JAPAN INTERNATIONAL COOPERATION AGENCY

STATE SECRETARIAT OF PLANNING, SCIENCE AND TECHNOLOGY
THE STATE OF SERGIPE, THE FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY
ON
WATER RESOURCES DEVELOPMENT
IN THE STATE OF SERGIPE
IN
THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT
SUPPORTING
(VOLUME I)
MASTER PLAN STUDY

[J] OPERATION AND MANAGEMENT

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THE STUDY ON WATER RESOURCES DEVELOPMENT
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SUPPORTING REPORT (J)
OPERATION AND MANAGEMENT

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CHAPTER 1 WATER RESOURCES MANAGEMENT PLAN

Current legal framework for water resources management is described in Sector Report I. Institutional plan for water resources development and management is also proposed in Sector Report I. In this section, required programs for equitable water resources management are proposed.

1.1 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 - waters destined for;
- a) domestic water supply without previous disinfecting or with simple disinfecting
- b) preservation of natural balance of aquatic communities

Class 1 - waters destined for;
- a) domestic water supply after simple treatment
- b) protection of aquatic communities
- c) recreation of primary contact (swimming, water ski, and diving)
- d) irrigation for vegetable consumed raw and fruits growing in contact with soil, consumed raw or with peel
- e) natural or intensive breeding of species for human consumption (fish culture)

Class 2 - waters destined for;
- a) domestic supply after conventional treatment
- b) protection of aquatic communities
- c) recreation of primary contact (water ski, swimming and diving)
- d) irrigation for vegetable and fruits-bearing plants
- e) natural or intensive breeding of species for human consumption (fish culture)

Class 3 - waters destined for;
- a) domestic supply after conventional treatment
- b) irrigation for arboreal or cereal crops for forage
- c) animal breeding

Class 4 - waters destined for;
- a) navigation
- b) landscape harmony
- c) insignificant use

2) Saline Water

Class 5 - waters destined for;
- a) recreation of primary contact
- b) protection of aquatic communities
- c) natural or intensive breeding of species for human consumption (fish culture)

Class 6 - waters destined for;
- a) commercial navigation
- b) landscape harmony

c) recreation of secondary contact

3) Brackish Water

Class 7 - waters destined for;
a) recreation of primary contact
b) protection of aquatic communities
c) natural or intensive breeding of species for human consumption (fish culture)

Class 8 - waters destined for;
a) commercial navigation
b) landscape harmony
c) recreation of secondary contact

The following recommendation for classification of waters is made for six river basin, exclusive 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. Individual uses and developments for industrial/ commercial purposes as well as uses for recreation or navigation are not considered, since these types of use are out of the scope of the Study.

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 (or the autarchy recommended in Section 5.3) might be required. The classification should be discussed with each River Basin Committee before its legislation.

In the State of Parana in Brazil, almost all river waters are classified as Class 2 with many exceptions of Class 1 for sources of public water supply, and with a few exceptions of Special Class for environmental preservation (Coastal Mountains) and of Class 3 in down streams of some cities. No specific concerns were found for irrigation uses.

In this Study, waters of upper stream near the intake points for existing and projected public water supply or irrigation as listed in the table below (all projected crops include those consumed raw), the waters are recommended to be classified as Class 1. Waters whose water quality may affect the source of domestic and irrigation water recommended as Class 2 in principle. In case treatment process for public water supply is assured in terms of quality and quantity, the waters 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).

In case of the natural contamination, such as chloride concentration in many waters in the state, if remedial measures, such as Vaza Barris project, are not possible, the water can not be used for the purposes as listed in each class in the Resolution. The classification must follow the natural conditions. Major critical issues are shown in Section 1.6.

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 supply (as listed below) should also be classified as Class 1.

Table-1.1 (1/4) Locations of Water Intake

No.	Intake	Basin	River	Municipality	Supply System	Status	Purpose
Surface Water							
1	Amparo do S. F.	SFR	SFR	Amparo do S. F.	Adutora Sertaneja	Existing	P. W. S.
2	Caninde	SFR	SFR	Caninde do S. F.	California	Existing	Irrigation
	Caninde	SFR	SFR	Caninde do S. F.	California I	Existing	P. W. S.
3	Xingo Dam	SFR	SFR	Caninde do S. F.	California II	Existing	P. W. S.
	Xingo Dam	SFR	SFR	Caninde do S. F.	Jacare-Curitiba	Projected	Irrigation
	Xingo Dam	SFR	SFR	Caninde do S. F.	Quixabeira	Projected	Irrigation
	Xingo Dam	SFR	SFR	Caninde do S. F.	Sao Francisco	Projected	Irrigation
4	Cotinguiba	SFR	SFR	Cotinguiba	Cotinguiba	Existing	Irrigation
5	Gararu	SFR	SFR	Gararu	Gararu	Existing	P. W. S.
	Gararu	SFR	SFR	Gararu	Gararu	Projected	P. W. S.
6	Lagoa Fundo	SFR	SFR	Gararu	Lagoa Fundo	Existing	P. W. S.
7	E. S. Francisco	SFR	SFR	Ilha das Flores	Serrao	Existing	P. W. S.
8	Ilha das Flores	SFR	SFR	Ilha das Flores	Ilha das Flores	Existing	P. W. S.
9	Escurial	SFR	SFR	N. S. de Lourdes	Escurial	Existing	P. W. S.
10	Neopolis	SFR	SFR	Neopolis	Neopolis	Existing	P. W. S.
	Neopolis	SFR	SFR	Neopolis	Neopolis	Projected	P. W. S.
	Neopolis	SFR	SFR	Neopolis	Neopolis	Existing	Irrigation
11	Betume	SFR	SFR	Pacatuba	Betume	Existing	Irrigation
12	Bonsucesso	SFR	SFR	Porto da Folha	Bonsucesso	Existing	P. W. S.
13	Ilha do Ouro No.4	SFR	SFR	Porto da Folha	Adutora de Alto Sertao	Existing	P. W. S.
14	Propia	SFR	SFR	Propia	Propia	Existing	Irrigation
	Propia	SFR	SFR	Propia	Propia Integrated	Existing	P. W. S.
15	Mussuipe	SFR	SFR	St. do Sao Francisco	Mussuipe	Existing	P. W. S.
16	Saude	SFR	SFR	St. do Sao Francisco	Saude	Existing	P. W. S.
17	St. Sao do Francisco	SFR	SFR	St. Sao do Francisco	St. Sao do Francisco	Projected	P. W. S.
18	Pacatuba	SFR	Betume R./St. Antonio R.	Pacatuba	Pacatuba	Projected	P. W. S.
19	New Dam	SFR	Mundeu R.	Japoata	Ladeirinhas	Projected	Irrigation
20	Japaotao	SFR	N.S. do Desterro R.	Japaotao	Japaotao	Existing	P. W. S.
21	Riacho Ribeira	SFR	Ribeira St.	St. do Sao Francisco	Pindoba	Existing	P. W. S.
22	Capela	J. R.	J. R.	Capela	Pirunga	Existing	P. W. S.
23	Diogo	J. R.	J. R.	Carmopolis	Carmopolis	Existing	P. W. S.
24	Capela	J. R.	Aldeira R.	Capela	Capela	Projected	P. W. S.
25	Lagatixo	J. R.	Lagartixo St.	Capela	Capela & Pedras	Existing	P. W. S.
26	N. S. das Dores	J. R.	Siriri R.	Siriri	N. S. das Dores	Existing	P. W. S.
27	Siriri	J. R.	Siriri R.	Siriri	Siriri	Existing	P. W. S.
28	Bernardo	J. R.	Siriri R.	Capela	Siririzinho	Existing	P. W. S.
29	Capela	J. R.	Siriri R.	Capela	Capela	Projected	P. W. S.
30	Rosario do Catete	J. R.	Siriri R.	Rosario do Catete	Rosario do Catete	Projected	P. W. S.
31	N. S. das Dores	J. R.	Siriri R./Pinol R.	Siriri	N. S. das Dores	Projected	P. W. S.
32	Cajueiro dos Caldas	S. R.	S. R.	Malhador	Malhador	Existing	P. W. S.
33	Central I	S. R.	S. R.	Riachuelo	Riachuelo	Existing	P. W. S.
34	Riachuelo	S. R.	Jacarecica R.	Riachuelo	Riachuelo	Projected	P. W. S.
35	Jacarecica Dam	S. R.	Jacarecica R.	Itabaiana	Jacarecica	Existing	Irrigation
36	Jacarecica II Dam	S. R.	Jacarecica R.	Itabaiana	Jacarecica II	Projected	Irrigation
27	Cabrita	S. R.	Pitanga R.	S. Cristovao	Aracaju Integrated	Existing	P. W. S.
38	Poxim	S. R.	Poxim R.	S. Cristovao	Aracaju Integrated	Existing	P. W. S.
39	Malhador	S. R.	Velmelho R.	Malhador	Malhador	Projected	P. W. S.
40	Barragem do Muniz	V. R.	V. R.	Sao Cristovao	Sao Cristovao	Existing	P. W. S.
41	Banho Morno	V. R.	V. R.	Sao Cristovao	Sao Cristovao	Existing	P. W. S.
42	Vaza Barris Dam	V. R.	V. R.		Vaza Barris Dam	Projected	P. W. S.
	Vaza Barris Dam	V. R.	V. R.		Vaza Barris	Projected	Irrigation
43	Sao Cristovao	V. R.	Comprido R.	Sao Cristovao	Sao Cristovao	Existing	P. W. S.
44	Coqueiros	V. R.	Coqueiros St.	Itabaiana	Itabaiana Integrated	Existing	P. W. S.
45	Ribeira	V. R.	Ribeira R.	Itabaiana	Itabaiana Integrated	Existing	P. W. S.

