (Homogeneous Micro-Regions: similar characteristics in natural and socio-economic conditions). The present regional socio-economic framework by MRH is summarized as follows.

- Concentration of the state's population for central region (Grande Aracaju) composed of MRH-Aracaju and MRH-Baixo Cotinguiba is high and reaches about 42% of the state's one. Moreover concentration level of 2nd & 3rd economic sector's GRDP for the same region is very high level and reaches about 75 % of the state's one.
- Difference of the GRDP per capita among MRHs is very wide. Three MRHs which have regional core cities, namely MRH-Itabaiana, MRH-Lagarto and MRH-Estancia, have approximately from 35% to 40% of GRDP per capita of the central region. And other MRH's GRDP per capita is estimated reaching only from 10% to 20% of the central region's one.

To estimate future water demand, it is necessary to decide the future socio-economic framework. The main factors: state population and GRDP to decide the future socio-economic framework of the Sergipe State are obtained as follows.

- SUPES in SEPLANTEC provided population projections for the state with a breakdown of its municipality level during the period 1990 to 2010 in the 1996 annual publication. These projections were based on the result of the 1991census. In this study, the future population is projected on the basis of the 1996 census results, applying the method of the SUPES projection. The projected state population in 2020 is 2.78 million and the growth rate is 2.3% on average between 1996 and 2020.
- Official GRDP projection is not available, although the report of "Plano Purianual 1996-1999, Governo de Sergipe" tried to give the projection. Only the national development plan named "Perennial-Year Plan 1996-1999, Message from National Congress" proposed the target growth of 4.6% per annum on average during the planning period. The plan, however, presents the projections only until the year 1999. After that, no projection scenarios were suggested in any of the development plans, at present. Therefore, GRDP in the future are estimated on the following assumptions. Till the year

2000, GRDP of the state will increase at the same growth rates (5.0%) as GDP's growth after 1997. Beyond the year 2000, GRDP is assumed to keep the same rate of 5.0%, in order to alleviate the economic disparity between the national average and state level. GRDP by Sector: Agriculture Sector will be assumed to grow at the rate of 1 % per annum after 1997. The annual growth rate of industrial sector and services sector after 1997 was estimated as 5.36 % in average.

- By 2020, GRDP of the state will reach to R$15.0 billion at 1998 constant prices. It is 3.4 times of that (R$4.4 billion) in 1995. Thus, it accounted for 0.8% in Brazil, which become larger than the percentage (0.55%) in 1995. GRDP per capita is estimated at R$5,400 in 1998 constant prices. It is 1.95 times of that (R$2,770) in 1995 and 58% of the national average, which become larger than that (54%) in 1995. Thus, the regional disparity could shrink and the people's lives would get closer to the national level for this period.

On the basis of the future population and GRDP obtained as mentioned above, the two scenarios: 1) Trend Scenario and 2) Strategic Scenario for future socio-economic framework are proposed to estimate future water demand. Summary of the scenarios is shown in Table-1.2. Refer to Figure-1.1. For the formulation of the master plan, Strategic Scenario is employed due to the following reasons.

- Prospected high level of concentration of population (42% - 48%) and economic activity (GRDP 75% - 80%) to the central region estimated by Trend Scenario has quite a possibility which break out the new problems regarding to social area and environmental area. And it needs a large amount of investment to solve these problems.
- Although the rise of GRDP per capita in central region is estimated to be about R$3,700, those in regional core cities and other areas might range from R$2,200 to R$300. It means that socio-economic disparity among the regions would become larger.
- A harmonized development of the state is expected with a full use of water resources, human resources and other natural resources. From these viewpoints, the decentralized progress is desirable.

Table-1.2 Scenario for Future Socio-economic Framework

Items	Trend Scenario	Strategic Scenario
Feature	Scenario drawn under the assumption that the present socio-economic framework will continue up to the target year without any change	Scenario drawn on the policy of decentralization to alleviate the foreseeable problems such as over-concentrated situation of population and economic activity in the central region, and to alleviate the large socioeconomic disparity among the regions
Population	<<No Change>>	<<No Change>>
GRDP	<<No Change>>	<<No Change>>

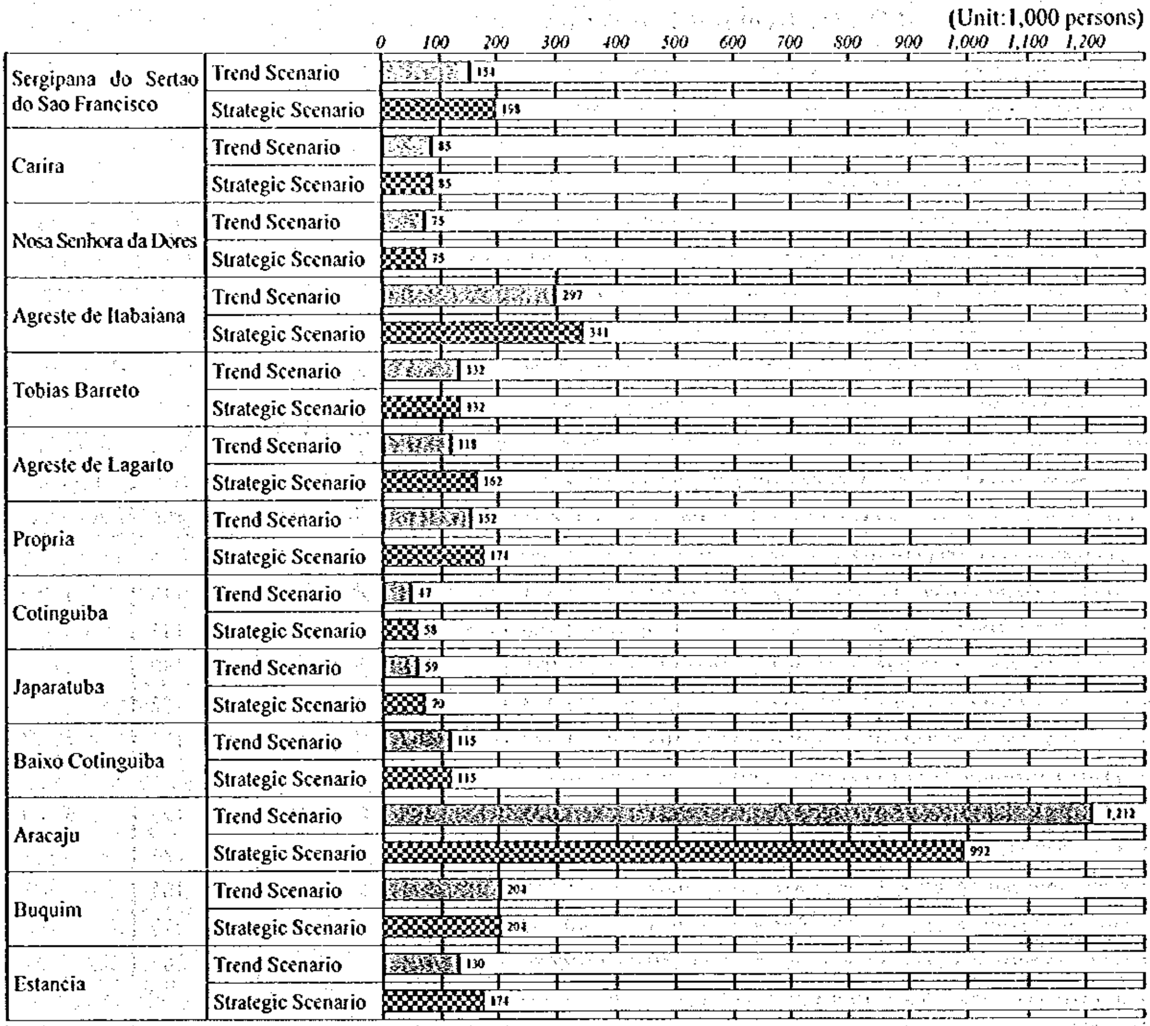


Figure-1.1 Population Projection in 2020 by Micro-region

1.2.2 Future Water Demand

(1) Domestic Water Demand Projection

The future water consumption rate was projected based on the actual consumption data of DESO in 1997. The peak level of the year was multiplied with 125% considering the water supply restriction in the same year. Thus the projected water consumption rate was set as shown in Table-1.3. The consumption rate of public tap system in small rural area was set at 70 litters/capita/day. The whole water demand of the state by strategic scenario is estimated at 433,000m^3/day.

Table-1.3 Projected Domestic Water Consumption Rate

Unit: litters/capita/day

Region	Residential	Commercial	Public	Total
Aracaju	155	20	15	190
Urban Area	135	13	12	160
Large Rural Area	100	8	12	120
Small Rural Area	70	—	—	70

(2) Industrial Water Demand Projection

The industrial demand in 2020 is estimated at 668,500 m^3/day, showing 1.5 times of domestic water demands in 2020 by strategic scenario.

(3) Irrigation Water

Presently, nine irrigation projects are under the operation and total water supply volume for the irrigation amounts to 1,043,300m^3/day. However, the irrigation water demand is estimated to increase to the volume of 1,850,800m^3/day by 2020 due to the proposed eight irrigation projects in the Mater Plan.

