INTRODUCTION OUTLINE OF THE STUDY

1 Background to the Study

With the macro-economy in Brazil having established some kind of stability, the correction of regional and social disparities is an important issue for the achievement of steady macroeconomic growth. For example, looking at the per capita national income, that in the north of the country is equivalent to just one-third or less of that in the south. As a measure to help resolve this situation, administrative and fiscal authority relating to regional development has largely been transferred from the federal government to state governments, and as a result the role played by state governments in the promotion of regional development has become more and more important.

Sergipe State (area: 22,050 km^2, population: 1,600,000), the target of the Study, is located in the northeast of Brazil. As in other northeastern states, the main issue currently facing Sergipe State concerns increasing statewide socio-economic levels in accordance with an effective development program. With a view to overcoming poverty and the so-called "struggle for survival" in the said state, the development of basic infrastructure and promotion of industrial growth based on this have become priority policies. In particular, with respect to infrastructure development, the comprehensive development of water resources is an issue that requires urgent attention. However, a master plan has yet to be compiled for water resources development based on a comprehensive and long-term viewpoint, and there thus is an urgent need to draw up and implement such a plan.

In Sergipe State, since agriculture is unable to absorb the natural increase in the rural population, a movement of population from rural to urban areas is taking place. In particular, in the semi-arid belt in the northeast of the state, agricultural production is struggling to grow because of difficulties in expanding irrigation facilities, and a large exodus of the population is occurring. As for the urban areas, the incoming population is being absorbed and secondary and tertiary industries are expanding. As a result, the water demand has increased so much that infrastructure development has been unable to keep up, and there are shortages of domestic water and industrial water.

Rainfall varies according to district from 1,400 mm in coastal areas to 500 mm in the northwest, and the climate in the coastal belt is relatively damp, whereas that in inland areas is semi-arid. Six rivers flow through Sergipe State, but water use is most advanced on Sao Francisco River (basin area: 640,000 km^2, length: 2,000 km), which possesses good quality water and an abundant flow (annual average flow: 2,600 m^3/s, minimum flow: 600 m^3/s). Since flow in the other rivers dries up during the dry season and high chlorine concentration can be seen in some, it is not possible to expect large-scale water resources development here. Groundwater is used in districts where river water is scarce; however, because the chlorine concentration of such groundwater is high especially in the semi-arid belt, it cannot be directly used as drinking water and water quality needs to be improved.

It is against the background described above that the Government of Brazil made a request to the Government of Japan for the provision of technical cooperation with respect to the Study on Water Resources Development in the State of Sergipe in the Federative Republic of Brazil (the Study). In response to this request, the Government of Japan consigned the Japan International Cooperation Agency (JICA), the implementing agency of the Study, to

dispatch the preliminary study team to Brazil in November 1997, and the scope of work (S/W) was signed and exchanged on December 5, 1997. In accordance with the S/W, it was decided that JICA would dispatch the Study Team to Brazil in order to conduct the Study.

2 Objectives of the Study

The objectives of the Study, targeting the whole of the State of Sergipe, are as given below:

1) To compile a master plan, having the year of 2020 as its target year, for water resources development in each river basin;
2) To conduct a feasibility study on priority projects selected within the master plan, in order to ascertain the suitability of each project; and
3) At the same time, to carry out the transfer of technology to the counterparts in Sergipe State during the course of the Study implementation.

3 Study Area

The State of Sergipe, the Study area, is located in the northeast of Brazil, and is one of the nine northeastern states. It has an area of 22,050 km^2 and is the smallest of all states in Brazil. The eastern part of the state faces on to the Atlantic Ocean, and the state is situated between Lat. 9°30'49" to 11°34'05" S. and Long. 36°23'40" to 38°15'00" W.

Climate in Sergipe State is divided into three (3) distinct belts according to temperature and rainfall as shown in Table-1; that is to say 1) the high temperature and high humidity belt (Subumido), 2) the intermediate belt (Agreste), and 3) the semi-arid belt (Semi-Arido). Sergipe State can be divided into six river systems and Table-1 gives the particulars of each basin.