Table-1.1 (2/4) Locations of Water Intake

No.	Intake	Basin	River	Municipality	Supply System	Status	Purpose
46	Itaporanga D' Ajuda	V. R.	Tejupeba R.	Itaporanga D' Ajuda	Itaporanga D' Ajuda	Projected	P. W. S.
47	Cajaiba Dam	V. R.	Trairas R.	Itabaiana	Itabaiana Integrated	Existing	P. W. S.
	Cajaiba Dam	V. R.	Trairas R.	Itabaiana	Pocao da Ribeira	Existing	Irrigation
48	Estancia	P. R.	P. R.	Estancia	Estancia	Projected	P. W. S.
49	Aninha	P. R.	Aninha R.	Araua	Araua	Existing	P. W. S.
50	Araua	P. R.	Araua R./Camboata R.	Araua	Araua	Projected	P. W. S.
51	Boquim	P. R.	Araua R./Garangal R.	Boquim	Boquim	Projected	P. W. S.
52	Pedrinhas	P. R.	Araua R./Tributary	Pedrinhas	Pedrinhas	Projected	P. W. S.
52	Areias	P. R.	Areias St.	Araua	Pedrinhas	Existing	P. W. S.
54	Piaui Dam	P. R.	Cabacio R	Lagarto	Piaui	Existing	Irrigation
55	Capoeira	P. R.	Capoeira St.	(Bahia)	Tobias Barreto	Existing	P. W. S.
56	Taboca	P. R.	Fundo R.	Itaporanga D' Ajuda	Sape	Existing	P. W. S.
	Tobacco	P. R.	Fundo R.	Itaporanga D' Ajuda	Genipado	Existing	P. W. S.
57	Grilo	P. R.	Grilo St.	Boquim	Boquim	Existing	P. W. S.
58	Guararema I	P. R.	Guararema R.		Itabaianinha Pipeline	Projected	P. W. S.
59	St. Luzia do Itanhy	P. R.	Guararema R./Ariquitiba R.	St. Luzia do Itanhy	St. Luiza do Itanhy	Projected	P. W. S.
60	Guararema II	P. R.	Indiaroba R.		Itabaianinha Pipeline	Projected	P. W. S.
61	Cristinapolis	P. R.	Itamirim R.	Cristinapolis	Cristinapolis	Projected	P. W. S.
62	Piauitinga	P. R.	Piauitinga R.	Salgado	Piauitinga Integrated	Existing	P. W. S.
63	Estancia	P. R.	Piauitinga R.	Estancia	Estancia	Existing	P. W. S.
	Estancia	P. R.	Piauitinga R.	Estancia	Estancia	Projected	P. W. S.
64	Estancia	P. R.	Piauitinga R./Capivara R.	Estancia	Estancia	Projected	P. W. S.
65	Salgado	P. R.	Piauitinga R./Grilo R.	Salgado	Salgado	Projected	P. W. S.
66	Entre Rios	P. R.	Quebardas R.	Estancia	Entre Rios	Projected	Irrigation
67	Estancinha	P. R.	Riachao R.	Estancia	Estancinha	Projected	Irrigation
68	Cidade Nova	P. R.	Riacho Biribinha St.	Estancia	Cidade Nova	Existing	P. W. S.
69	Brejo	R. R.	Da Jiboia R.	Cristinapolis	Cristinapolis	Existing	P. W. S.
70	Fundo	R. R.	Fundo R.	Itaporanga D' Ajuda	Itaporanga D' Ajuda	Existing	P. W. S.
	Fundo	R. R.	Fundo R.	Itaporanga D' Ajuda	Itaporanga D' Ajuda	Projected	P. W. S.
71	Riacho do Imbe	R. R.	Guararema R.	Umbauba	Itabaianinha Integrated	Existing	P. W. S.
72	Jabiberi Dam	R. R.	Jabiberi R.	Tobias Barreto	Tobias Barreto	Projected	P. W. S.
	Jabiberi Dam	R. R.	Jabiberi R.	Tobias Barreto	Jabiberi	Existing	Irrigation
73	Indiaroba	R. R.	Paripe R.	Indiaroba	Indiaroba	Existing	P. W. S.
	Indiaroba	R. R.	Paripe R.	Indiaroba	Indiaroba	Projected	P. W. S.
Groundwater							
1	Brejao dos Negros	SFR		Brejo Grande	Brejao dos Negros	Existing	P. W. S.
2	Brejo Grande	SFR		Brejo Grande	Brejo Grande	Existing	P. W. S.
	Brejo Grande	SFR		Brejo Grande	Brejo Grande	Projected	P. W. S.
3	Ilha das Flores	SFR		Ilha das Flores	Ilha das Flores	Projected	P. W. S.
4	Japoata	SFR		Japoata	Japoata	Projected	P. W. S.
5	Ladeirinhas	SFR		Japoata	Ladeirinhas	Existing	P. W. S.
6	Poxim	SFR		Japoata	Poxim	Existing	P. W. S.
7	Tatu	SFR		Japoata	Tatu	Existing	P. W. S.
8	Lagoa Redonda	SFR		Monte Alegre de Sergipe	Lagoa Redonda	Existing	P. W. S.
9	Estiva do Raposo	SFR		Pacatuba	Estiva do Raposo	Existing	P. W. S.
10	Pacatuba	SFR		Pacatuba	Pacatuba	Existing	P. W. S.
11	Ponta de Areia	SFR		Pacatuba	Ponta de Areia	Existing	P. W. S.
12	Ponta dos Mangues	SFR		Pacatuba	Ponta dos Mangues	Existing	P. W. S.
13	Alagamar	SFR		Pirambu	Alagamar	Existing	P. W. S.
14	Espinheiro	SFR		Sao Francisco	Espinheiro	Existing	P. W. S.
15	Galante	SFR		Sao Francisco	Sao Francisco	Existing	P. W. S.
16	Sao Francisco	SFR		Sao Francisco	Sao Francisco	Existing	P. W. S.
	Sao Francisco	SFR		Sao Francisco	Sao Francisco	Projected	P. W. S.
17	St. do Sao Francisco	SFR		St. do Sao Francisco	St. do Sao Francisco	Existing	P. W. S.
18	Capela	J. R.		Capela	Miranda	Existing	P. W. S.
19	Muribeca	J. R.		Capela	Muribeca	Existing	P. W. S.
	Muribeca	J. R.		Capela	Muribeca	Projected	P. W. S.

Table-1.1 (3/4) Locations of Water Intake

No.	Intake	Basin	River	Municipality	Supply System	Status	Purpose
20	Capela	J. R.		Capela	Saude	Existing	P. W. S.
21	Mercado	J. R.		Carmopolis	Aguada	Existing	P. W. S.
22	Treme	J. R.		Carmopolis	Aguada	Existing	P. W. S.
23	Pedrinhas	J. R.		Carmopolis	Aguada	Existing	P. W. S.
24	Idelfonso	J. R.		Carmopolis	Aguada	Existing	P. W. S.
25	Well 1432	J. R.		Carmopolis	Carmopolis	Existing	P. W. S.
26	Bairro Novo	J. R.		Carmopolis	Carmopolis	Existing	P. W. S.
27	Ecoclube	J. R.		Carmopolis	Carmopolis	Existing	P. W. S.
28	Conjunto	J. R.		Carmopolis	Carmopolis	Existing	P. W. S.
29	Carmopolis	J. R.		Carmopolis	Carmopolis	Projected	P. W. S.
30	Fonte Olhos	J. R.		General Maynard	General Maynard	Existing	P. W. S.
31	General Maynard	J. R.		General Maynard	General Maynard	Existing	P. W. S.
	General Maynard	J. R.		General Maynard	General Maynard	Projected	P. W. S.
32	Prata	J. R.		Japaratuba	Japaratuba	Existing	P. W. S.
33	Sao Jose	J. R.		Japaratuba	Japaratuba	Existing	P. W. S.
34	Japaratuba	J. R.		Japaratuba	Japaratuba	Projected	P. W. S.
35	Pirambu	J. R.		Pirambu	Pirambu	Existing	P. W. S.
	Pirambu	J. R.		Pirambu	Pirambu	Projected	P. W. S.
36	Ribeiropolis	J. R.		Ribeiropolis	Ribeiropolis	Existing	P. W. S.
37	Caldas	J. R.		Rosario do Catete	Rosario do Catete	Existing	P. W. S.
38	Siriri	J. R.		Siriri	Siriri	Projected	P. W. S.
39	Pedrinhas	S. R.		Areia Branca	Pedrinhas	Existing	P. W. S.
40	B dos C	S. R.		Barra dos Coqueiros	Atalaia Nova	Existing	P. W. S.
	B dos C	S. R.		Barra dos Coqueiros	Barra dos Coqueiros	Existing	P. W. S.
41	Barra dos Coqueiros	S. R.		Barra dos Coqueiros	Barra dos Coqueiros	Projected	P. W. S.
42	Estiva	S. R.		Laranjeiras	Laranjeiras	Existing	P. W. S.
43	Tintina	S. R.		Laranjeiras	Laranjeiras	Existing	P. W. S.
44	Fonte da Mata	S. R.		Maruim	Divina Pastora	Existing	P. W. S.
45	Mata do Cabau	S. R.		Maruim	Divina Pastora	Existing	P. W. S.
46	Divina Pastora	S. R.		Maruim	Divina Pastora	Projected	P. W. S.
47	Lavanderia	S. R.		Maruim	Maruim	Existing	P. W. S.
48	Pista	S. R.		Maruim	Maruim	Existing	P. W. S.
49	Cohidro	S. R.		Maruim	Maruim	Existing	P. W. S.
50	Fazenda	S. R.		Maruim	Maruim	Existing	P. W. S.
51	Maruim	S. R.		Maruim	Maruim	Projected	P. W. S.
52	Moita Bonita	S. R.		Moita Bonita	Moita Bonita	Existing	P. W. S.
53	Serra do Machado	S. R.		Moita Bonita	Serra do Machado	Existing	P. W. S.
54	Ibura	S. R.		N.S. Scorro	Aracaju Integrated	Existing	P. W. S.
	Ibura	S. R.		N.S. Scorro	Aracaju Integrated	Existing	P. W. S.
55	Oiteiro	S. R.		N.S. Scorro	Aracaju Integrated	Existing	P. W. S.
	Ibura	S. R.			Aracaju Integrated	Projected	P. W. S.
56	Fazenda Lombada	S. R.		St. Amaro das Brotas	St. Amaro das Brotas	Existing	P. W. S.
57	St. Amaro das Brotas	S. R.		St. Amaro das Brotas	St. Amaro das Brotas	Projected	P. W. S.
58	Frexeira	S. R.		St. Rosa de Lima	Canabrava	Existing	P. W. S.
59	Jaqueira	S. R.		St. Rosa de Lima	St. Rosa de Lima	Existing	P. W. S.
60	Santa Rosa de Lima	S. R.		St. Rosa de Lima	St. Rosa de Lima	Projected	P. W. S.
61	Macambira	V. R.		Macambira	Itabaiana Integrated	Existing	P. W. S.
62	Sao Cristovao	V. R.		Sao Cristovao	Sao Cristovao	Projected	P. W. S.
63	Sercado	V. R.		Sao Domingos	Sao Domingos	Existing	P. W. S.
64	Lagoa	V. R.		Sao Domingos	Sao Domingos	Existing	P. W. S.
65	Mulunga	V. R.		Sao Domingos	Sao Domingos	Existing	P. W. S.
66	Casa Caiada	P. R.		Araua	Casa Caiada	Existing	P. W. S.
67	Pastor	P. R.		Boquim	Pastor	Existing	P. W. S.
68	Convento	P. R.		Indiaroba	Convento	Existing	P. W. S.
69	Crasto	P. R.		Indiaroba	Crasto	Existing	P. W. S.
70	Pontal	P. R.		Indiaroba	Pontal	Existing	P. W. S.
71	Brasilia	P. R.		Lagarto	Brasilia	Existing	P. W. S.
72	Agua Fria	P. R.		Salgado	Agua Fria	Existing	P. W. S.
73	Pe da Serra	P. R.		Salgado	Piauitinga Integrated	Existing	P. W. S.
74	Salgado	P. R.		Salgado	Piauitinga Integrated	Existing	P. W. S.
75	15 Voa Vista	P. R.		Salgado	Piauitinga Integrated	Existing	P. W. S.