Table-1.4 Summary of Future Water Demand Projection

Items	River Basins	S. Francisco River Basin	Japaratuba R. Basin	Sergipe R. Basin	Vaza Barris River Basin	Piaui R. Basin	Real R. Basin	Total or Average
(1) Population (1000 persons)								
- 2000	*Trend Projection*	232	97	841	168	294	118	1,750
- 2010	*Trend Scenario*	266	116	1,106	203	331	141	2,163
	Strategic Scenario	302	124	1,026	210	361	140	
- 2020	*Trend Scenario*	332	147	1,494	253	380	172	2,778
	Strategic Scenario	396	163	1,327	267	453	172	
(2) GRDP (Million R$ in 1998 Constant Price)								
- 2000	*Trend Projection*	352	331	3,907	485	460	125	5,660
- 2010	*Trend Scenario*	524	532	6,523	766	701	174	9,220
	Strategic Scenario	828	662	5,858	744	763	165	
- 2020	*Trend Scenario*	763	983	10,868	1,040	1,093	273	15,020
	Strategic Scenario	1,262	1,080	9,680	1,194	1,538	265	
(3) GRDP per Capita (R$ in 1998 Constant Price)								
- 2000	*Trend Projection*	1,520	3,400	4,650	2,890	1,560	1,060	3,230
- 2010	*Trend Scenario*	1,970	4,590	5,900	3,770	2,120	1,230	4,270
	Strategic Scenario	2,740	5,340	5,710	3,540	2,670	1,180	4,270
- 2020	*Trend Scenario*	2,300	6,690	7,270	4,110	2,870	1,590	5,400
	Strategic Scenario	3,190	6,610	7,300	4,460	3,390	1,540	
(4) Water Demand (1000m^3/day)								
<Domestic Use >								
- 2000	*Trend Projection*	31.2	13.5	144.3	23.4	39.5	15.7	267.7
- 2010	*Trend Scenario*	37.2	16.6	190.3	29.0	45.3	19.0	337.4
	Strategic Scenario	42.9	17.8	174.6	30.1	50.1	18.8	334.3
- 2020	*Trend Scenario*	48.0	21.2	256.3	36.9	52.8	23.5	438.7
	Strategic Scenario	58.2	23.9	223.5	39.2	64.5	23.5	432.8
<Industrial Use>								
- 2000	*Trend Projection*	8.2	18.1	165.0	16.6	28.7	0.7	237.4
- 2010	*Trend Scenario*	13.7	30.9	278.5	29.7	46.7	1.3	400.8
	Strategic Scenario	20.2	32.5	261.4	33.7	51.7	1.3	
- 2020	*Trend Scenario*	22.9	52.0	464.0	52.2	75.2	2.2	668.5
	Strategic Scenario	42.6	56.8	411.8	60.8	94.3	2.2	
< Irrigation Water>								
- 1998	*Current*	811.4	-	26.1	108.5	55.8	41.5	1,043.3
- 2020	*Estimate*	2,294.9	-	120.8	360.1	76.7	41.5	2,894.1

1.3 Water Resources Potential

1.3.1 Surface Water Potential

Surface water potential for the six rivers in Sergipe state was evaluated from the basin main rainfall and flow regime analysis for each river basin. Reference points were chosen and the main river basins were divided into sub-basins based on major tributaries or relevant landmarks such as bridges.

(1) Basin Mean Rainfall and River Flow Analysis

Of the 59 rainfall gauges included in the SUDENE database, 29 were selected for use in the water resources assessment, based on the availability of data and distribution of the stations. Thiessen Polygons were drawn and Thiessen Coefficients were measured for each of the reference points. Basin mean rainfall was then calculated for the sub-basins using the average annual rainfall data for the 30-year period from 1968-1997.

Flow regime analysis was undertaken using the historical data from the 12 ANEEL river flow gauging stations. The discharge at each reference point was then calculated from the known discharge at the gauging stations based on the ratios of catchment area and basin mean rainfall. For each reference point, the average, low flow and drought conditions were calculated.

(2) Surface Water Potential

There are several possible definitions of surface water potential. The maximum potential is based on the average flow conditions and assumes that flows in the wet season can be stored until the dry season. A more practical definition is based on the low flow condition, for example the average minimum 7-day flow, and corresponds to the potential that can be achieved without the construction of storage facilities. In Brazil, the Q(7,10) indicator is used as the criteria of low flow -- that is, the 10-year return period minimum 7-day flow. Surface water potential was calculated from the flow regime results at the most downstream reference point (river mouth). The results based on annual average flows and low flows in both an average and drought year are presented for the six main river basins in Table-1.5.

Table-1.5 Surface Water Potential

River Basin	Average Flow (m^3/s)	Annual Potential (MCM/yr)	Ave Min 7-day Flow (m^3/s)	Annual Potential (MCM/yr)	10-yr Min. 7-day Flow (m^3/s)	Annual Potential (MCM/yr)
Sao Francisco	1,780.00	56,134.0	1,640.000	51,719.0	1,279.000	40,335.0
Japaratuba	10.60	334.3	1.129	35.6	0.215	6.8
Sergipe	13.84	436.5	1.213	38.3	0.210	6.6
Vaza Barris	15.64	493.2	1.393	43.9	0.492	15.5
Piaui	22.92	722.8	2.074	65.4	1.336	42.1
Real	20.46	645.2	2.031	64.0	0.437	13.8

Note: Average Flow : Annual average flow at downstream Ref. Pt. (river mouth)
Ave. Min 7-day Flow : Average 7-day minimum flow at downstream Ref. Pt. (river mouth)
10-yr Min 7-day Flow : 10-yr return period 7-day minimum flow at downstream Ref. Pt.
(except Sao Francisco data at Propria ANEEL gauging station)

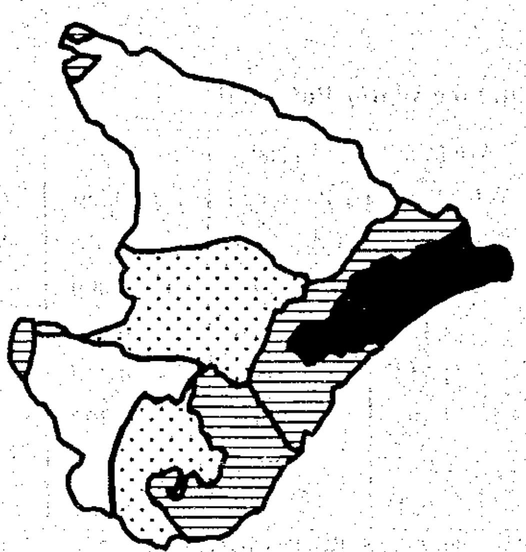
1.3.2 Groundwater Potential

Aquifers in Sergipe State are divided into 14 units. Groundwater development potential of the aquifers depends on three (3) factors: groundwater recharge, well capacity and groundwater quality. The groundwater development potential was analyzed based on Well Data-base analysis, field survey and numerical simulation. The result of the analysis is shown in Table-1.6. As shown in the table, there are great differences in the groundwater potential among the aquifers. The integrated evaluation of the groundwater development potential by aquifer which is decided by the three (3) factors, is shown in Table-1.6 and Figure-1.2. The total groundwater development potential of all the Sergipe State is estimated at 66.15 m^3/s (2,086 MCM/year) and at 46.07 m^3/s (1,453 MCM/year) if water quality is considered.

Table-1.6 Groundwater Development Potential by Aquifer

Aquifer	Groundwater Recharge	Well Capacity		Rate of Fresh water	Potential Rank of Aquifer
		Expected Yield	Success Rate		
	m^3/s	m^3/day	%	%	
Alluvium covering Sergipe	12.11	600	95	100	A-B
Alluvium covering Craton	2.34	600	95	100	B
Sergipe covered by Barreiras	21.31	140	80	85	A-B
Craton covered by Barreiras	5.97	70	85	90	B
Tucano Basin	1.08	100	60	60	B
Sergipe Basin	8.54	140	70	60	A-B
Caninde Belt	0.27	40	45	10	D
Poco Redondo Belt	0.33	40	45	10	D
Maranco Belt	0.18	40	45	10	D
Macurure Belt	2.34	40	60	15	D
Vaza-Barris Belt	5.05	80	75	40	C
Estancia Belt	2.27	50	70	50	D
Sao Francisco Craton	2.73	40	75	30	C
Itabaiana Dome Craton	1.62	70	75	35	C
Total	66.15	-	-	-	-

Note: 'Fresh water' means chlorine concentration (Cl) is less than 250 ppm.
'Rank'; A : High, B : Medium, C : Low, D: Very Low



Rank of Aquifer	Available Scale of Groundwater Development
A	Available for large urban water supply
B	Available for medium to small urban water supply
C	Available for small urban and large rural supply
D	Available only for small rural water supply. Desalinization is needed.

Figure-1.2 Integrated Evaluation of Groundwater Development Potential

1.3.3 Total Water Resources Potential

The total basin area of the six rivers in Sergipe is equal to over 671,000 km^2, or around 30 times the 22,000 km^2 area of Sergipe state. The average annual rainfall across the state is 1,090 mm/year or over 24,000 MCM/year. The total annual river flow volume passing through the state, or along the borders with other states, amounts to 58,765 MCM/year or 2.5 times the total annual rainfall. Of this total annual flow volume, 95% is the Sao Francisco river flow.

Groundwater is available widely throughout the state and the groundwater potential is equivalent to 8.7% of the annual rainfall or around 2,086 MCM/year. However, if water quality considerations are included, the good quality potential is reduced to 1,473 MCM/year.

For both surface water and groundwater, high salinity is a serious problem in the northern semi-arid areas of the state. In order to develop the water resources potential, it is necessary to fully consider the water quality aspects and to propose remedial measures or operation and maintenance methods to overcome these problems.

Table-1.7 Water Resources Potential in Sergipe State

Items \ River Basins	S. Francisco River Basin	Japaratuba R. Basin	Sergipe R. Basin	Vaza Barris River Basin	Piaui R. Basin	Real R. Basin	Total or Average
RIVER BASIN AREA (km^2)							
Total Basin Area	640,276	1,722	3,725	16,260	4,450	4,798	671,231
Area within State	633,000	0	52	13,700	188	2,240	647,180
Area out of State	7,276	1,722	3,673	2,560	4,262	2,558	22,050
ANNUAL RAINFALL							
- Basin Rainfall (mm/year)	—	1,281	1,112	1,233	1,315	1,237	1,090
- Annual Volume (Mm^3/year)	—	2,206	4,084	3,155	5,604	3,164	24,034
SURFACE WATER							
Average Flow (m^3/s)	1,780	10.60	13.84	15.64	22.92	20.46	1,863.5
Annual Runoff (Mm^3/year)	56,134	334	436	493	723	645	58,765
FLOW REGIME (m^3/s)							
Q-95 day (25%)	2,801	11.51	11.73	16.80	25.59	16.19	2,882.8
Q-185 day (50%)	1,990	4.36	5.01	8.64	13.19	7.52	2,028.7
Q-275 day (75%)	1,743	2.12	2.18	4.55	6.75	4.21	1,762.8
Q-355 day (95%)	1,650	1.16	1.14	1.61	2.65	2.04	1,658.6
Min Q-7day (Ave)	1,643	1.13	1.21	1.39	2.07	2.03	1,650.8
Q(7,10)	1,279	0.22	0.21	0.49	1.34	0.44	1,281.7
GROUNDWATER							
Groundwater Potential							
- mm/year	84	152	131	99	80	54	95
- Mm^3/year	611	262	481	253	341	138	2,086
- 1,000 m^3/day	1,675	717	1,318	694	934	378	5,715
- m^3/s	19.38	8.30	15.26	8.03	10.81	4.38	66.15
- m^3/s/1,000 km^2	2.66	4.82	4.15	3.14	2.54	1.71	3.00
Groundwater Potential with Good Quality (Cl<250ppm)							
- Good Quality Rate	73 %	74 %	69 %	65 %	70 %	56 %	70 %
- mm/year	61	113	91	64	56	30	66
- Mm^3/year	444	195	334	164	239	77	1,453
- 1,000 m^3/year	1,216	533	916	449	654	210	3,978
- m^3/s	14.07	6.17	10.67	5.19	7.57	2.43	46.10
- m^3/s/1,000 km^2	1.93	3.58	2.90	2.03	1.78	0.95	2.09
TOTAL WATER RESOURCES POTENTIAL							
Total Potential (Mm^3/year)	56,578	529	770	657	962	722	60,218

Note: Total Water Resources Potential = Surface Water (Average Flows) + Groundwater (Good Quality)
Average Flow for Sao Francisco taken as average since the completion of Xingo Dam.