Table-1 Climatic Division and Conditions in Sergipe State

Climatic Division	Subumido Belt	Agreste Belt	Semi-Arido Belt
Area	Atlantic coast part	Intermediate part	Mainly northwestern part
Annual rainfall	1,000 – 1,400 mm	700 – 900 mm	400 – 700 mm
Rainy season	April - August	April – August	-
Dry season	December-January (1-3 months)	October-March (4-6 months)	July-November (4-6 months)
Annual average temperature	25 °C		
Annual average relative humidity	74 %		

Table-2 River Conditions in Sergipe State

River	Sao Francisco River	Japaratuba River	Sergipe River	Vaza Barris River	Piaui River	Real River
Basin Area	640,000km^2	1,840km^2	3,310km^2	15,900km^2	4,450km^2	4,460km^2
In-state Basin Area	7,184km^2 (33%)	1,840km^2 (8%)	3,270km^2 (15%)	2,150km^2 (14%)	4,150km^2 (19%)	2,500km^2 (11%)
River Length	2,700km	124km	210km	In-state)152km	150km	140km

4 Scope and Contents of the Study

The Study shall be implemented over two (2) phases – the Master Plan Study and the Feasibility Study for priority projects. Figurre-1 gives the flowchart of the Study, and the main work items in each study phase are shown as follows:

Phase 1: Master Plan Study

< 1. First Work Period in Brazil > 1998/June – 1998/December

Based on analysis of basic data and plans pertinent to water resources, the water resources potential and water demand were clarified. Problems and issues concerning water resources management and operation were evaluated. Based on the clarification and evaluation, the design and planning criteria for water resources development were set and the strategy of the development plan was established. Main work contents are as follows:

(1-1) Meeting on Inception Report
(1-2) Collection of Existing Data
(1-3) Review of Related Plans
(1-4) Interpretation of Satellite Imagery
(1-5) Field Reconnaissance
(1-6) Field Surveys on Hydrology, Water Quality, Water Use and Groundwater Potential
(1-7) Water Resources Potential Study
(1-8) Study on Water Use & Development Issues
(1-9) Socio-economic Framework
(1-10) Water Demand Projection
(1-11) Water Balance in Water Resources Development
(1-12) Design and Planning Criteria
(1-13) Strategy of Water Resources Development
(1-14) Preparation of Progress Report [1]

< 2. First Work Period in Japan > 1999/January – 1999/March

Based on the strategy of water resources development established in the first work period in Brazil, the Master Plan, including a rough facility plan and water resources management plan, were compiled. Also, priority project was selected for targeting the Feasibility Study in Phase-2. Main work contents are as follows:

(2-1) Preparation of Facility Plan
(2-2) Institutional Plan
(2-3) Operation and Maintenance Plan
(2-4) Water Resources Management Plan
(2-5) Cost Estimate of Master Plan
(2-6) Initial Environmental Examination
(2-7) Evaluation of the Master Plan
(2-8) Phasing Program for Implementation of Master Plan
(2-9) Selection of Priority Projects
(2-10) Preparation of Interim Report
(2-11) Preparation for First Technical Seminar

Phase 2: Feasibility Study for Priority Projects

< 3. Second Work Period in Brazil > 1999/May – 1999/October

With respect to the priority project selected, additional data collection and supplementary field surveys was carried out and design and planning criteria was examined. Main work contents are as follows:

(3-1) Meeting on Interim Report
(3-2) 1st Technical Seminar
(3-3) Additional Data Collection
(3-4) Supplementary Field Surveys
(3-5) Design Criteria
(3-6) Environmental Impact Assessment
(3-7) Preparation of Progress Report [2]

< 4. Second Work Period in Japan > 1999/October – 1999/December

The design and planning criteria for the priority project will be confirmed and evaluated. Draft Final Report will be prepared. Main work contents are as follows:

(4-1) Facility Design and Construction Plan
(4-2) Operation and Maintenance Plan
(4-3) Cost Estimate of the Project
(4-4) Evaluation of the Project
(4-5) Implementation Program
(4-6) Preparation of Draft Final Report
(4-7) Preparation for Second Technical Seminar
(4-8) Preliminary Evaluation on Transfer of Technology

< 5. Third Work Period in Brazil > 2000/January

The Draft Final Report will be explained and discussed. Main work contents are as follows:

(5-1) Meeting on Draft Final Report
(5-2) 2nd Technical Seminar
(5-3) General Evaluation on Transfer of Technology

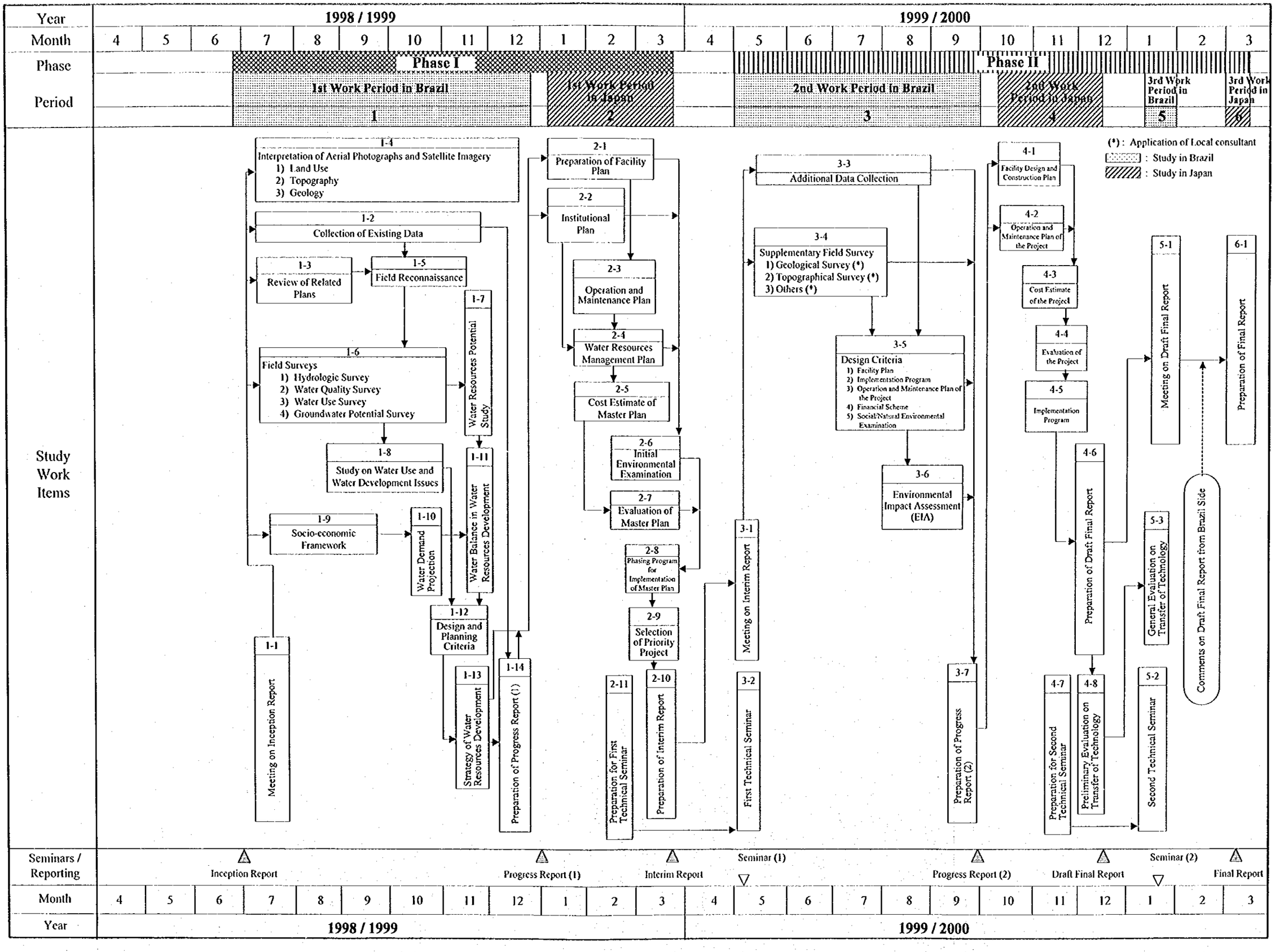


Figure-1 Study Flowchart

PART I

MASTER PLAN STUDY

PART I MASTER PLAN STUDY

CHAPTER 1 STUDY AREA

1.1 Socio-economy

1.1.1 Administrative Units

Presently, according to the Constitution of the Federative Republic of Brazil and the Constitution of the State of Sergipe, the state's central government is divided into two types of organs: the organs of the direct administration and of the indirect administration.

1) Organs of the Direct Administration
The responsible of the state administration is the Governor. The state has 17 secretariats with their attribution under his control, for example: Secretariat of Finance, Secretariat of Planning, Science and Technology. In addition to these secretariats, the state has some assistant organs for Governor such as Cabinet of Governor, Vice Governor & his Cabinet and Cabinet of State Police.

2) Organs of the Indirect Administration
The state has 8 autarchies, 10 public enterprises and companies, and 3 foundations under the administration of the secretariats, for example: State Administration of Environment (ADEMA), Sanitation Company (DESO), State Company of Housing and Public Works (CEHOP), and Company of Water Resources Development and Irrigation (COHIDRO).

The State of Sergipe is composed of 75 municipalities presently. Each municipality has the administration organ under the control of the Mayor and has the city hall and city council.