Table-1.1 (4/4) Locations of Water Intake

No.	Intake	Basin	River	Municipality	Supply System	Status	Purpose
76	Emsetur	P. R.		Salgado	Salgado	Existing	P. W. S.
77	St. Luzia do Itanhy	P. R.		St. Luzia do Itanhy	St. Luzia do Itanhy	Existing	P. W. S.
78	Samambaia	R. R.		(Bahia)	Samambaia	Existing	P. W. S.
79	Poco Verde	R. R.		Poco Verde	Poco Verde	Existing	P. W. S.
80	Faz. Fonte Grande	R. R.		Umbauba	Itabaianinha Integrated	Existing	P. W. S.

Note: SFR: Sao Francisco River, J.R.: Japaratuba River, S.R.: Sergipe River, V.R.: Vaza Barris River, P.R.: Piaui River, R.R.: Real River, P.W.S.: Public Water Supply

1.2 Hydro-meteorological and Hydro-geological Observation, and Water Quality Monitoring

After or in parallel with the environmental classification, the following observation and monitoring should be carried out regularly.

1.2.1 Meteorology

(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.

(a) 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.

(b) 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.

(c) 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-1.2 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	

(d) Data to be Collected

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

(a) 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 endorsed 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.

(b) Collection and Input of Data

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.

Daily rainfall is read by the gauge reader and recorded on forms kept at the gauge location. Every two weeks, the daily totals are sent to the regional EMDAGRO office in each municipality but only the monthly total is then forwarded to the central headquarters for data inputting. 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. The regional EMDAGRO offices have recently been equipped with desk-top computers and it is recommended that the responsibility for data input and archiving be passed to the local offices. The completed data files could then be forwarded to a central data processing office by email or floppy disk.

1.2.2 Surface Water

(1) Necessity for Hydrometric Observation

The current hydrometric observation network is not adequate for the monitoring and analysis of surface water resources of the State. The accurate measurement of river flows is necessary for two main reasons:

1) Monitoring and assessment of surface water resources
2) Monitoring of available discharge at surface water intake points

(2) Hydrometric Observation Network

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 hydro-power 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-1.3.

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. In addition, staff gauges and gauge readers are required at the independent water supply systems proposed in Section 5.4.

Table-1.3 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 Proposed new stations
Vaza Barris	4	Ponte SE-302, Faz. Belem, Salgado, Rch. Das Trairas	Existing ANEEL stations Proposed new stations
Piaui	3	Piauitinga, Piaui - Estancia, Araua	Existing ANEEL station Proposed new stations
Real	4	Faz. Tourao, Itabi, Jabiberi, Itamirim	Existing ANEEL stations Proposed new stations

(3) 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 is 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 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.

(4) Basic Analyses

With the data collected in the measurement of the above, the following basic analyses is necessary by SRH/WA.

1) Preparation of discharge rating curve
2) Calculation of discharge by station
3) Calculation of annual flow regime by station

(5) Sediment Sampling and Analysis

Although sedimentation is not problematic in Sergipe, sampling and analysis of sediment for main rivers might be useful for existing and future reservoir development and management.

1.2.3 Groundwater

(1) Necessity of Groundwater Monitoring

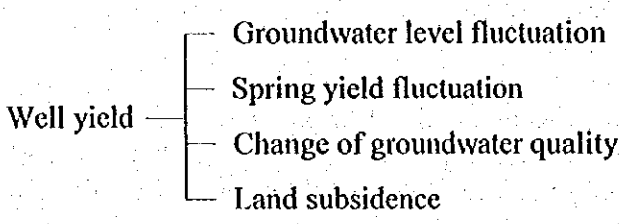
Over abstraction of groundwater, which can disturb the balance between groundwater recharge and discharge in natural conditions, causes regional groundwater level decline and problems in groundwater quality. These phenomena, namely groundwater hazards, may take place in large area, and a great number of people who live in the area and drink groundwater may suffer health problems and economic damage from the groundwater hazards. Over pumping must be regulated to prevent the groundwater disasters. The purposes of the groundwater monitoring are to prevent the groundwater hazards and conserve groundwater resource. Groundwater hazards caused by over pumping are as follows;

- Water table draw-down and drying up of wells
- Yield decrease and drying up of springs
- Water quality problem
- Sea water intrusion into aquifer in the coastal area
- Land subsidence in the coastal area

Sever groundwater hazards listed above have not yet appeared so far in Sergipe State, however, there is a high possibility of the deterioration in the near feature. In the case of groundwater hazards, the result of the monitoring can clarify the relationship between over pumping and groundwater hazards, and adequate countermeasures such as pumping regulation will be formulated based on the analysis. On the other hand, groundwater monitoring has another function of evaluating groundwater potential, hence, the groundwater monitoring is useful for both groundwater resource conservation and groundwater resource development.

(2) Method of Groundwater Monitoring

The result of groundwater monitoring must clarify the relationship shown below;



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 data-base. Then, the representative wells/springs should be selected as monitoring wells/springs referring to the well data-base, and the groundwater monitoring should be started. For this purpose, SRH should make the well data-base and select monitoring wells/springs, and users of wells/springs should carry out the groundwater monitoring. For such springs as are now in intensive use and important for common use, SRH should carry out the monitoring. Groundwater monitoring should be carried out step by step as described below.

(a) First Stage

Data-base 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 data-base.

(b) Second Stage

Representative wells/springs should be selected as monitoring wells/springs referring to the well data-base, then the groundwater monitoring should be regularly carried out.

Monitoring sites

The groundwater monitoring shall be carried out at the important springs and wells with great yield. Actual monitoring sites shall be selected after completion of the well data-base. In case of extraordinary phenomena indicating groundwater hazards in groundwater level or water quality, additional observation wells should be set near the monitoring site to collect additional data.

Observation items and observation frequency

Users of the monitoring wells/springs should carry out the groundwater monitoring regularly on items listed below, and should report the results to SRH. The groundwater monitoring should be carried out once a month as a rule.

- Yield of wells/springs
- Groundwater level of wells
- Groundwater quality
- Unusual deformation of buildings/facilities caused by differential ground settlement

Concerning groundwater quality, owners of the monitoring wells/springs can report the results of water quality tests which are usually carried out by the owners for its' original purposes. SRH, if needed, can order water quality test to the owners of the monitoring wells/springs which do not have any water quality data. Concerning land subsidence, unusual deformation of buildings/facilities caused by differential ground settlement, such as inclination of buildings, pipe deformation, uneven ground etc., should be reported to SRH.

(c) 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.

Concerning land subsidence, for the time being unusual deformation of the buildings/facilities should be observed with the eye. After the land subsidence is made clear to be taking place, accurate land subsidence should be measured by leveling. The other kinds of groundwater hazards such as groundwater contamination caused by discharge of toxic substance into the ground should be dealt individually by SRH or ADEMA.

1.3 Water Quality Monitoring

1.3.1 Establishing Monitoring System

Currently no regular quality monitoring of waters 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.

Although, some of the sites, being near each other, can be grouped and one representing site can be selected for the efficiency of the monitoring. If the aquifers in a municipality can be grouped into one, the number could be near 35.

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 the table below. Items for regular monitoring should be continuously revised, preferably once in five years, taking changes in industrial process along waters and use in agricultural and household chemicals, as well as progress in monitoring and monitoring equipment, into account.

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.

1.3.2 Monitoring Items

The following items monitoring can be recommended as a base of discussion.