1.4 Water Resources Development Plans

1.4.1 Criteria for the Master Plan

(1) Goal Setting

Target year for the Master Plan was set at the year of 2020. Strategic scenario of regional development for water resources development is adopted for the Master Plan in Sergipe State. Water supply rate, unit consumption, water loss rate of municipal and industrial water supply are set as shown in the following tables.

Table-1.8 Water Supply Rate and Loss Rate in Public Water Supply

Item		1997	1998	2000	2005	2010	2015	2020
Municipal Water Supply Rate	Urban Area	100%	100%	100%	100%	100%	100%	100%
	Rural Area	35.0%	37.2%	41.5%	52.4%	63.2%	74.4%	85.0%
Industrial Water Supply Rate		5.0%	5.0%	5.0%	10.0%	15.0%	20.0%	29.8%
Water Loss Rate	Private-tap System	42.0%	41.3%	40.0%	36.3%	32.5%	28.8%	25.0%
	Public-tap System	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%

(2) Planning Criteria

Public water supply systems are divided into following two categories: 1) urban and large rural area and 2) small rural area. In urban and large rural area, municipal and industrial water is supplied by private-tap system, which is divided into integrated system and independent system. In small rural area, domestic water is supplied by public-tap system, by means of groundwater development. Desalinizer is also planned if necessary.

Agriculture water supply projects are classified into: 1) Irrigation Project, 2) Livestock Project and 3) Aquiculture Project. Irrigation water development plan is mainly discussed in this study, because necessary water amount of the others is considered to be negligible.

In this Study, the 20% and 100% of Q(7,10) is applied as compensation discharge for direct intake plan and for dam plan respectively. Low flow security in plans of weirs and direct intakes has been set to ensure the abstraction of new development discharge even in the worst drought in ten years for municipal and industrial water supply, and in five years for irrigation water supply. In the case of dam development, both cases of single and multi-purpose, low flow security is set against the worst drought in ten years.

Groundwater is developed by deep wells and following criterion are applied for the groundwater development plans: 1) Water supply in urban areas requires large volume of water. Pumped water from one borehole is determined based on the assessment of safe yield. Desalinizer is not installed and pure water wells should be developed, 2) A deep well in rural areas is assumed to cover an area with 100 people. A desalinizer should be installed if saline water is appeared.

(3) Design Criteria

Design of facilities in the master plan has been conducted in accordance with the Brazilian and/or Japanese applicable codes and standards or other internationally accepted standards. Allowable stress design method in SI/MKS metric system is employed.

1.4.2 Water Supply Plans

(1) Supply Water Shortage – Water to be Developed

Supply water shortage is estimated and is shown in Table-1.9.

Table-1.9 Supply Water Shortage by River Basin

Unit : m^3/day

Area	Items		Sao Francisco R. Basin	Japaratuba R. Basin	Sergipe R. Basin	Vaza Barris R. Basin	Piaui R. Basin	Real R. Basin	Total
Urban and Large Rural Area (Private-tap System)	2000	Present Capacity	28,472	14,312	180,270	23,744	24,752	9,888	281,438
		Demand	42,395	18,935	248,422	30,612	49,403	17,916	407,683
		Shortage	13,923	4,623	68,152	6,868	24,651	8,028	126,245
	2020	Demand	97,647	49,174	439,622	71,488	131,329	29,860	819,120
		Shortage	69,175	34,862	259,352	47,744	106,577	19,972	537,682
Small Rural Area (Public-tap System)	2000	Present Capacity	345	165	418	389	585	277	2,179
		Demand	1,010	450	1,104	1,004	1,627	739	5,934
		Shortage	665	285	686	615	1,042	462	3,755
	2020	Present Capacity	185	89	224	208	313	148	1,167
		Demand	1,797	809	2,408	1,259	2,842	1,405	10,520
		Shortage	1,612	720	2,184	1,051	2,529	1,257	9,353
< Total >	2000	Present Capacity	28,817	14,477	180,688	24,133	25,337	10,165	283,617
		Demand	43,405	19,385	249,526	31,,616	51,030	18,655	413,617
		Shortage	14,588	4,908	68,838	7,483	25,693	8,490	130,000
	2020	Present Capacity	28,657	14,401	180,494	23,952	25,065	10,036	282,605
		Demand	99,444	49,983	442,030	72,747	134,171	31,265	829,640
		Shortage	70,787	35,582	261,536	48,795	109,106	21,229	547,035

(2) Water Supply Plan

Water resources development plans for independent and integrated water supply systems are graphically shown in Figure-1.4.

< Independent Water Supply System >

Independent water supply systems are to supply water to the 35 municipalities. In general, the nearer water resources are the cheaper development. The first alternative is groundwater development if there has good groundwater potential aquifer. In case of no good groundwater potential and much developed water requested, surface water development by weirs and intake pumps was adopted.

Table-1.10 Independent Water Supply System

Water Resources	Municipalities	Developed Water	Remarks
Surface Water	12: Gararu, Nosssa Senhora das Dores, Tobias Barreto, Neopolis, Santana do Sao Francisco, Capela, Pacatuba, Boquim, Cristinapolis, Indiaroba, Itapolanga D'Ajuda, Santa Luzia do Itanhy	89,249m^3/day	----
Groundwater	16: Muribeca, Brejo Grande, Ilha das Flores, Divina Pastora, Santa Rosa de Lima. Siriri, Japaratuba, Japoata, Pirambu, Sao Francisco, Carmopolis, General Maynnard, Maruim, Santa Amaro da Brotas, Barra dos Conqueiros, Sao Cristovao	30,152m^3/day	123 Deep Well
The Both Resources	7: Malhador, Riachuelo, Rosario do Catete, Araua, Pedrinhas, Salgado, Estancia	68,000m^3/day	176 Deep Well
Total	35 Municipalities	187,401m^3/day	299 Deep Well

< Integrated Water Supply System >

The area includes the existing seven systems of integrated water supply and California I System for Caninde, accounting for 41 municipalities out of 75 municipalities in Sergipe State. Compiling the on-going, existing planned and proposed projects, ten cases of alternative plans for the area of integrated water supply are proposed. Of these alternatives, the optimum plan was selected and is conceptually shown in Figure-1.3.