1.1.2 Census Population

Population distribution is one of the most fundamental information to formulate a water resources development plan. Although the latest population census was worked out in 1991, the provisional population census was made by IBGE in 1996. Thus, the population distribution was principally based on the 1996 census in this study.

According to the 1996 census by IBGE, Brazil has a population of 157 million. This population increased by 10 million as compared to the 1991 census. During the 1990s, the average growth rate was 1.36% per annum. It slowed down from 1.93% per annum during 1980s. In Sergipe State, the 1996 census population was 1.62 million or 1.03% of the national population. The average growth rate during the 1990s was 1.71% per annum. This growth rate was larger than that of the country.

The population in the urban area of Sergipe State was 1.14 million in the 1996 census or shared 70% of the state population, still less concentrated compared with that of Brazil which shared 78% in the census. The average growth rate during the 1990s was 2.62% per annum, which, though slowed down from 4.42% per annum during the previous decades, showed more accelerated rate than that of Brazil, 2.09% per annum. Meanwhile, the population in the rural area of the state in the 1996 census has moved downward continuously to 0.48 million or shared only 30% in the state.

Among the 75 municipalities in the state, Aracaju City, the capital of the state, has the largest population and a function of not only politics but also economic center of the state. Its census population was 428,194 or 26% of the state population in 1996.

According to the 1991 census, a population density of the state was 68 persons/km^2. The density of the respective micro-regions were ranged from the largest one of 617 persons/km^2 in Aracaju Micro-region to the smallest of 21 persons/km^2 in Sergipana do Sertao do Sao Francisco Micro-region. An average family size was 4.23 in the state according to the 1991 census.