Table-1.4 Required Items for Regular Water Quality Monitoring

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

1.3.3 Reporting Results of Hydrological Assessment and Water Quality Monitoring

The results of hydrological assessment and water quality monitoring 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.

1.4 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 followings.

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.

Examination and registry of environmental auditors should be managed by a federal organ or ADEMA. In case a fake report or an inadequate report by an environmental auditor is found, the auditor will lose the license, or the profession. 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 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.

1.5 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, 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 regulated land use and development in terms of the followings.

1.5.1 Forest Development, Preservation and Management

Although large scale forest development or preservation for water resources conservation might not 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.

(1) Areas for Groundwater Recharging

Forest areas hold water, after rain fall 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.

Table-1.5 Effects of Change in Land Use on Water Resources Conservation

Change in Land Use of Forest	Effect on Capability in Water Retention and Groundwater Recharging
Change in Forestry Management	
- careful cutting with sufficient intervals	0
- cutting all trees	* to **
Change Land Use to	
- pasture	**
- farmland	** to ***
- residential areas	***

Note: 0; little change, *; small change, **; medium change, ***; large change
Source: Forest hydrology, Y. Tsukamoto, 1992, modified by the Study Team

(2) 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.

1.6 Restriction of Contaminating Activities near Sources of Water

1.6.1 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.

1.6.2 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.

1.7 Costs of Programs for Water Resources Management

The programs proposed above will incur the following initial and operation costs. 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.

Classification

The cost of a study for the classification can be roughly estimated at R$ 25 to 30 thousand for a river basin and R$ 160 thousand for all of the five basins and sub-basins of the Sao Francisco River.

Meteorological Stations

Construction of five meteorological stations and rehabilitation of one station would take a cost of R$ 72 thousands.

Rainfall Gauges

Purchase of 40 sets of complete rainfall gauges would cost R$ 24 thousand.

River Flow Measurement

The cost for installment of and AWLR system at an existing station would cost R$ 24 thousand, and construction of a new station would require a cost of R$ 30 thousand. The improvement of river flow measurement network would require an investment of R$ 600 thousands.

Measurement could be efficiently done by contracting with residents or a branch offices of relevant entity near the station after preparation of manual and simple training for readers. Annual cost for a station could be around R$ 1 thousand for a station and R$ 24 thousand in total.

Water Quality Monitoring

Establishment of a laboratory in ADEMA will take the cost of R$ 60 thousands with two sets of equipment and materials for the analysis of water quality of items for regular monitoring. For the initial monitoring of all items in the CONAMA Resolution, items which cannot be analyzed in the laboratory of ADEMA should be outsourced to other laboratories out of the State, and the analysis will require the cost of R$ 220 thousand. Procurement of 10 sets of handy quality analyzers to DESO branch offices and dam operation offices will require the cost of R$ 36 thousand.

Operation of monthly monitoring and reporting, and sending samples twice a year, carried out by a technician of each DESO branch office, payable to DESO might be R$ 42 thousand annually for a branch and R$ 210 thousand per year in total.

CHAPTER 2 CURRENT CONDITIONS OF OPERATION AND MAINTENANCE FOR WATER SUPPLY

2.1 Entities in Charge

2.1.1 Domestic Water Supply in Urban Areas and Large Villages

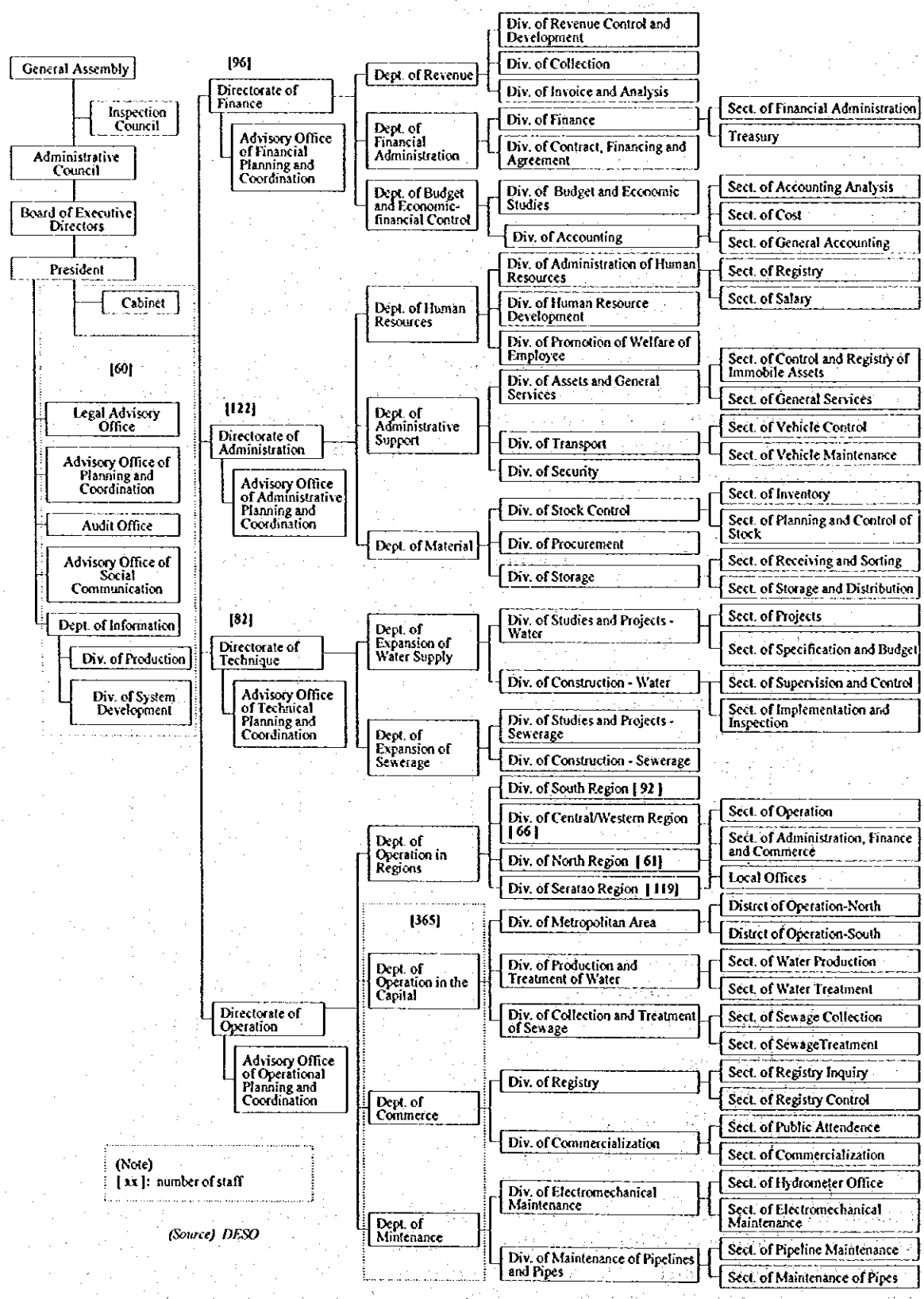
Currently in the State of Sergipe, the water supply for domestic use is mainly implemented by DESO (Sanitation Company of Sergipe) in urban areas and large villages. Four Municipal Governments out of 75 ones operate water supply schemes by themselves with assistance of FNS (National Foundation of Health). However, the involvement of FNS is decreasing. As for industrial water supply, many of industries supply by themselves, while some of industries, especially small industries, use water supplied by DESO.

DESO has employed as many as 1,066 (Sept.,1998) persons for the services of water supply to the population of 1,320 thousand (82% of the total population of the State) and sewerage services for the population of 176 thousand (29% of the total). DESO is a state-owned company (so called mixed-economy society), almost 100% of whose share is held by the State Government.

Table-2.1 Outline of the Services by DESO

		1996 Nov.	1998 Oct.
1.	**Water Supply**		
1.1	Covered Locations	252	292
	Municipal Capital	70	70
	Villages	182	222
1.2	Population Covered	1,214,913	1,319,988
	(%) to the Total Population	78 %	82 %
1.3	Connection	265,449	296,850
	Connected	250,611	276,033
	Disconnected	17,310	23,907
1.4	Volume of Billed Water	4,922,339 m^3	5,114,544 m^3
1.5	Volume of Consumed Water	4,643,703 m^3	4,757,005 m^3
1.6	Volume of Produced Water	8,505,429 m^3	8,549,901 m^3
1.7	Pipe Extension	3,931 km	4,183 km
2.	**Sewerage**		
2.1	Covered Locations	3	3
	Population Covered	158,784	176,264
	(%) to the Total Population	27 %	29 %

Headquarters of DESO, being comprised of Directorates of Administration, Finance and Technique, and advisory offices to the Presidents, employs 360 persons which account for 34% of the total personnel. The rest of 706 persons, or 66% of the staff, are engaged in operation and maintenance, including some commercial activities, or seconded to the State Government or other companies. Out of the staff for operation and maintenance 365 persons, or 52% of the staff, are engaged in the operation and maintenance in the Capital region (Aracaju), while the rest of 337 persons work in the other regions over the state.



(Source) DESO

Figure-2.1 Organization Structure of DESO

Current structure of water tariff by DESO is given below. DESO takes fixed charge plus progressive block tariff: where succeeding blocks of units of water are sold at higher and higher prices. From small to medium scale user, tariff of residential water is lower than that for commercial or industrial user, while large commercial or industrial users enjoy slightly lower tariff than that for large residential users. The tariff up to 100 m^3 for public institutes are comparatively high.