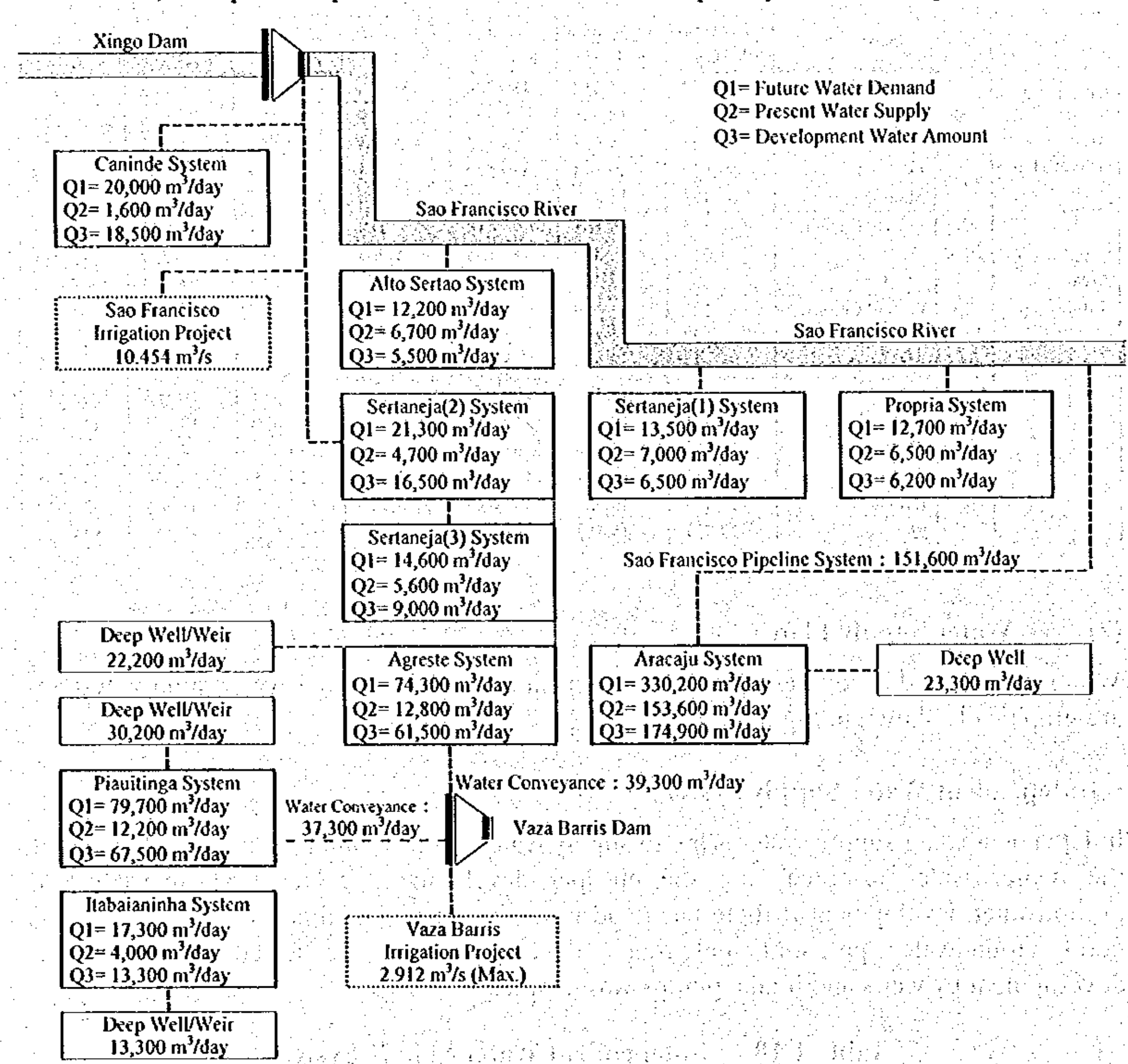
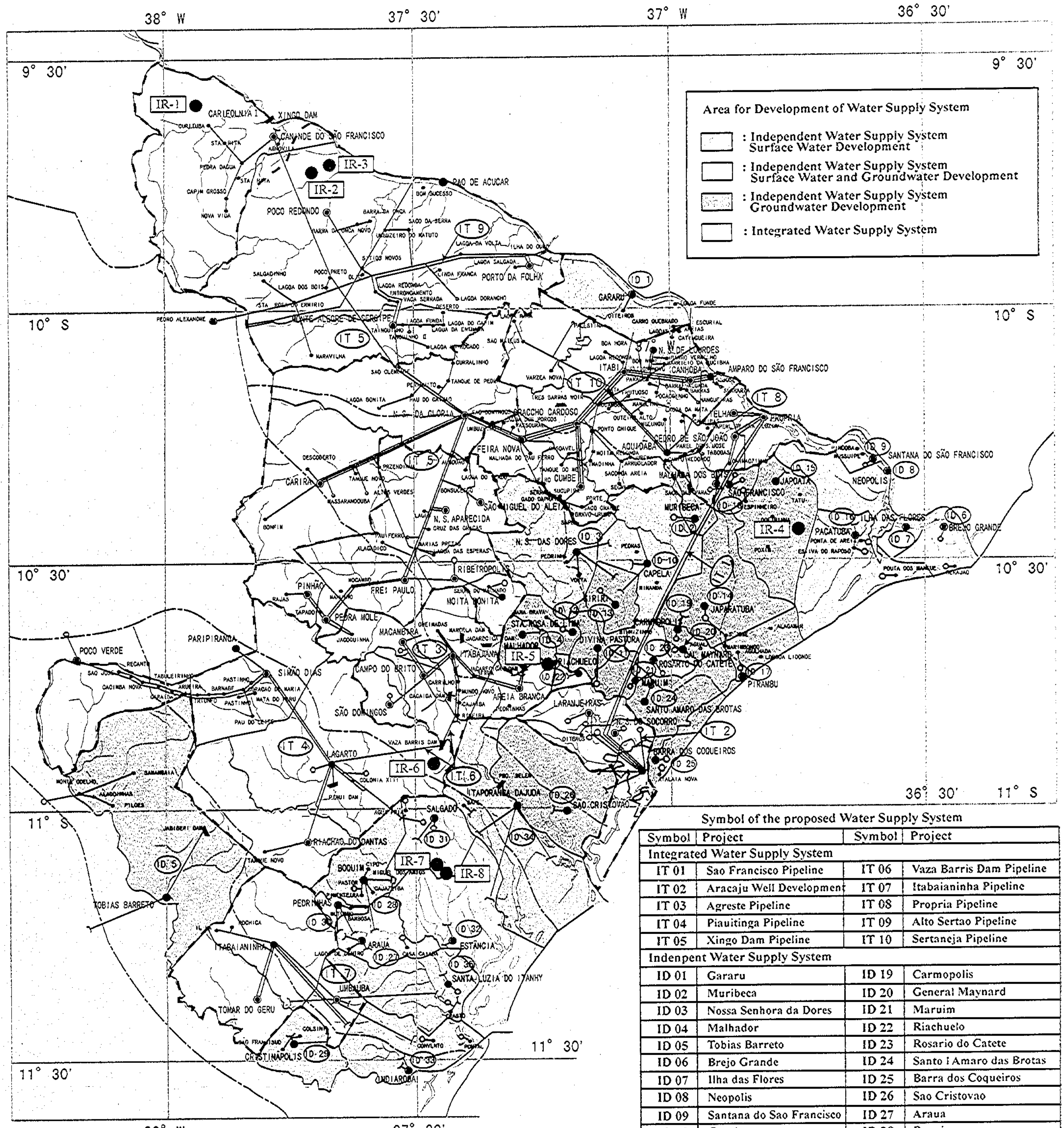


Figure-1.3 Optimum Integrated Water Supply Plan

< Rural Water Supply System >

Deep wells were applied for water resources development in small rural areas. Assuming that a deep well is installed in each village that has 100 person with the unit consumption rate of 70 lit./capita/day, a deep well should supply 7 m³/day of domestic water. As expected yield in Sergipe State is estimated to be 40~600m³/day, a deep well has enough potential of water. Taking into account 10% of water loss and fresh water rate, the necessary numbers of wells and desalinizers in 2020 are estimated by municipalities. The total number of deep wells and desalinizers necessary in Sergipe State are 1,242 wells and 566 desalinizers.



Legend

- —— : Existing Pipelines
- —— : Proposed Pipelines
- ◉ : City
- • : Village
- ○ : Existing Wells
- ○ : Proposed Wells
- —·— : Boundary of River Basin
- —— : River
- - - - : Block Division of Integrated Water Supply
- • : Proposed Irrigation Project

Symbol of the proposed Water Supply System

Symbol	Project	Symbol	Project
Integrated Water Supply System			
IT 01	Sao Francisco Pipeline	IT 06	Vaza Barris Dam Pipeline
IT 02	Aracaju Well Development	IT 07	Itabaianinha Pipeline
IT 03	Agreste Pipeline	IT 08	Propria Pipeline
IT 04	Piauitinga Pipeline	IT 09	Alto Sertao Pipeline
IT 05	Xingo Dam Pipeline	IT 10	Sertaneja Pipeline
Indenpent Water Supply System			
ID 01	Gararu	ID 19	Carmopolis
ID 02	Muribeca	ID 20	General Maynard
ID 03	Nossa Senhora da Dores	ID 21	Maruim
ID 04	Malhador	ID 22	Riachuelo
ID 05	Tobias Barreto	ID 23	Rosario do Catete
ID 06	Brejo Grande	ID 24	Santo I Amaro das Brotas
ID 07	Ilha das Flores	ID 25	Barra dos Coqueiros
ID 08	Neopolis	ID 26	Sao Cristovao
ID 09	Santana do Sao Francisco	ID 27	Araua
ID 10	Capela	ID 28	Boquim
ID 11	Divina Pastora	ID 29	Cristianapolis
ID 12	Santa Rosa de Lima	ID 30	Pedrinhas
ID 13	Siriri	ID 31	Salgado
ID 14	Japaratuba	ID 32	Estancia
ID 15	Japoata	ID 33	Indiabora
ID 16	Pacatuba	ID 34	Itaporanga D'Ajuda
ID 17	Pirambu	ID 35	Santa Luzia do Itanhy
ID 18	Sao Francisco		
Irrigation Project			
IR 01	Quixabeira	IR 05	Jacarecica II
IR 02	Jacare-Curituba	IR 06	Vaza Barris
IR 03	Sao Francisco	IR 07	Entre Rios
IR 04	Ladeirinhas	IR 08	Estancinha

Figure-1.4 Water Resources Development Plan (Integrated System and Independent System)

1.4.3 Irrigation Water Supply Plans

Irrigation water resources development plan is proposed in Table-1.11. Of the eight proposed projects, Xingo Dam Pipeline Project and Vaza Barris Dam project are newly proposed as multi-purpose projects with municipal and industrial water supply project. Another six projects were proposed by COHIDRO.

In view of water resources, the three irrigation projects to abstract water from Sao Francisco River has no water source problem because of plenty water resources. The Ladeirinhas irrigation projects is located in the east side of Sergipe State and around here has large surface potential. Although Mundeu River has no flow data, Santo Antonio River near Ladeirinhas site has abundant surface potential of about 140 $m^3/s/km^2$ of Q(7,10) discharge. The irrigation projects of Entre Rios and Estancinha, are located in Piauitinga River Basin, which has surface potential of 50-120 $m^3/s/km^2$ of Q(7,10) discharge. Therefore these irrigation projects are estimated to be feasible in view of water resources.

Table-1.11 Plan of Irrigation Water Resources Development

Project Name	Irrigation Area (ha)	Average Irrigation Water (m^3/day)	Peak Irrigation Water (m^3/s)	Water Sources
Quixabeira	3,668	95,368	2.944	SFR: Direct Intake from Xingo Dam Reservoir
Jacare-Curituba	3,681	113,556	3.051	SFR: Xingo Dam Conduit
Sao Francisco	16,000	441,863	10.454	SFR: Xingo Dam Conduit
Ladeirinhas	890	29,309	0.721	Mundeu R./ JR: New Dam
Jacarecica II	1,100	49,063	1.097	Jacarecica R./ SR: Jacarecica II Dam
Vaza Barris	2,500	103,630	2.912	VR: Vaza Barris Dam
Entre Rios	261	6,550	0.180	Grotao R. or Quebrados R. and Piauitinga R./PR: Direct Intake
Estancinha	109	22,953	0.062	Piauitinga River
<Total>	28,209	842,292	21.421	

1.4.4 Water Resources Development Plans by River Basin

Plan of water resources development and supply in six main river basins for the target year 2020 is summarized in Table-1.12. Refer to Figure-1.5.