Table-1.1 Census Population and Annual Growth

Unit: 1,000 persons

Nation or State	1970	1980		1991		1996	
	Population	Population	Growth (%)	Population	Growth (%)	Population	Growth (%)
Brazil	93,139.0	119,002.7	2.48	146,825.5	1.93	157,079.6	1.36
Sergipe	901.6	1,140.1	2.37	1,491.9	2.47	1,624.2	1.71
Urban	420.0	623.0	4.02	1,002.4	4.42	1,140.6	2.62
Rural	481.6	517.1	0.71	489.5	-0.50	483.6	-0.24
River basin							
Sao Francisco	168.1	193.4	1.41	217.3	1.06	224.2	0.63
Japaratuba	65.1	71.6	0.95	84.5	1.52	90.8	1.44
Sergipe	333.7	478.3	3.67	677.3	3.21	759.2	2.31
Vaza Barris	99.6	104.0	0.43	141.5	2.84	165.2	3.15
Piaui	166.1	208.7	2.31	267.6	2.29	273.5	0.44
Real	68.9	84.1	2.01	103.7	1.92	111.3	1.43

Source: "Censo Demogarfico-1970, 1980 and 1991 – IBGE", and "Contagem da Populacao – IBGE"
Note: As there is no statistical information regarding river basin population in the state, The Study Team conducted the distribution of population by each river basin.

1.1.3 Labor Force

In 1991, the labor force in Sergipe State registered 530,700. Of this number, 513,100 or 96.7% were employed. Thus, an unemployment rate was only 3.3% in the state. This rate was somewhat larger than that in the 1980 census year.

In the past, the agricultural sector, so called as the primary sector, used to absorb the greatest portion of manpower resources in the state. In the 1991 census this sector accounted for only 149,200 or 29.7% of the total labor force. It recorded a drastic decrease to 149,700 or 42.3% in the 1980 census from 161,000 or 60.9% in the previous census 1970. The secondary sector employed the smallest share of the labor force among the three major economic sectors. Its share was 17.4% in the state in 1991. On the other hand, the number of workers in the tertiary sector expanded at an annual rate of 6.5% in the state during 1980s.

1.1.4 Gross Regional Domestic Product

Gross domestic product (GDP) in Brazil was R$658 billion at market prices in 1995. Per capita GDP was R$4,246 as shown in Table-1.4. Gross regional domestic product (GRDP) of Sergipe State in 1995 was R$3.60 billion, accounting for 0.55% of GDP. Per capita GRDP in 1995 was R$2,256, which was only 53% of the national per capita GDP.

For six years, GDP increased from R$600 billion to R$660 billion in real terms, i.e., average growth rate of 1.3% per annum. GRDP in Sergipe State grew at a rate of 1.0% per annum on average for the same period, which was smaller than the growth rate of the country. Then, the share of the state in the country diminished for this period.

Table-1.2 GDP & GRDP at 1995 Constant Prices

Unit: R$ billion

Economic Sector	1990	1991	1992	1993	1994	1995
Gross Domestic Product in Brazil						
1. Agriculture	55.5	57.0	60.1	59.5	65.0	68.3
2. Industry	173.8	170.1	162.9	173.7	185.7	189.0
-Manufacturing	111.5	108.9	104.5	112.9	121.7	123.8
3. Services	333.2	330.2	327.5	331.9	338.1	343.8
-Commerce	31.8	31.8	31.0	33.1	35.1	38.0
4. Sub-total	562.5	557.3	550.4	565.1	588.8	601.1
5. GDP at Factor Cost	511.5	510.4	505.7	521.4	546.3	561.8
6. GDP at Market Price	601.8	584.8	574.3	597.0	638.8	658.1
Gross Regional Domestic Product in Sergipe						
1. Agriculture	0.55	0.62	0.51	0.31	0.41	0.42
2. Industry	1.01	0.91	0.95	0.98	0.98	1.00
3. Services	1.60	1.67	1.66	1.72	1.80	1.90
4. GRDP at Factor Cost	3.16	3.21	3.12	3.01	3.19	3.31
5. GRDP at Market Price	3.37	3.40	3.31	3.20	3.47	3.60

Source: Anuario Estatistico do Brasil 1996,1997, IBGE
Agregados Economicos Regionais, Nordeste do Brasil, 1965-95,1996,MPO, SUDENE
Note: Value added of the respective sectors was calculated applying the economic indices in the references above.