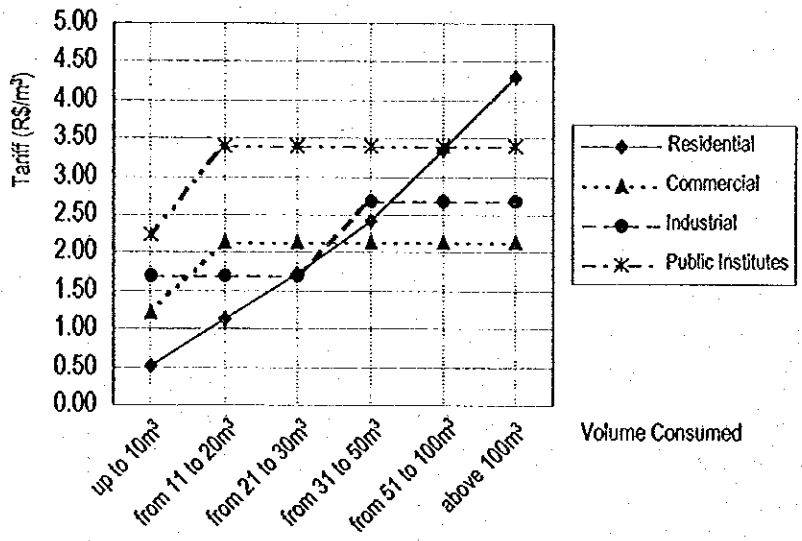


Figure-2.2 Water Tariff by DESO (Jun. 1998)

According to the financial data provided by DESO, the net losses of the recent three years amount to 7% to 9% of total operating expense. The personnel costs still share as high as 46% of the total costs in 1997. Administration costs accounted for nearly 36% in 1997 whose portion to the total operational expenditure increased by 2% annually in recent three years, while costs for operation, maintenance and commercial activities shared around 60% in 1997 whose portion in the operational expenditure has been decreasing by 2% to 4% annually, on the contrary.

Table-2.2 Profit/Loss Statements of DESO

(amount: R$ thousand)

	1997		1996		1995	
	amount	% to OE	amount	% to OE	amount	% to OE
Operating Revenue	63,611	93%	52,953	94%	42,287	95%
Water Supply	57,062	84%	47,071	83%	37,424	84%
Sewerage Service	6,549	10%	5,881	10%	4,863	11%
Operating Expense	68,114	100%	56,568	100%	44,563	100%
Operation and Maintenance Cost	39,992	59%	34,773	61%	29,003	65%
Personnel Cost	18,304		17,113			
Material Cost	2,216		1,183			
Outsourcing Cost	11,120		8,120			
General Expense	58		48			
Depreciation	8,294		8,310			
Commercial Cost	858	1%	671	1%	586	1%
Personnel Cost	672		562			
Material Cost	15		52			
Outsourcing Cost	164		54			
General Expense	7		3			
Administration Cost	24,246	36%	19,279	34%	14,362	32%
Personnel Cost	12,644		10,901			
Material Cost	1,489		1,365			
Outsourcing Cost	7,446		5,523			
General Expense	2,572		1,396			
Depreciation	95		95			
Tax and Duty	3,017	4%	1,844	3%	612	1%
Operating Loss	Δ4,503	-7%	Δ3,615	-6%	Δ2,275	-5%
Non-operating Revenue	1,499	2%	459	1%	442	1%
Financial Receipt	965		56		136	
Others	534		403		306	
Non-operating Expense	1,842	3%	1,808	3%	1,469	3%
Net Loss	Δ4,847	-7%	Δ4,964	-9%	Δ3,303	-7%
(Personnel Cost)	31,620	46%	28,576	51%		
(Outsourcing Cost)	18,730	27%	13,697	24%		

Source: DESO

2.1.2 Domestic in Small Rural Areas and Agricultural Water

COHIDRO (Company of Water Resources Development and Irrigation) takes a major role in domestic water supply in rural areas through provision of public tab systems. COHIDRO is also in charge of irrigation. As of October 1998, COHIDRO employs 488 persons not only for the services mentioned above but also for actions on agricultural land and on mechanization of agriculture. The organization structure of COHIDRO is illustrated in the figure below.

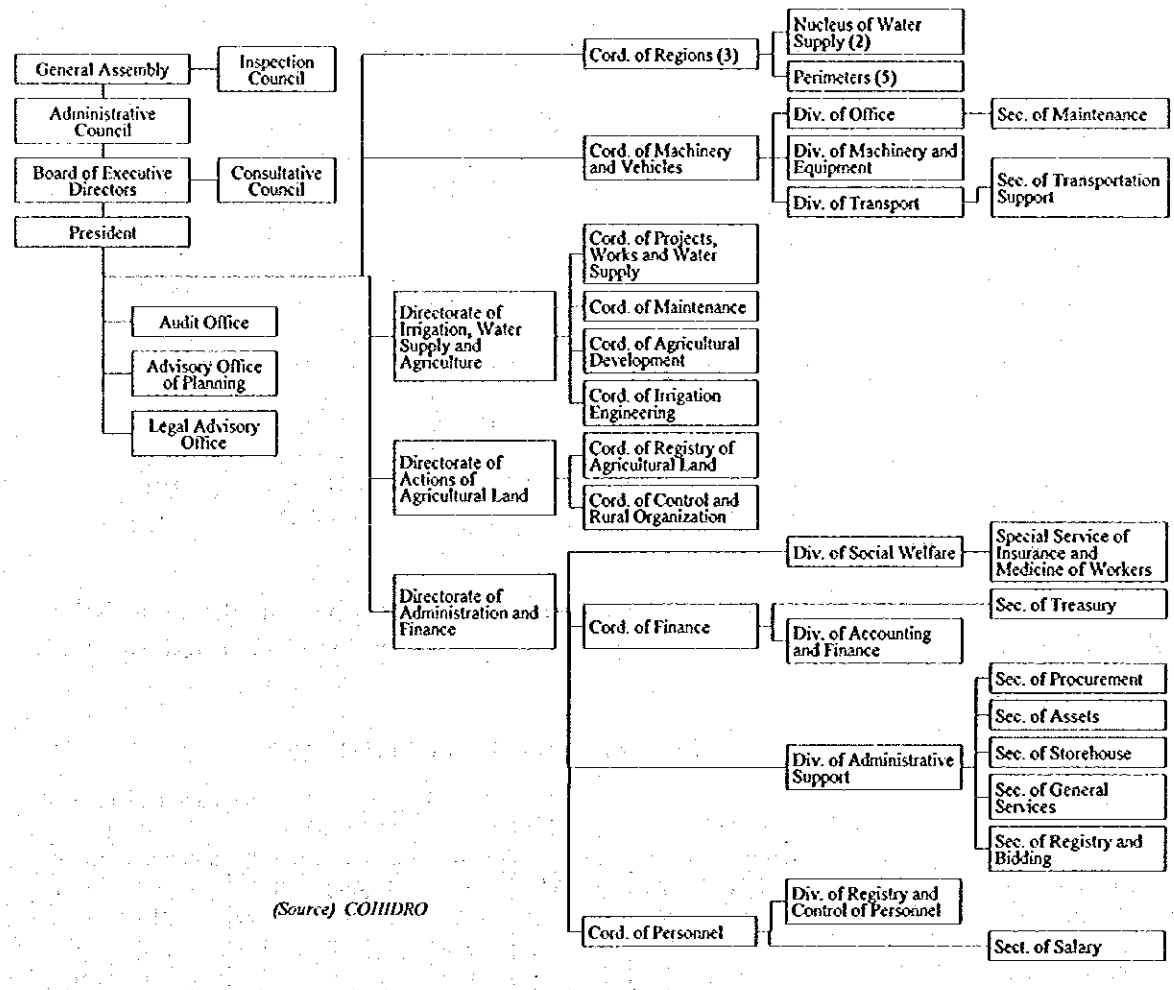


Figure-2.3 Organization Chart of COHIDRO

Currently users of domestic water supplied by COHIDRO do not pay for the services even for the cost of operation and maintenance, such as electricity for pumps, while some part of the costs for irrigation are charged on users, whose tariff is shown in the table below. In some perimeters, the tariff for irrigation service is charged by volume of water used, while in other perimeters the tariff is set by area of land cultivated. The level of the tariff varies widely in cases that the tariff is charged by land area, while the rate charged by volume is unified in all three perimeters.

Table-2.3 Tariff for Irrigation Water

Perimeter	Tariff	Unit
1. California	R$ 66.660	/ha./4 month
2. Jacare-Curituba	not yet determined	
3. Neopolis	R$ 4.500	/ha./month
4. Jacarecica	R$ 0.025	/m³
5. Pocao da Ribeira	R$ 0.025	/m³
6. Piaui	R$ 0.025	/m³
7. Jabiberi	R$ 30.000	/ha./4 month

Source: COHIDRO

Amount of tariff collected and O&M expenses in irrigation perimeters in 1998 are given below. The cost recovery by tariff collection remains quite low. The rate of tariff collections seems very low.

Table-2.4 Tariff Revenue and O&M Expenses in Irrigation Perimeters

(Unit: R$)

Perimeter	Tariff Revenue	Energy Cost	Other O&M Costs	Total O&M Cost	Deficit
Jacarecica	36,824	57,431	140,693	198,124	161,300
(% to Total O&M Cost)	(19%)	(29%)	(71%)	(100%)	(81%)
Pocao da Ribeira	92,955	286,497	254,450	540,947	447,992
(% to Total O&M Cost)	(17%)	(53%)	(47%)	(100%)	(83%)
Piaui	24,855	77,293	177,060	254,353	229,498
(% to Total O&M Cost)	(10%)	(30%)	(70%)	(100%)	(90%)
California	144,609	1,408,703	638,212	2,046,915	1,902,306
(% to Total O&M Cost)	(7%)	(69%)	(31%)	(100%)	(93%)
Jabiberi	11,435	0	41,250	41,250	29,815
(% to Total O&M Cost)	(28%)	(0%)	(100%)	(100%)	(72%)
Total	310,679	1,829,926	1,251,667	3,081,593	2,770,914
(% to Total O&M Cost)	(10%)	(59%)	(41%)	(100%)	(90%)

Source: COHIDRO

Profit/loss statements of COHIDRO in recent four years are given in the table below. Most of the figures in the statement develop irregularly. Large losses occurred especially in recent two years.