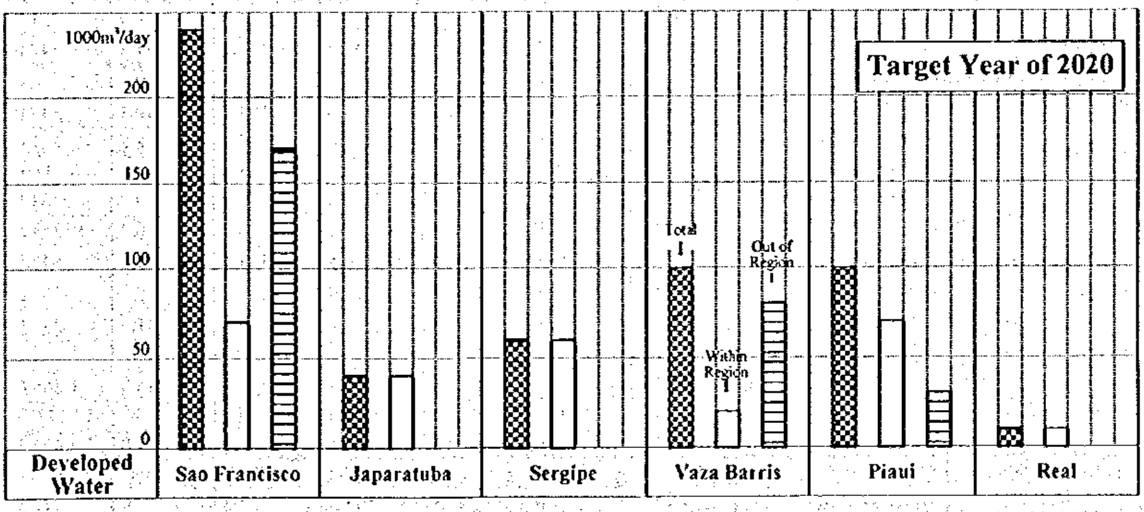


Figure-1.5 Water Resources Development and Water Use by River Basin

Table-1.12 Water Resources Development Plan by River Basin (Master Plan: Target Year of 2020)

Unit of Water Volume : 1000m³/day

Items		Sao Francisco	Japaratuba	Sergipe	Vaza Barris	Piaui	Real	Total
1. Projected Population in 2020 (1000 persons)		395.6	163.5	1,326.6	267.5	453.3	171.9	2,778.4
− Urban Area		*303.2*	*121.9*	*1,202.8*	*202.7*	*307.1*	*99.6*	*2,237.3*
− Rural Area		*92.4*	*41.6*	*123.8*	*64.8*	*146.2*	*72.3*	*541.1*
(Large Rural)		*64.7*	*29.1*	*86.7*	*45.4*	*102.3*	*50.6*	*378.8*
(Small Rural)		*27.7*	*12.5*	*37.1*	*19.4*	*43.9*	*21.7*	*162.3*
2. Water Supply Project								
<Urban and Large Rural>								
★ Water Demand – Consumption Base		98.8	80.3	633.5	100.6	152.6	24,330	1,090.0
− Domestic Water		*56.3*	*23.0*	*220.9*	*37.9*	*61.4*	*22.0*	*421.5*
(Urban Area)		*48.5*	*19.5*	*210.5*	*32.4*	*49.1*	*15.9*	*375.9*
(Large Rural Area)		*7.8*	*3.5*	*10.4*	*5.5*	*12.3*	*6.1*	*45.6*
− Industrial Water		*42.5*	*57.3*	*412.5*	*62.7*	*91.2*	*2.3*	*668.5*
★ Public Water Supply								
☆ Supply Water-Consumption Base		73.2	36.9	329.7	53.6	98.5	22.4	614.3
− Domestic Water (Urban Area)	Supply Rate	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*
	Supply Volume	*48.5*	*19.5*	*210.5*	*32.4*	*49.1*	*15.9*	*375.9*
− Domestic Water (Large Rural)	Supply Rate	*85.7%*	*85.7%*	*85.7%*	*85.7%*	*85.7%*	*85.7%*	*85.7%*
	Supply Volume	*6.7*	*3.0*	*8.9*	*4.7*	*10.5*	*5.2*	*39.0*
− Industrial Water	Supply Rate	*42.5%*	*25.1%*	*26.7%*	*26.3%*	*42.6%*	*53.9%*	*29.8%*
	Supply Volume	*18.0*	*14.4*	*110.3*	*16.5*	*38.9*	*1.3*	*199.4*
☆ Supply Water – Supply Base		97.7	49.2	439.6	71.4	131.3	29.9	819.1
− Current Supply Capacity - Supply Base		28.5	14.3	180.3	23.7	24.7	9.9	281.4
− Developed Water Supply - Supply Base		69.2	34.9	259.3	47.7	106.6	20.0	537.7
★ Private Water - Consumption Base		25.5	43.4	303.7	47.0	54.1	2.0	475.7
☆ Domestic Water		1.1	0.5	1.5	0.8	1.7	0.9	6.5
☆ Industrial Water		24.4	42.9	302.2	46.2	52.4	1.1	469.2
<Small Rural>								
★ Public Water Supply (Domestic Water)								
☆ Water Demand - Consumption Base		1.9	0.9	2.6	1.4	3.1	1.5	11.4
☆ Supply Water - Consumption Base	Supply Rate	*83.3%*	*83.3%*	*83.3%*	*83.3%*	*83.3%*	*83.3%*	*83.3%*
	Supply Volume	1.6	0.7	2.2	1.1	2.6	1.3	9.5
☆ Supply Water - Supply Base		1.8	0.8	2.4	1.3	2.8	1.4	10.5
− Current Supply Capacity - Supply Base		0.2	0.1	0.2	0.2	0.3	0.1	1.1
− Developed Water Supply - Supply Base		1.6	0.7	2.2	1.1	2.5	1.2	9.3
★ Private Water Supply (Domestic Water)		0.3	0.1	0.4	0.2	0.5	0.3	1.9
<Total Developed Water Volume>		70.8	35.6	261.5	48.8	109.1	21.2	547.0
<Developed Public Water Supply>								
★ Development inside the Region		243.5	35.9	57.0	98.3	102.2	10.1	547.0
☆ Water Resources	Surface Water	239.3	16.9	16.8	92.8	86.4	8.8	461.0
	Groundwater	4.2	19.0	40.2	5.5	15.8	1.3	86.0
☆ Water Use	Within the Region	70.7	34.0	54.7	21.0	73.4	9.7	263.5
	Out of the Region	172.8	1.9	2.3	77.3	28.8	0.4	283.5
★ Water Resource of Use inside Region		70.8	35.6	261.5	48.8	109.1	21.2	547.0
☆ Developed within the Region		70.7	34.0	54.7	21.0	73.4	9.7	263.5
☆ Developed out of the Region		0.1	1.6	206.8	27.8	35.7	11.5	283.5
3. Irrigation Water Project								
★ Total Irrigation Water - Development Base		1,117.7	0	61.5	136.7	30.9	18.8	1,365.6
☆ Present Irrigation Facilities	Area	14,843ha	0ha	252ha	1,100ha	703ha	225ha	17,123ha
	Water Volume	437.6	0	12.4	33.1	21.4	18.8	523.3
☆ New Irrigation facilities	Area	24,239ha	0ha	1,100ha	2,500ha	370ha	0ha	28,209ha
	Water Volume	680.1	0	49.1	103.6	9.5	0	842.3

1.4.5 Project Costs

Project cost in the implementation stage is composed of construction cost, compensation cost, consulting engineering services cost, administration cost, contingency and government tax. Price level for cost estimation is August 1998, 1US$=1.18R$=¥141.40.

Result of cost estimate is as follows:

Water Supply Project	:	R$945.80million	(US$801.53million)
Irrigation Project	:	R$427.50million	(US$362.29million)
Total Cost	:	R$1,373.30million	(US$1,163.81million)

Table-1.13 Summary of Project Costs

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
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

Breakdown of main project cost is shown in Table-1.14

Table-1.14 Cost of Main Project

Project Name	Cost (R$ million)	Remarks
Integrated Water Supply Projects		
- Xingo Dam Pipeline	145.66	Water Supply Volume = 43,999 (m^3/day)
- Propria	4.81	Water Supply Volume = 6,189 (m^3/day)
- Alto Sertao	20.52	Water Supply Volume = 5,495 (m^3/day)
- Sertaneja	33.15	Water Supply Volume = 6,493 (m^3/day)
- Itabaianinha	34.30	Water Supply Volume = 13,321 (m^3/day)
- Aracaju	285.02	Water Supply Volume = 174,892 (m^3/day)
- Agreste	89.42	Water Supply Volume = 61,476 (m^3/day)
- Piauitinga	89.05	Water Supply Volume = 67,534 (m^3/day)
<Total>	701.93	Water Supply Volume = 379,399 (m^3/day)
Irrigation Projects		
- Estancinha	1.00	Irrigation Area = 109 ha
- Entre Rios	2.40	Irrigation Area = 261 ha
- Ladeirinhas	28.74	Irrigation Area = 890 ha
- Sao Francisco	223.07	Irrigation Area = 16,000 ha
- Vaza Barris	54.84	Irrigation Area = 2,500 ha
- Quixabeira	35.05	Irrigation Area = 3,668 ha
- Jacarecica-II	44.55	Irrigation Area = 1,100 ha
- Jacare-Curituba	37.85	Irrigation Area = 3,681 ha
<Total>	427.50	Irrigation Area = 28,209 ha

1.5 Water Resources Management and Maintenance Plans

1.5.1 Institutional Plan

(1) Organization Plan

According to the State Policy of Water Resources, water resources management can be managed with the organizations shown in Figure-1.6. The SRH has to be strengthened to discharge the following major duties from the beginning period. Proposed organization at the first stage is illustrated below. In the future, water agency (WA) could be separated as an independent organization for operational functions for water resources management as the second stage. Finally, the State Fund of Water Resources (FUNERH) could be established for managing the fund from the charging system.