The real growth rates of the main economic sectors on average per annum during 1990 to 1995 were shown in Table-1.3.

Table-1.3 Real Growth of G(R)DP by Economic Sector

Unit: %

Economic Sector	1991	1992	1993	1994	1995	'90-'95
Brazil						
1. Agriculture	2.8	5.4	-1.0	9.3	5.1	4.2
2. Industry	-2.1	-4.3	6.7	6.9	1.8	1.7
-Manufacturing	-2.4	-4.1	8.1	7.8	1.7	2.1
3. Services	-0.9	-0.8	1.4	1.9	1.7	0.6
-Commerce	0.1	-2.5	6.6	6.0	8.5	3.7
Total	-0.9	-1.2	2.7	4.2	2.1	1.3
Sergipe State						
1. Agriculture	13.1	-18.2	-39.0	30.6	2.7	-5.4
2. Industry	-10.0	4.6	3.1	-0.3	2.2	-0.2
3. Services	4.7	-0.6	3.3	5.0	5.2	3.5
Total	1.4	-2.5	-3.6	5.9	4.0	1.0

Source: Anuario Estatistico do Brasil,1996,1997,IBGE
Agregados Economicos Regionais, Nordeste do Brasil, 1965-95, 1996, MPO, SUDENE

As shown in Table-1.4, in terms of average annual growth between 1990 and 1995, both per capita GDP and per capita GRDP of the state were calculated as of 0.4% and -0.5%, respectively. These figures imply that both economic conditions have kept almost the same level for the past six years, although the economy has fluctuated for the period. These in 1991 and 1992 were resulted in serious negative growth in particular. In 1995, these barely recovered to the 1990 level in consequence of the recent real growth.

Table-1.4 Real Growth of G(R)DP per Capita

G(R)DP per Capita at 1995 Const. Prices (R$)	1990	1991	1992	1993	1994	1995
Brazil	4,168	3,980	3,857	3,956	4,177	4,246
Sergipe	2,312	2,282	2,184	2,073	2,210	2,256
Annual Growth Rate (%)	1991	1992	1993	1994	1995	'90-'95
Brasil	-4.5	-3.1	2.6	5.6	1.7	0.4
Sergipe	-1.3	-4.3	-5.1	6.6	2.1	-0.5

Source: Anuario Estatistico do Brasil 1996,1997,IBGE
Agregados Economicos Regionais , Nordeste do Brasil, 1965-95, 1996, MPO, SUDENE

1.1.5 Economic Sector Profile

(1) Agricultural Sector

Value added (VA) of agriculture sector accounted for 13.8% of GRDP on average during 6 years from 1990 to 1995, which fluctuated between 9.7% in 1993 and 18.2% in 1991. The real growth of agriculture sector during the same period was a decline of 5.4% per annum, which was far greater than 0.24% decline per annum of the rural population between 1991 and 1996 census.

Production tendency changed so much during this decade. The crop area of cotton, sugarcane and maize declined between 1985 and 1996 as shown in Table-1.5. Particularly, the area of cotton declined dramatically. Adversely, the production of coco and orange increased remarkably. Orange production in particular increased more than 40% during the same period and shared substantial portion in the agriculture sector of the state.

As to the livestock, pig and poultry population increased slightly but cattle population and the production of milk and eggs decreased remarkably between 1990 and 1995.