Table-2.5 Profit/Loss Statement of COHIDRO

(amount: R$ thousand)

	1997		1996		1995		1994	
	amount	% to OE	amount	% to OE	amount	% to OE	amount	% to OE
Operating Revenue	1,861	15%	2,545	23%	11,662	80%	6,362	93%
Revenue from Services	1,958	16%	1,832	17%	11,205	77%	6,210	91%
Other Revenue	0	0%	713	7%	458	3%	152	2%
Revenue Deducted	Δ96	-1%	0	0%	0	0%	0	0%
Operating Expense	12,572	100%	10,915	100%	14,617	100%	6,861	100%
Operation Cost for Services	7,570	60%	1,043	10%	4,286	29%	237	3%
Administration Cost	4,786	38%	8,992	82%	9,494	65%	6,148	90%
Depreciation	216	2%	880	8%	837	6%	476	7%
Operating Loss	Δ10,711	-85%	Δ8,370	-77%	Δ2,954	-20%	Δ499	-7%
Non-operating Revenue	211	2%	462	4%	254	2%	332	5%
Non-operating Expense	1,335	11%	8	0%	84	1%	533	8%
Tax and Duty	0	0%	186	2%	301	2%	233	3%
Net Loss	Δ11,835	-94%	Δ8,103	-74%	Δ3,085	-21%	Δ932	-14%

Source: COHIDRO

2.2 Current Status of State-owned Companies

For the administration of the state, state-owned companies take important roles, taking a major functions as a part of indirect administration. In the State Government, indirect administration, being composed of autarchies (autarquias), foundations (fundacoes), public enterprises (empresas publicas) and companies of mixed economy (sociedades de ecomonia mista), is mainly in charge of provision of public services as a statutory entities except in the fields of education, public safety and public health as shown in the table below. Most of the state-owned companies has be suffered from large amount of accumulated deficits.

COHIDRO has the largest accumulated deficits, followed by SERGIPORTOS and EMDAGRO. Public services in rural areas seem to have low cost recovery, supported by the provision in the article 178 of the State Constitution, which establishes obligation of the State to provide free extension services in rural and agricultural areas.

EMDARGO is competent for technical assistance to farmers, agricultural credit, rural extension (education) services, agricultural research, animal and vegetable sanitation, and encouragement and stimulation of agriculture, including livestock breeding , organizing agricultural and rural communities and services on commercialization and supply. Services on commercialization and supply, however, have been shifted to the private sector. Reorganizing and restructuring of COHIDRO and EMDARGO is intensively discussed, examining a merger of the two entities.

Concession of water supply services in Aracaju currently carried out by DESO is also discussed by Regulatory Agency for Concession of Services (ASES) affiliated to SEPLANTEC.

Table-2.6 Current Status of State Government Entities

Name	Staff in Active as of June 1998 (persons)	Personnel Cost in 1997 (R$ thousand)	Cumulative Deficit as of June 1998 (R$ million)
Direct Administration	**32,057**		
Civil House	422		
Cabinet of Vice Governor	18		
Secretariat of Administration	179		
Secretariat of Finance	1,285		
Secretariat of Planning, Science and Technology	151		
Secretariat of Agriculture, Supply and Irrigation	492		
Secretariat of Education, Sports and Leisure	17,591		
Secretariat of Culture	327		
Secretariat of Industry, Commerce, and Tourism	28	**262,612**	—
Secretariat of Justice, Citizenship and Public Defense	480		
Secretariat of Public Safety	6,028		
Secretariat of Social Actions and Labor Affairs	82		
Secretariat of Transport and Energy	21		
Secretariat of Environment	7		
Secretariat of Health	4,856		
Secretariat of Public Services	17		
Office of State General Prosecutor	73		
Autarchies	**2,282**		
State Administration of Environment (ADEMA)	37		
DER	857		
HEMOSE	68		
IPH	193	**11,745**	—
Institute of Technology and Research (ITPS)	95		
JUCESE	20		
DETRAN	155		
Institute of Social Welfare (IPES)	857		
Foundations	**501**		
PENASCER	223	**3,764**	—
FUNDESE	148		
FUNDESP	130		
Public Enterprises and Companies	**3,730**		**176.90**
Company of Industrial Development and Mineral Resources (CODISE)	154		21.22
Company of Water Resources Development and Irrigation (COHIDRO)	464		36.05
Enterprise of Development of Agriculture and Livestock (EMDAGRO)	438		26.18
SERGIPORTOS	39		31.90
Enterprise of Tourism (EMSETUR)	84	**33,174**	18.08
State Company of Housing and Public Works (CEHOP)	269		20.85
Company of Data Processing (PRODASE)	163		4.18
Graphic Service (SEGRASE)	84		(0.22 surplus)
Sanitation Company (DESO)	1,081		15.69
State Bank (BANESE)	954		2.97
Grand Total	**38,570**	**311,295**	

Source: Final Report, Review of Public Administration of the State of Sergipe, SEPLANTEC, Sep. 1998

CHAPTER 3 ISSUES IN OPERATION AND MAINTENANCE FOR WATER SUPPLY

3.1 Efficiency in Urban and Large Rural Water Supply

3.1.1 Personnel

As shown in section 2.11, DESO employed 1,066 persons in Oct. 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.

Table-3.1 Indicators for One Employee of Water Suppliers

Indicators	DESO (1998)*1	Japan (1996)*2	unit
Covered Population	1,380	2,060	persons
Billed Water	5.3	24.5	thousand m^3/month
Share of Personnel Cost to the Total	46.4	20.4	%

Note: *1:Data of Oct. 1998 and 90% of the staff in DESO are assumed to be engaged in water supply,
*2:Average of the year of around 1,900 water suppliers in Japan
Source: DESO, Journal of Japan Water Works Association, vol.67.8, Aug. 1998

3.1.2 Administration Cost

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.

3.1.3 Tariff of Water Supply in Urban and Large Rural Areas

(1) Level

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.

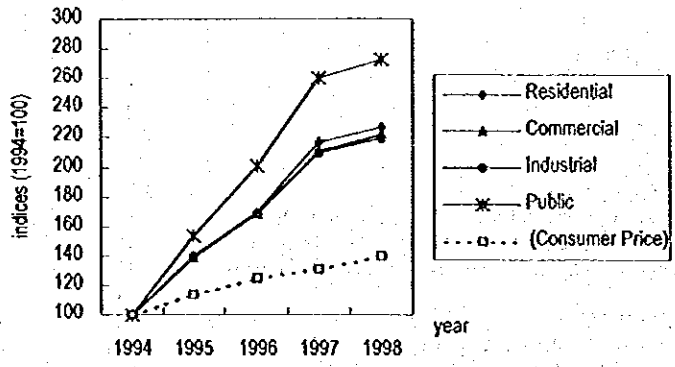


Figure-3.1 Escalation of Tariff

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).

Table-3.2 Comparison of Water Tariff

(unit: US$/m³)

Consumption	A: DESO (Residential, 1997)	B: Japan (13mm, 1996)	B/A
10 m³/month	4.41	11.42	2.6
15 m³/month	9.19	17.44	1.9
20 m³/month	13.98	23.50	1.7
GRDP per Capita	2,585 *1(Sergipe)	39,640 *2	15.3

Note: US$1=Jpyen 120=R$1.18,
*1: estimated by JICA Study Team, *2:GDP of Japan in 1995 by World Bank
Source: DESO, Handbook of Water Works, Association of Water Works of Japan, 1997

(2) Structure

International comparison of the tariff for large commercial/industrial users (10,000m³/year) might show the high level of DESO's tariff more clearly, although some countries may have water supply scheme destined for industrial or other specific users and the service quality might not be same as that for residential use. The tariff of DESO for large commercial/industrial users in 1995 was higher than that in Belgium, Netherlands and France. The tariff for large commercial/industrial users of DESO was more than three times of that in the U.S. After 1995, DESO's tariff for the same users has been escalated 1.66 times up to now.

Table-3.3 Comparison of Water Tariff for Large Commercial/Industrial Users

(unit:US$/m³)

Country	Jul. 1995
Germany	2.05
Belgium	1.59
Netherlands	1.50
France	1.47
U. K.	0.97
Australia	0.95
Finland	0.95
Italy	0.77
Ireland	0.68
Sweden	0.68
Spain	0.67
South Africa	0.53
U. S.	0.52
Norway	0.42
Canada	0.38
DESO	1.73

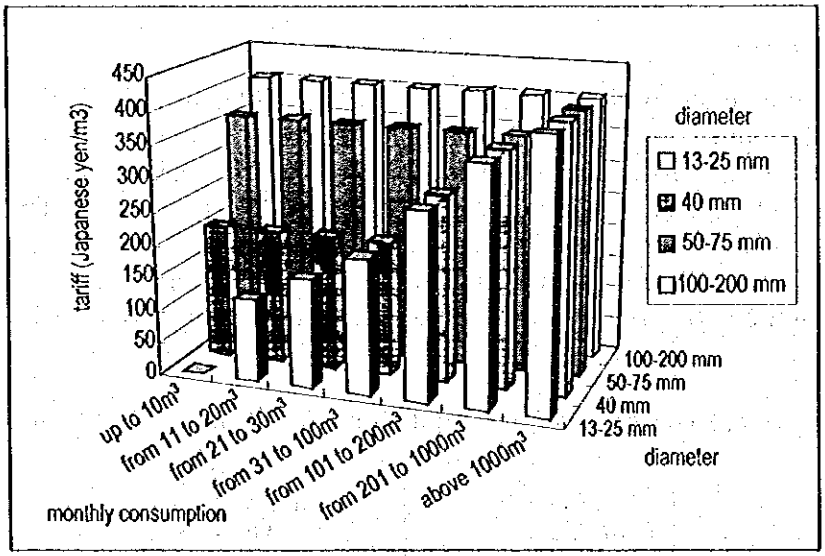
Note: US$1=R$0.936
Source: DESO, and Water Engineering & Management, US, Vol.143, No.6, Jun. 1996

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.