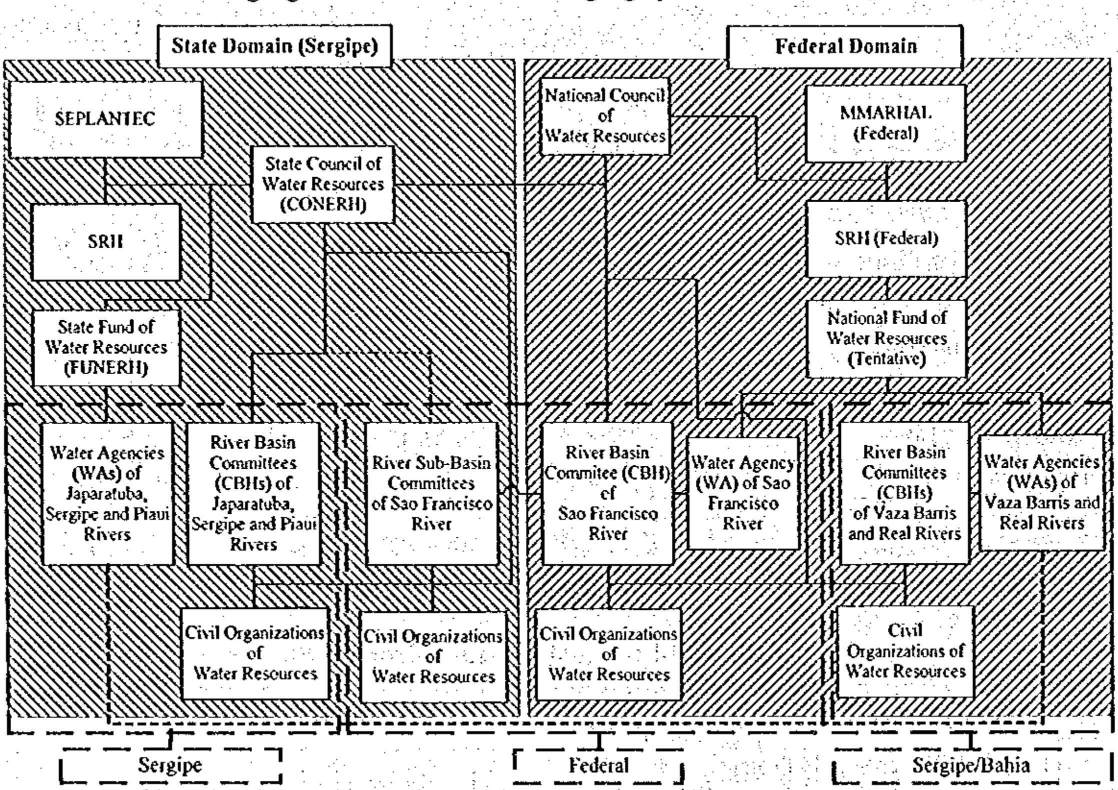


Figure-1.6 Organization Framework in the State Policy of Water Resources

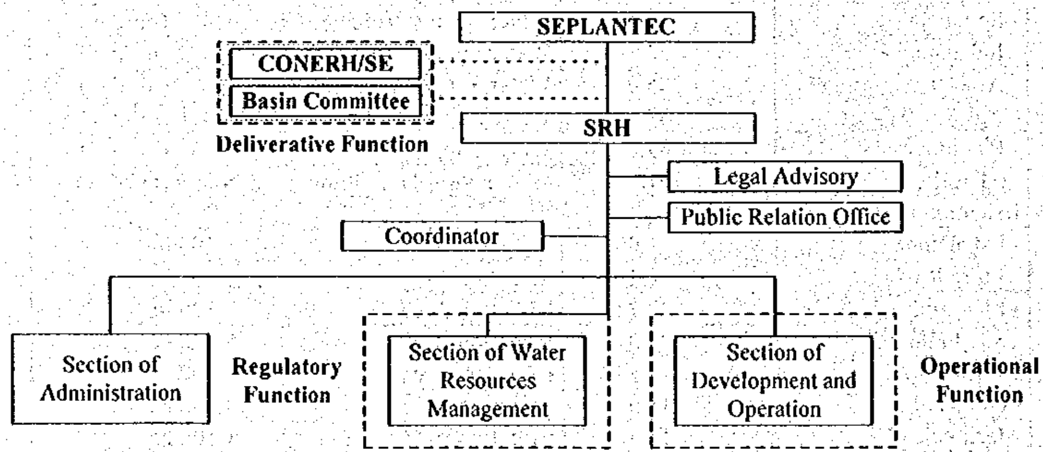


Figure-1.7 Organization Plan of SRH at First Stage

(2) Water Rights and Charging System

< Grant of Water Rights >

Allocation of water resources is fatally important for efficient use of limited water. The institution for water rights granting should be established immediately. Priority order in the granting can be use for i) support of human lives, ii) keeping natural & social environment, iii) public utilities, iv) economic activities, v) amusement. The competent agency should examine the following conditions to control water quality and quantity and to allocate water rights efficiently and equitably.

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 as well as not to decrease the availability of other users
4) To avoid the grant to water use for pollutant dilution, because the dilution does not make the quantity of pollutant decrease and makes the treatment of effluent difficult technologically.

In the future, a new mechanism would be necessary for reallocating water to increase aggregate economic benefits. In advanced countries in the field of water resources allocation, the following mechanisms are applied for maximization of benefits.

< Charging to Use of Water Resources >

As stipulated in the state and federal policy of water resources, water is a kind of economic goods. Optimal allocation can be achieved by charging on use of the resource. US$50 per lit/sec is tentatively set up to cover annual expenses of WA in the future. If the charging system takes a firm hold in the state and is accepted by water resources users, the system might shift to market trading system of water resources.

(3) Participation of Civil Organizations

Participation and decentralization, is a must in the water sector, particularly in rural water supply, and they should participate into the management. Then, they will take the responsibility for their water system. In fact, the stronger the participation of users and their sense of ownership of water system, the more successful the project will be. The participation of civil organization is to put into practice through CONERH and RBCs.

(4) Cost Allocation of Multi-purpose Facilities

"Separable Cost Remaining Benefit Method" is recommendable for Brazil to allocate the costs of multiple-use facilities.

1.5.2 Water Resources Conservation Plan

(1) Classification of Waters According to the Predominant Use

Waters of upper stream near the intake points for public water supply and irrigation projects are recommended as Class 1. Waters whose water quality may affect those sources are recommended as Class 2. Waters of insignificant use may be classified as Class 3. Classification with comprehensive analyses on all types of water use and on future land use development is necessary for each basin.

(2) Hydro-meteorological Observation and Water Quality Monitoring

A system of regular observation and monitoring on water volume and quality by river basin, by region and by season should be implemented to assure present and future availability of water.

1) Meteorology Observation
2) Surface Water Observation
3) Groundwater Observation
4) Water Quality Monitoring

The results of hydrological assessment and water quality monitoring should be published, preferably as annual reports. These reports are useful for users of water. The publication is also effective for the promotion of awareness on water resources of the people.

(3) Control of Effluent Discharge

Obligation of monitoring quality and quantity of effluent can be attributed to factories or industries. A system should be examined for licensing environmental auditors. The system will promote proper and feasible monitoring of effluent. As for pollution control caused by agricultural activities, close cooperation with entities in charge of agricultural extension services can be recommended.

(4) Regulation of Land Development and Use for Water Resources Conservation

Change in land use may cause effects on availability of water resources in quality and in quantity, causing changes in regional hydrological cycle or contamination by land users. Land use should be regulated, considering water resources conservation in quality and in quantity.

(a) Forest Development, Preservation and Management

In the recharging areas for aquifers of intensive use and of importance, afforestation should be promoted and forests should be preserved and well managed. In the identified forest, fire protection is important. Compensation for restricted land use or forestry activities can be funded from collected fees in water rights granting. Forest belts along courses of water should be developed and preserved to protect the water quality and to prevent sedimentation in reservoirs and rivers.

(b) Restriction of Contaminating Activities near Sources of Water

Illegal dumping along waters should be strictly prohibited. Waste disposal sites should be located with sufficient distance from the areas of groundwater recharging and on the valleys of rivers of Class 1 and dam reservoirs. In the recharging areas for ground waters of importance, especially, all discharging of effluent to the ground should be prohibited or restricted.

1.5.3 Proposal for Improvement of Operation and Maintenance

(1) Urban Water Supply System

< Improved Efficiency of Management of DESO >

Streamlining of the staff allocation and raising motivation of employees is common in the management of private business. DESO have to make annual objectives of sales, profits and tasks to achieve the objectives. Each section should have allocated tasks to achieve the norms and objectives with indicators to measure the attainment. Salaries and promotion of each person would preferably be determined by degree of contribution to the achievement of the norms or objectives. In response to the expansion of the operation, the staff in the administrative sections should move to the operational sections. 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 months will serve for improved efficiency. Outsourcing is an effective measure to introduce competition in a monopolized sector. To obtain the benefit of the competition, restructuring of the sections should follow.

< Tariff Control >

Strengthening the accounting system with enhanced cost analysis capability should firstly take place. Investigation on water use should accompany. 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. A deliberative committee should be organized with the initiative of SESP. Yard-stick tariff setting should be discussed in the committee. Small users up to 5 m^3/month, as civil minimum, could be the target of the social tariff. The social 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) Rural Water Supply System

< Responsibility Re-allocation in Agricultural and Rural Water Management >

Parts of the functions of COHIDRO and EMDAGRO, including agricultural extension, should be attributed to *an autarchy*. Technical and financial assistance for rural water services should be added to the responsibility of the autarchy.

< Operating and Supporting Entities for Rural Water Supply >

Basically, water supply in small villages should be operated by local communities, hiring one person in charge of operation. Technical assistance, including training of operating persons, periodical facility inspection, repair and replacement, is inevitable, and should be discharged by the autarchy.

< Tariff Collection and Financial Arrangement for Rural Water Supply >

Operation and maintenance cost, excluding depreciation, should be covered by tariff collection from the beginning. Gradually, the tariff collection should be enhanced to cover the repair and depreciation cost. Repair and depreciation cost should be collectively raised as reserve fund. Repair or replacement can be paid from the fund. Even in that case, some part of the cost should be born by the community, because full payment from the funds may spoil the intention for careful operation and maintenance. Unified tariff of

R$ 1.4/person/month can be set, 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.

< Establishing Management System of Irrigation >

Operation and maintenance of irrigation facilities should be operated by farmers' community with technical assistance by the autarchy. The tariff should be set to fully cover operating costs and investment costs, except the cost for technical assistance by the autarchy. To attain the full cost recovery, careful agronomic, marketing, economic and financial analysis is necessary in feasibility studies. 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/WA should be determined by volume. For the equitable demand control and proper water resources development, charging to individual farmers or to users group would preferably charged by volume as much as possible.

1.5.4 Operation against Drought

(1) Conditions of Droughts

Conditions of droughts or water shortage in Sergipe can be summarized as follows:

- At present, 65% of the rural population do not have public water supply schemes, depending their water supply on unstable and vulnerable rainfall collecting system. Water tank trucks of Civil Defense is 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.
- 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 measures in case of droughts.
- Although in most of urban and large rural areas water supply 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.
- Rainfed agriculture is directly affected by droughts.
- Public water supply schemes whose water source are boreholes will have a little damage by droughts.

(2) Measures against Droughts

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 is realized.

< 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 can not be met, 3) emergent water distribution should be carried out.

Promotion of Water Saving

For the promotion of water saving, information on the present and prospective available volumes of water 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.

Water saving for the suppliers, especially in private tap system, is prevention of water loss. Currently, DESO is implementing a project of meter installation to detect the points of water loss. Early implementation of the project as well as subsequent projects for the repairs of detected points would be important.