Diameter (mm)	Basic Charge for a Month
13	850 JP yen
20	1,140
25	1,440
40	6,580
50	20,100
75	44,365
100	91,965
150	155,280
200	342,700

+



Note: Actually, charge collections are made once in two months. The above figures are adjusted to monthly ones.
Source: Dep. of Water Works, Chofu Municipal Government

Figure-3.2 Tariff Structure of Chofu City, Japan

3.2 Rural Water Services

3.2.1 Responsibility Allocation and Operating Entities

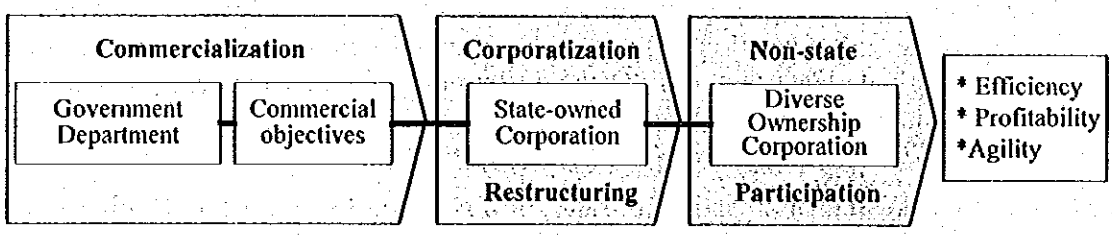
COHIDRO's services in rural areas include construction of water facilities, operation and maintenance of irrigation, actions on agricultural lands, and mechanization. Actually in management of irrigated perimeters, not only operation and maintenance of irrigation facilities but also extension services 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 could not solve fundamental problems of the two companies.

COHIDRO and EMDAGRO are so called companies of mixed-economy, having characteristics of 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 as shown in the figure below. However, most of the functions of EMDAGRO 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".

As discussed in "Final Report of Review of Public Administration of the State of Sergipe", actions on agricultural land, currently carried out by COHIDRO, should be transferred to SAGRI (State Secretariat of Agriculture, Supply and Irrigation) or Office of State General Prosecutor. Since the activities are highly legal and political matter, the function is not suitable for activities of a commercial company even it is a public ones.



Source: Improving State Enterprise Performance, Russell Muir and Joseph P. Saba, the World Bank, Oct. 1995

Figure-3.3 Development of Operational Entities for Public Services

3.2.2 Cost Recovery of Rural Water Services

As for rural domestic water supply, the COHIDRO hand over 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 other operational costs are paid by municipalities. 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 depreciation are covered by tariff collection. An old data shows that the tariff collection rate varied from 32% to 78%. 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.

COHIRO seems to have an opinion that farmers in perimeters are poor, cannot pay, and COHIDRO should supply irrigation water with low tariff. However, crop sales of the farmers with irrigation are generally higher than those of farmers without irrigation water. The resources used to subsidized the farmers in perimeters should be used for the farmers without irrigation water, who might be poorer. It would be necessary to change the management of irrigation projects, applying the methods used by CODEVASF.

CHAPTER 4 OPERATION AND MAINTENANCE PLAN FOR WATER SUPPLY

4.1 Improved Efficiency of Management for Urban and Large Rural Water Supply

Target of the efficiency in the management of DESO would be to reduce the share of administrative 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.

4.1.1 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 is common in the management of private business. DESO should introduce the management prevailing in the private companies.

DESO have 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 remain 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.

4.1.2 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 includes 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 yard-stick 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 which 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, in addition to the above-mentioned points.

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.

Before the concession, careful examination by SESP and ASES is necessary for successful introduction.

4.1.3 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 the figures below. 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. Current progressing block should be continued, though consideration of the degree of the progressiveness and income redistribution functions.

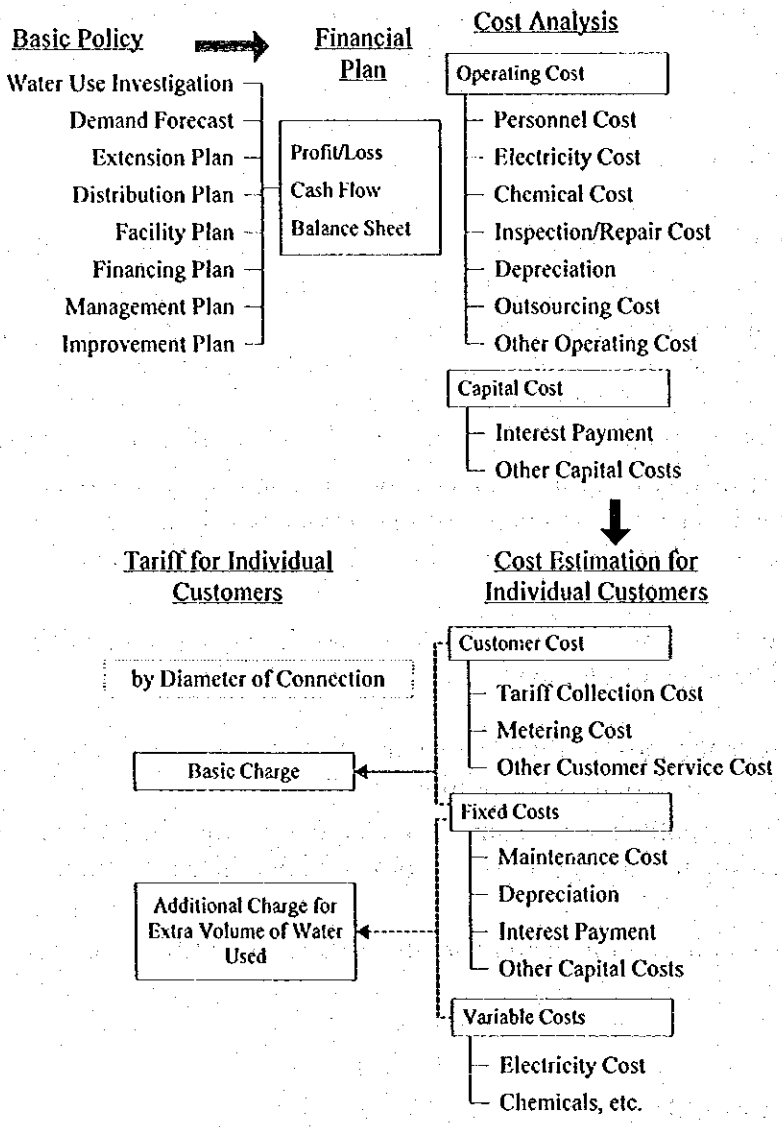


Figure-4.1 Recommended Calculation of Tariff

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.

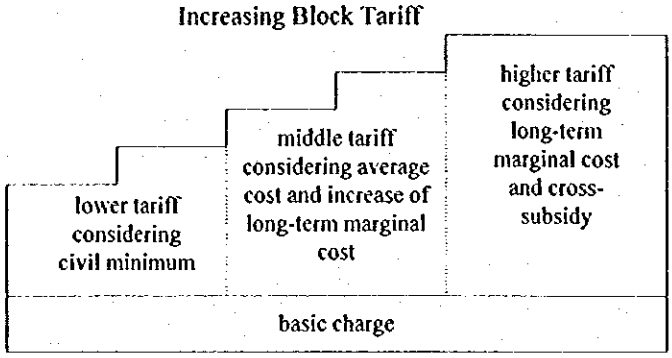


Figure-4.2 Tariff Structure Considering Income Redistribution and Demand Control

For the equitable tariff control, a deliberative committee should be organized to check, evaluates 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.

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.

Adding members of representatives to from customers the committee is also recommendable.

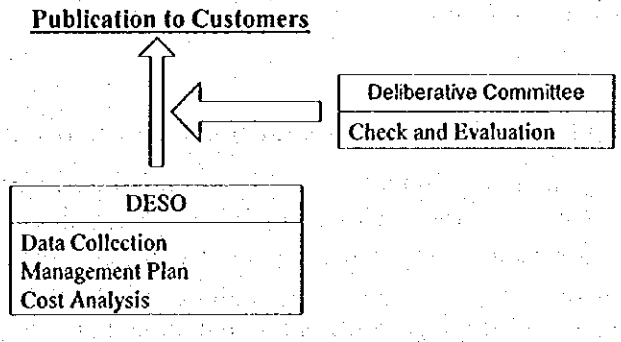


Figure-4.3 Recommended Procedure of Tariff Revision

Social interests sometimes conflict with commercial interests which DESO may have during the course 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.

4.2 Establishing Management System of Rural Water Services

4.2.1 Responsibility Re-allocation in Agricultural and Rural Management

The following functions of COHIDRO and EMDAGRO 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 Secretary of Justice.

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 rural water supply (domestic water supply in small rural areas and irrigation), 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.

4.2.2 Operating and Supporting Entities for Small Rural Water Supply

Basically, water supply in small villages should be operated by local communities, hiring one person in charge of operation. 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.

4.2.3 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.

4.2.4 Establishing Management System of Irrigation

Operation and maintenance of irrigation facilities, in principle, should be managed by farmer's community or users association in each perimeter 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/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 charged by volume as much as possible where metering is feasible.

4.3 Cost Estimation of Operation and Maintenance of Water Supply Projects

In this section, operation and maintenance cost (O&M costs) of water supply projects proposed in the Master Plan is estimated.

4.3.1 General

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 the following items. Although depreciation may be included in O & M cost, estimation of 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.