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. 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. In order to reduce overall social and economic losses caused by water supply restriction, aerial difference in the restriction should be avoided within an integrated water supply system.

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. 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.

In case of the restriction of water supply, each household will store the water in some containers. To reduce the damages of the water supply restriction, manner of storage and use of stored water should be guided through campaigns. Collaboration with public health sectors in Municipal Governments and the State Government would be required.

Emergent Water Distribution

Further efforts should be placed for the planning of the emergent distribution. 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 proposed in Section 5.3 (or COHIDRO and EMDAGRO) should collaborate with Civil Defense for the planning of efficient emergent 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 emergent water distribution can be more efficient. 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.

< Agricultural Water >

In the following section, measures against droughts in water supply for livestock breeding and rainfed agriculture, which are vulnerable to droughts, are discussed.

Livestock Breeding

DESO has installed taps on the pipelines of some integrated water supply systems, 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. Fund raising by groups of small-scale farmers should be promoted for them to apply this service.

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.

Rainfed 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. 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. Collaboration with EMBRAPA is inevitable.

< Accumulation and Dissemination of Information on 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 and information should be collected in the database of SRH/WA as an part of information system of water resources management. Studies on damages caused by droughts will be necessary.

1.6 Implementation Schedule

The following distinctions were set to give high priority to the water resources development projects: 1) Large water shortage and rate of beneficiaries, 2) Long period for plan and construction, 3) Large construction volume, and 4) Multi-purpose project.

Implementation schedule for water resources management plans is formulated with the following concepts: 1) For the implementation of sequence of programs, a program whose implementation is prerequisite to another program is placed earlier, 2) For the preparation of a program of social interests or multiple sector, two years are considered as necessary, and 3) Overburden on a division of the government is to be avoided.

Based on the above criterion, implementation schedules are shown in the following tables.

Table-1.15 Implementation Schedule of Water Resources Development Project

Proposed Projects	Water Developed (m^3/day)	First Stage 2000 - 2004					Second Stage 2005 – 2009					Third Stage 2010 - 2014					Fourth Stage 2015 - 2019					
		00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
A Water Resources Development Project																						
1 Industrial and Municipal Water Supply	**547,103**																					
1.1 Urban and Large Rural Area (Integrated System)	**379,399**																					
a Project Expansion of Sao Francisco Pipeline System	*151,600*	###	###	###									###									
b Project Expansion of Agreste Pipeline System	*22,200*		***	###																		
c Project Expansion of Piauitinga Pipeline System	*30,200*		***	###																		
d Aracaju Well Development Project	*23,292*	***	###																			
e Project Expansion of Itabaianinha Pipeline System	*13,321*			***	###			***	###					###								
f Project Expansion of Propria Pipeline System	*6,189*							***	###					###								
g Project Expansion of Alto Sertao Pipeline System	*5,495*								***	###					###							
h Project Expansion of Sertaneja Pipeline System	*6,493*								***	###					###							
i Xingo Dam Pipeline Project	*43,999*		***	###	###	###	###					###	###	###								
j Vaza Barris Dam Project	*76,610*		***	***	***	###	###	###		###	###			###	###	###	###					
1.2 Urban and Large Rural Area (Independent System)	**158,351**	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	
2 Small Rural Area (Municipal Water Supply Only)	**9,353**	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	
3 Irrigation Water Supply	**1,906,301**																					
a Quixabeira 3,688 ha	*262,873*													***	###	###	###					
b Jacare-Curituba 3,681 ha	*272,394*	###	###																			
c Sao Francisco 16,000 ha	*933,333*			***	###	###	###	###	###	###	###	###	###	###								
d Ladeirinhas 890 ha	*58,147*												***	***	###	###	###					
e Jacarecica II 1,100 ha	*97,900*	###	###	###																		
f Vaza Barris 2,500 ha	*260,000*						***	###	###	###	###											
g Entre Rios 261 ha	*16,095*																***	###	###			
h Estancinha 109 ha	*5,559*																		***	###	###	

Note: ***: Plan and Design ###: Construction

		00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
B Water Resources Management Program																						
1 Institutional Plan																						
a Grant of Water Rights		***	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	
b Charging to Use of Water Resources		***	***	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	
c Organization Set-up		***	***	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	
d Cost Allocation for Multi-purpose Facilities		***	***	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	
2 Water Resources Management Programs																						
a Improvement in Efficiency of Water Supply in Urban and Large Rural Areas		***	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	
b Management System of Rural Water Services		***	***	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	
3 Management Improvement of Water Supply																						
a Classifications of Waters		***	***	***	***	***	***	###	###	###	###	###	###	###	###	###	###	###	###	###	###	
b Enhancement of Hydrological Assessment		***	***	***	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	
c Water Quality Monitoring							***	***	###	###	###	###	###	###	###	###	###	###	###	###	###	
d Establishing a System for Effluent Control		***	***	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	
e Regulation of Land Development and Use							***	***	###	###	###	###	###	###	###	###	###	###	###	###	###	
4 Operation against Drought		###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	###	

Note: **: Legislative arrangement, institutional set-up, initial training or other preparations
##: regular operations and management with gradual enhancement and periodical institutional review

1.7 Evaluation of the Master Plan

1.7.1 Technical Evaluation

The proposed Master Plan of Water Resources Development in the State of Sergipe was planned according to the following technical information, standards, judgment and proper planning procedures, and is assessed to be technically feasible as a result.

1) The information related to socio-economic conditions, topographical and hydro-geological conditions, hydrological conditions, environmental conditions, water use conditions and so on are collected from the data and information that the Federal Government and the State Government own and was applied to the Master Plan after precise examination and careful selection. And the standards established by the Federal Government were applied for the planning and design required in the Master Plan. However, the international standards such as in Japan and USA were also used when necessary.
2) The long-term projection of the state population for the estimation of future water demand was conducted applying the same method of the State Government based on the latest population census of 1996. However, population decentralization was recommended in the Master Plan to alleviate the centralization of economy and population in the state capital and to mitigate the economic disparity among regions.
3) To attain the sustainable water resources development, the plan was established based on the study of possibility of safe water supply estimating water resources potential by regions and considering probability evaluation. Concretely, probability draught discharge for the surface water and safe yield for the groundwater were applied in the Master Plan.
4) The projects were planned sufficiently for 10-year return period draught year as to the safety of supply. Current water supply systems don't always maintain the safety of supply. However, when kept mechanically in good repair as proposed in the Mater Plan, the safety could be lifted as a result.
5) The catchment area should be found near the demand area from the economic viewpoint. Therefore the resources that contain small quality problem such as high salinity-concentration surface water and groundwater were also recommended for development. The simple desalination equipment for rural water supply in the semi-arid region and surface water quality improvement of Vaza Barris dam by storing inundated water are the good examples.
6) The information and opinions concerning the basic policy of the Master Plan and alternatives of the plan were exchanged aggressively between the Study Team and organization related to water of the State Government through 10 workshops.

The proposed Master Plan of Water Resources Development in the Sergipe State was set for target year of 2020 based on the population and economic growth projection conducted by the Study Team. Therefore the plan should be reviewed and changed if necessary according to the change of socio-economic conditions and accumulated collections of hydrologic data.

1.7.2 Social Evaluation

(1) Increase of Employment Opportunity and Activation of Regional Economy

Construction works for projects such as dam and pipelines for domestic and industrial water supply and irrigation water supply would offer a new labor opportunity to the people unemployed and underemployed of the region in construction sector itself and the related sectors. The consumption by the workers will stimulate the business activities of the region. Thus, this increased consumption by new workers will induce a multiplied economic effect to the region, which activate the regional economy as a whole.

(2) Improvement of Safe Water Coverage and Public Hygiene

After the completion of the projects in 2020, all incremental urban population and 85% of rural population (only 37% in 1998) could enjoy their living conditions with safe and sufficient potable water. According to the water use survey conducted by the Study Team on August 1998, almost all (93%) of rural inhabitants without residential water supply systems desired an implementation of the projects for private tap system in the area. The most remarkable reason that was seen in the survey was a hygienic improvement in Agreste Sergipano meso-region, while stable supply in the rest of meso-regions. Also according to the survey, those inhabitants spend around 2 hours for carrying water to satisfy their demand for living. The expansion of potable water supply could decrease water-borne diseases and mortality rate in the region. And it is clear that the inhabitants not supplied with potable water at moment in the dwellings can reduce significantly the time spent for carrying water. These times saved could be used for another effective activities.

(3) Mitigation of Economic Disparity and Alleviation of Centralization in the State Capital

The industrial water supply rate currently assumed at only 5% of the demand. The industries supplied by public entities pointed out instability of water supply. They are not satisfied completely with current water supply system. Considering this, the industrial water supply rate will be lifted to 30% by the target year of 2020 in the master plan. Irrigated agriculture projects could produce many benefits as follows: 1) higher yields per unit area of land, 2) extension of cultivating season and possible multi-cropping, and 3) safe cropping particularly during droughts and so on. Thus, the projects will alleviate the impact of water scarcity in the project area of the state that will attract the manufacturing companies to set up its plant in the region and also give agricultural farmers an incentive to cultivate harder. That will stimulate intensively regional economic activities and bring the people more sufficient living conditions there. As a result, it could lead the mitigation of economic disparity compared with the nation level and the alleviation of economic and demographic centralization to metropolitan area like Aracaju.

1.7.3 Economic Evaluation

54 projects are analyzed in this section: 10 projects of Integrated System, 35 projects of Independent System, Small Rural Area System in each municipality (aggregated to 1 project for analysis) and 8 projects of Irrigation Water Supply System.

For economic evaluation, Economic Internal Rate of Return (EIRR) of the project is used to ascertain the economic viability. In addition, other economic indices such as Net Present Value (NPV) and Benefit-Cost Ratio (B/C) are also used to verify the economic viability. Several conditions and assumptions are applied in estimating cost and benefit on the basis of economic value to get these indices.

The EIRR of total (54) projects resulted in 13.1%. The EIRR of 37 projects or 70% of 54 projects exceeded opportunity cost of 10%. As a whole, the projects are assessed to be in economic efficiency and worth promoting.