1) Operation and maintenance expenses
2) Commercial expenses
3) Administrative expenses

O&M cost is divided into the following three expenses in the estimation:

a) Expenses for personnel
b) Expenses for materials and others
c) Expenses for energy

4.3.2 Estimation of Operation and Maintenance Cost

O & M cost in the Master Plan has been estimated using unit costs per capacity or other equivalent parameter of each facility to be constructed. Unit costs or equivalent data have been collected from the related organizations. Graphs or charts for cost estimation, such as showing the correlation between parameter and cost, have also been utilized.

(1) Water Supply in Urban and Large Rural Areas

(a) 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:

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

(b) 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:

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

(c) 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 operation and maintenance plan of DESO proposed above, no incremental cost is estimated. As for rural water supply, administrative activities by the autarchy proposed above are assumed to be conducted with resources of current extension networks. No increment is also projected.

(2) Rural Water Supply

Power of pump for standard design of water supply system by well is given by the following expression by analyzing the correlation between the power of pump, PP, 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 Manufacture, Perenne.

(3) 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.

CHAPTER 5 OPERATION AGAINST DROUGHTS

5.1 Conditions of Droughts

Water resources potential in Sergipe is high in the coastal Leste region and low in the inland Sertao region, according to the isohyetal map, flow regime of rivers and groundwater potential and its salinity. On the contrary, potential of droughts is high in inland areas. 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.
- Also in urban and large rural areas, water shortage sometimes occurs due to insufficient capacity of the water facilities and to unstable water sources, and the water supply is often restricted.
- Even in 2020, 15% of the rural population will not have public water supply schemes and will continue to depend their water supply on the rainfall collecting system, 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, due to the limited storage capacity.
- Rainfed agriculture is directly affected by droughts.
- Public water supply schemes whose water source are boreholes will have a little damage by droughts.

5.2 Proposed Measures against Droughts

In the Master Plan for water resources development, public water supply for 100% of urban population and 85% of rural population is planned corresponding to the drought of once in ten years. For irrigation, water supply corresponding to the drought once in five years is planned. 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 schemes proposed in the Master plan are realized.

5.2.1 Domestic Water

Against droughts, first of all 1) water saving would be necessary when a drought is expected to occur or at an early stage of a drought. In case further severe water shortage, 2) restriction of water supply should be conducted. Finally, when minimum requirement for water can not be met through the water supply system, emergent water distribution should be carried out.

(1) 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 at the times when a drought is expected or at the beginning of a drought. 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. Water loss rate in the private tap system in Sergipe is 42% in 1998, while the rate is planned to be reduced to 25% by 2020. 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. Reduction of water loss will contribute to management improvement of DESO.

As the charging for water rights can contribute to efficient use of limited water resources, 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. For the introduction of the seasonal tariff, information on water use, conditions of economic loss caused by restriction in water supply and amount of the losses by the restriction should be clarified. It is important that the seasonal tariff increment should not be applied to the basic charge (up to 10m3/month for residential use).

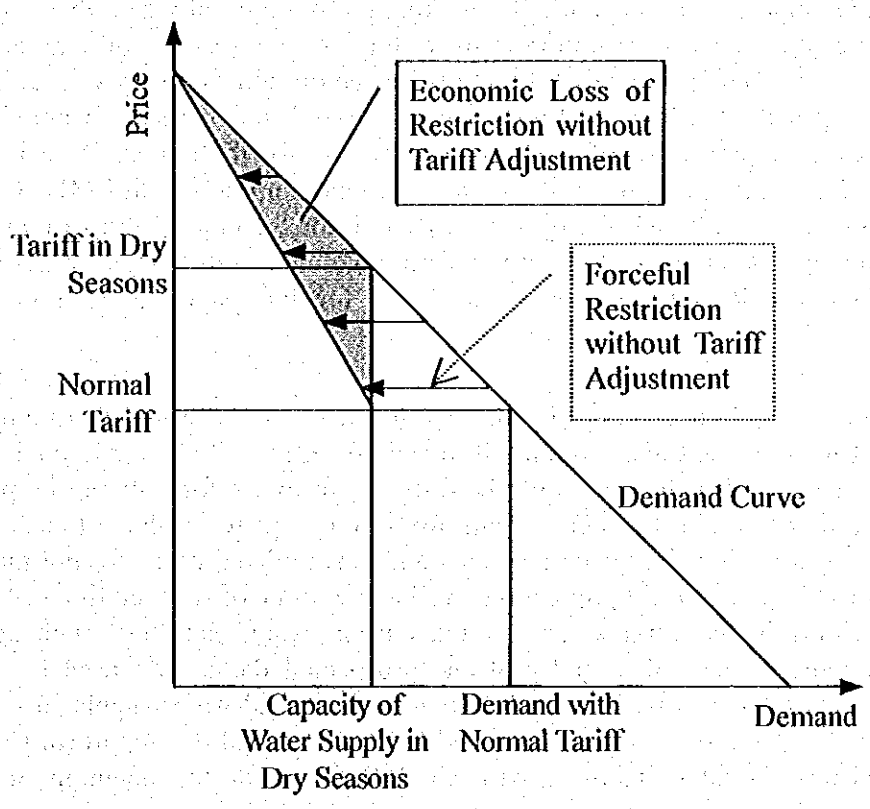


Figure-5.1 Economic Feasibleness of Seasonal Tariff

(2) 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 or drought resisting capability of each scheme should be analyzed. The parts to be improved or enhanced in the processes of the system, from the intake to the distribution, 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.

In case of the restriction of water supply, each household will store the water in some containers. There may occur some sanitary problems when their manner of storage is not adequate. 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 (Prefeituras) and the State Government would be required.

(3) Emergent Water Distribution

When the water supply system cannot provide minimally required water, there is no other way than emergent water distribution. According to the records of emergent water distribution by Civil Defense, the distribution is carried out almost every year to the inland municipalities near the border with Bahia State, such as Municipality of Caninde do Sao Francisco. Current procedure of the emergent water distribution is; i) requests from municipalities, ii) assessment by Civil Defense, through contracts with EMDAGRO, etc., and iii) distribution. Although the present procedure for the emergent distribution seems to be adequate, data on number of target population, volume of distributed water and costs for the distribution do not seem to be analyzed for the planning of more efficient distribution.

At present, a great deal of resources is allocated to the emergent water distribution. The importance of the emergent distribution will remain even after 2020. Although planning for efficient emergent distribution would be difficult, further efforts should be placed for the planning, there would be some room for improvement in the efficiency of the 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, such as rainfall collecting systems or borcholes, 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 4.2 of this report (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 as proposed in the Master Plan in the areas neighboring to the areas where the water supply is seriously affected by droughts, the emergent 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 projected by Civil Defense, managing entities as well as the supporting entity of the water supply schemes and SRH. When the cost recovery is achieved in the developed water supply schemes, compensation financial arrangement is required.

5.2.2 Agricultural Water

Since current irrigation facilities was designed with a certain level of design droughts, no major drought damages will not occur in existing irrigation perimeters at times of more frequent droughts than the designed ones. However, like domestic water, water saving 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 rainfed agriculture, which are vulnerable to droughts, are discussed.

(1) Livestock Breeding

Livestock breeding is a kind of economic activity. However, livestock is inevitable to sustain lives of people and the livestock is the important asset of the farmers. Livestock breeding should not be discussed only in economic terms. Historically, water use for livestock watering has been given a higher priority than other economic activities in 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, while appraisal on the projects should be made as normal crediting. 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.

(2) Rainfed Agriculture

Agriculture is 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.

5.2.3 Accumulation and Dissemination of Information on Droughts

As mentioned above, 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 an important part of information system of water resources management. Studies on damages caused by droughts will be necessary.

CHAPTER 6 IMPLEMENTATION SCHEDULE AND PRIORITY PROJECTS

6.1 Water Resources Management Plans

Implementation schedule of water resources management plans is shown in the Table-6.1. Implementation schedule for water resources management plans is formulated with the following concepts, in principle.

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, while one year is allocated for preparation of a program within a sector or a division of the government.
3) Overburden on a division of the government is to be avoided.

(1) Water Resources Management and Conservation Programs

Enhanced hydrological assessment is a base for water resources development and management. However, the enhancement requires substantial initial costs and training of the staff. The enhancement may take three years.

Classification of waters requires comprehensive studies. After the studies, discussion among sectors and communities of different localities, such as residents between upstream and downstream is necessary. A long period of preparation should be taken. Water quality monitoring and regulation of land development/use can follow. Besides, effluent control can start earlier although full-fledged control can be attained after the classification and water quality monitoring.

6.2 Management Improvement of Water Supply

Streamlining the management of DESO can start soon although efforts to attain sufficient level of the efficiency should continue. Establishing tariff control system may take comparatively long period.

Establishing management system may take as long as two year or more, since it requires the change in sense of cost recovery of rural people. Well organized management will promote full cost recovery cost recovery. Financial arrangement for funding reserves for repairs and replacement and for cross-subsidy in rural water supply can be evolved corresponding to the expansion of operation.

Table-6.1 Implementation Schedule of Water Resources Management Plans

Programs	Initial Cost (R$ 1,000)	Annual Cost (R$ 1,000)	1st: 2000-2004					2nd: 2005-2009					3rd: 2010-2014					4th: 2015-2019					
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Water Resources Management Programs	1,176	234																					
1 Classifications of Waters	160	---		@	@	@	**	**	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##
2 Enhancement of Hydrological Assessment	700	24	**	**	**	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##
3 Water Quality Monitoring	316	210						**	**	##	##	##	##	##	##	##	##	##	##	##	##	##	##
4 Establishing a System for Effluent Control	---	---	**	**	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##
5 Regulation of Land Development and Use	---	---						**	**	##	##	##	##	##	##	##	##	##	##	##	##	##	##
Management Improvement of Water Supply	---	---																					
1 Improvement in Efficiency of Municipal Water Supply			**	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##
2 Management System of Rural Water Services			**	**	##	##	(expansion corresponding to facility development)														##	##	##

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