Table-1.16 Economic Efficiency

Projects	EIRR	NPV (R$ million)	B/C
(1) Domestic and Industrial Water Supply Project	11.8	91.1	1.13
(1-1) Integrated System	10.8	32.9	1.06
1) Project Expansion of Sao Francisco Pipeline System	11.7	34.3	1.15
2) Aracaju Well Development Project	13.6	10.0	1.28
3) Project Expansion of Agreste Pipeline System	8.2	-4.8	0.86
4) Project Expansion of Piauitinga Pipeline System	25.6	19.0	1.59
5) Xingo Dam Pipeline Project	7.1	-17.7	0.76
6) Vaza Barris Dam Project	12.1	13.1	1.19
7) Project Expansion of Itabaianinha Pipeline System	4.7	-6.7	0.67
8) Project Expansion of Propria Pipeline System	17.8	1.3	1.26
9) Project Expansion of Alto Sertao Pipeline System	#	-4.8	0.56
10) Project Expansion of Sertaneja Pipeline System	#	-10.6	0.36
(1-2) Independent System	27.7	87.7	1.82
(2) Small Rural Water Supply (Single Well System)	#	-29.5	0.18
(3) Irrigation Projects	17.2	116.1	1.48
1) Quixabeira	26.9	9.4	1.93
2) Jacare-Curituba	22.5	27.7	1.68
3) Sao Francisco	22.3	83.1	1.68
4) Ladeirinhas	10.2	0.1	1.02
5) Jacarecica II	3.1	-16.3	0.55
6) Vaza Barris	15.0	11.8	1.46
7) Entre Rios	14.4	0.1	1.22
8) Estancinha	14.4	0.0	1.22
<<Total of Projects>> (1)+(2)+(3)	13.1	207.2	1.23
(4) Multi-purpose Projects			
- Xingo Dam Pipeline	15.2	65.4	1.33
- Vaza Barris dam	12.9	24.9	1.26

Main Assumptions: Price Level (August/1998), Opportunity Cost of Capital (10%), Standard Conversion Factor: (0.85)
Note: # (negative EIRR)

(1) Water Supply Projects

Integrated System

Generally the integrated system is costly. However, the EIRR of five projects exceeded the opportunity cost of 10%. The EIRR of the Integrated System resulted in 10.8%, slightly above the opportunity cost though five projects resulted in less than 10%.

Independent System

Independent System resulted in good economic efficiency of 27.7 % mainly due to the lower investment cost. The EIRR of twenty-five projects exceeded the opportunity cost of 10%.

Small Rural Water Supply

It is quite costly to provide water to small rural area that showed the negative EIRR.

(2) Irrigation Water Supply Projects

The EIRR of all projects resulted in 17.2 %. The EIRR of six projects out of total (8 projects) exceeded 14 %. As to the Vaza Barris, Ladeirinhas and Jacarecica-II, investment cost per hectare is terribly high due to the dam construction. However, the Vaza Barris project resulted in 15.0 % of EIRR that means to be in economic viability.

(3) Multi-purpose Projects

The EIRR of two Projects exceed opportunity cost of 10 % respectively. The both projects are assessed to be feasible. Xingo Dam Pipeline Project showed higher EIRR of 15.2 % due to economic contribution of agriculture sector. However, Vaza Barris Dam Project situated an advantageous position in both domestic and industrial sector.

1.7.4 Financial Evaluation

(1) Domestic and Industrial Water Supply Project

Water supply investment was mostly provided to DESO and COHIDRO. The averaged amount during 1994 to 1998 was R$ 20.3 million. The amount was 3.1% of the tax revenues in the state budget. The public entities spent R$ 24.0 million on average during 1995 to 1997, more than provided from the state budget of R$ 14.8. They have raised the difference mostly from the state banks generally with the conditions of long-term maturity and low interest rate.

The amount of water supply investment in the Master Plan was estimated at R$ 950 million. However, 70 % (R$660 million) of initial investment concentrate in the first decade.

The amount of water supply investment in the state budget was 3.1 % of the tax revenues on average during five years from 1994 to 1998. Tax revenues would increase generally with economic growth that would take place. Thus the future amount of water supply investment during 20 years from 2000 to 2019 was estimated at R$ 900 million. For the first decade, the amount would be R$ 390 million.

The water supply investment of the state budget is considered the principal source of funds, which would be R$ 390 million in the first decade and R$ 510 million in the second decade. Public entities are assumed also to share the financial burden: 10 % of the initial investment. As a result, an amount of R$ 210 million should be raised in the first decade as shown in the Table. However, initial investment could be covered entirely by the state budget in the second decade, moreover the excess amount of R$ 250 million could be used as a repayment source for debt.

Table-1.17 Estimated Source of Fund for Water Supply Projects

Items	1st decade	2nd decade	Total	Remarks
Initial investment (R$ million)	660	290	950	Master Plan
Source of Fund (R$ million)	450	540	990	State own fund
State Budget	390	510	900	3.1 % of tax revenue
Public Entities	60	30	90	Self-finance (10%)
Balance (R$ million)	(*)-210	+250	+40	Amount to be raised (*)

Judging from the current debt service ratio which was 7.7 % in 1998, the state government financial situation is expected to keep still healthy condition if the additional funds of R$ 210 million would be soft loan with long-term maturity and low interest rate.

The recovery of financing cost (R$ 70 million) in the rural water supply cannot be expected. As to domestic water supply, some portion of the cost could be covered by the entity in the second decade after expansion of the service and enhancing the management efficiency. So financial burden of the State Government could decrease in the second decade.

(2) Irrigation Water Supply Projects

In the Master Plan, total initial investment costs for 8 projects amount to R$ 430 million However, 70 % (R$280 million) of costs concentrate in the first decade. The funds for investment costs should be covered by the State Government, considering the size of investment costs and financial conditions of agricultural producers.

1.7.5 Initial Environmental Examination

The Initial Impact Assessments on each project identified in the Master plan Study were conducted. Environmental items on the social and natural environment, and the environmental pollution during the construction stage and operation stage was checked. The result of the assessments and the mitigation measures are shown in Table-1.18.

Table-1.18 Result of Initial Impact Assessment on Each Project

Project	Assessment (Construction / Operation)	Main Environmental Problems	Mitigating Measures / Remarks
Integrated Water Supply System			
Project Expansion of Sao Francisco Pipeline System	B / D	Dust, noise, vibration and traffic jam during construction works. Water right.	Machinery control. Propre construction plan. Major impacts are limited at construction stage.
Aracaju Well Development Project	D / C	Noise, vibration and turbid water during construction works. Saltwater intrusion.	Machinery control. Propre construction plan. Water quality monitoring. Major impacts are limited at construction
Project Expansion of Itabaiana Pipeline System	B/ D	Dust, noise and vibration during construction works.	Machinery control. Propre construction plan. Major impacts are limited at construction stage.
Project Expansion of Agreste Pipeline System	B / D	Dust, noise and vibration during construction works.	Machinery control. Propre construction plan. Major impacts are limited at construction stage.
Project Expansion of Piauitinga Pipeline System	B / D	Dust, noise and vibration during construction works.	Machinery control. Propre construction plan. Major impacts are limited at construction stage.
Xingo Dam Pipeline Project	B / D	Dust, noise and vibration during construction works. Loss of vegetation. Water right.	Machinery control. Propre construction plan. Major impacts are limited at construction stage. Reconsideration of water right.
Vaza Barris Dam Project	A / C	Relocation. Dust, noise and vibration during construction works. Loss of vegetation. Change physical environment. Change of hydrological situation. Effect on fishery and ecosystem in downstream area. Increase in water borne disease.	Propre relocation plan and compensation. Consideration of dam design and operation. Machinery control. Propre construction plan. Creation of buffer zone. Monitoring program. Education program.
Project Expansion of Itabaianinha Pipeline System	B / D	Dust, noise and vibration during construction works.	Machinery control. Propre construction plan. Major impacts are limited at construction stage.
Project Expansion of Propria Pipeline System	B / D	Dust, noise and vibration during construction works.	Machinery control. Propre construction plan. Major impacts are limited at construction stage.
Project Expansion of Alto Sertao Pipeline Project	B / D	Dust, noise and vibration during construction works.	Machinery control. Propre construction plan. Major impacts are limited at construction stage.
Project Expansion of Sertaneja Pipeline Project	B / D	Dust, noise and vibration during construction works.	Machinery control. Propre construction plan. Major impacts are limited at construction stage.
Independent Water Supply System			
Sao Francisco River Direct Intake Projects	B / D	Dust, noise, vibration and traffic jam during construction works. Water right.	Machinery control. Propre construction plan. Major impacts are limited at construction stage.
Deep Well Development Projects	B / C	Noise, vibration and turbid water during construction works. Saltwater intrusion.	Machinery control. Propre construction plan. Water quality monitoring. Major impacts are limited at construction stage.
River Development Projects	B / C	Dust, noise, vibration and turbid water during construction works. Increase in water borne disease.	Machinery control. Propre design and construction plan. Water quality monitoring. Education program.
Jabiberi Dam Raising Project	B / C	Land acquisition. Dust, noise, vibration and turbid water during construction works. Loss of vegetation. Increase in water borne disease.	Propre compensation. Consideration of dam design. Propre construction plan. Turbid water control. Education program.
Small Rural Water Supply			
Single Well Systems (Public Taps)	B / C	Noise, vibration and turbid water during construction works. Saltwater intrusion.	Machinery control. Propre construction plan. Water quality monitoring. Major impacts are limited at construction stage.
Irrigation Water Supply			
Quixabeira Irrigation	B / C	Turbid water during construction works. Salt damage. Increase in water borne disease. Water right.	Machinery control. Propre design and construction plan. Soil quality monitoring. Education program.
Jacare-Curituba Irrigation	B / C	Turbid water during construction works. Salt damage. Increase in water borne disease. Water right.	Machinery control. Propre design and construction plan. Soil quality monitoring. Education program.
Sao Francisco Irrigation	B / C	Turbid water during construction works. Salt damage. Increase in water borne disease. Water right.	Machinery control. Propre design and construction plan. Soil quality monitoring. Education program.
Ladeirinhas Irrigation	D / D	-	-
Jacarecica II Irrigation	B / C	Dust, noise and turbid water during construction works. Salt damage.	Machinery control. Propre design and construction plan. Soil quality monitoring.
Vaza Barris Irrigation	B / C	Dust, noise and turbid water during construction works. Salt damage.	Machinery control. Propre design and construction plan. Soil quality monitoring.
Entre Rios Irrigation	D / D	-	-
Estancinha Irrigation	D / D	-	-

A: High Negative Impact, B: Low Negative Impact, C: Unknown Impact, D: No Impact