Table-1.5 Main Agriculture Products

Item	Production (1,000 ton)			Crop Area (1,000 ha)		
	1985	1996	Changes	1985	1996	Changes
Cotton	13.5	0.8	-99.9 %	33.8	1.9	-94.4 %
Sugarcane	1,605.9	1,341.8	-16.4 %	26.5	22.4	-15.5 %
Cassava	461.1	597.0	29.5 %	35.2	39.8	13.1 %
Maize	98.5	114.2	15.9 %	98.5	81.6	-17.1 %
Coco (1000 fruits)	80.9	95.4	17.9 %	42.6	50.2	17.8 %
Orange (1000 fruits)	2,920.6	4,173.1	42.8 %	28.3	41.4	46.3 %

Source: "Municipal Agriculture Production, 1981-1996" (IBGE) and EMDAGRO for modification

(2) Mining and Industrial Sector

VA of mining and industrial sector accounted for 28.3% of GRDP on average during 6 years from 1990 to 1995. The real growth of the sector during the same period declined 0.2% per annum. Light industries such as textiles and food industries accounted for dominant shares in the state. On the other hand, mining sector, especially crude oil extraction industry, surged to 44% from almost nothing.

Number of establishments and distribution of gross production value were concentrated in large cities such as Aracaju, Estancia, Itabaiana and Laranjeiras that shared respectively 53.2% in 1991/92 and 73.5% in 1985.

Table-1.6 Mining and Industrial Aspect

Item	Number of Establishments			Distribution of Gross Production Value (%)		
	1980	1985	1991/92	1980	1985	1991/92
Sergipe	1,918	1,989	1,458	100.0	100.0	100.0
Mining	43	35	4	0.3	0.3	44.4
Manufacturing	1,875	1,954	1,454	99.7	99.7	55.6
Aracaju	383	409	627	50.7	35.8	-
Estancia	66	56	57	13.8	14.0	-
Itabaiana	126	132	86	2.0	1.4	-
Laranjeiras	14	38	6	4.2	22.3	-

Source: Censo Economico de 1985, Industria, Comercio e Service, Volume 2, IBGE
Cadastro Industrial Sergipe, 1991/92, SEICT, CODISE and SEBRAE

(3) Services Sector

VA of services sector accounted for 50.9% of GRDP on average during 6 years from 1990 to 1995. The real growth of the sector increased 0.9% per annum, in spite of decline in other sectors. Aracaju City also took a predominant position of the sector in the same years.

Table-1.7 Aspect of Services Sector

Item	Number of establishments		Contribution of Sales Amount (%)	
	1980	1985	1980	1985
Sergipe	5,609	7,439	100.0	100.0
Wholesale & retail	3,805	4,766	89.9	90.7
Others	1,804	2,673	10.1	9.3
Aracaju	2,424	2,979	66.3	59.8

Source: Censo Economico de 1985, Industria, Comercio e Servico, Volume 2, IBGE

1.1.6 Inflation

The consumer price index of Brazil moved moderately downwards during these years, as shown in Table-1.8. In Sergipe, the index declined also moderately till 1997 but upward movement has taken place in 1998 though moderate. According to SUPES survey, the price advances in 1998 were concentrated largely in the durable goods and food /beverage sector. The rest of items are showing moderately 2 to 5%.

Table-1.8 Consumer Price Index

Unit: %

Year	1994	1995	1996	1997	1998*
Brazil (1)	1238.0	25.9	11.3	7.2	1.8
Sergipe (2)	995.5	13.9	9.2	5.6	6.8

Source: (1) Precos ao Consumidor, Brasil Total, FGV, Conjunura Economica, 1998 October
(2) Indice de Vida – Aracaju, SEPLANTEC/SUPES, 1998 September
* As of September

1.1.7 State Finances

(1) Financial Composition

The state government recorded a deficit balance for three consecutive fiscal years from 1994 till 1996. In fiscal year of 1997, the huge amount of surplus was realized due to privatization of a state owned electric enterprise, ENERGIPE. In fiscal 1998, the government estimated a balanced budget.

As shown in Table-1.9, some 40 to 50% of total revenue was derived from transfers from Federal Government, some 30 to 35% from taxes, mainly ICMS (a kind of value added tax) and the rest from loans. The major item among expenditures was personnel expenditure. Investment, including financial investment, in total expenditures was 18% on average during the 5 years, fluctuating from 8.9% in 1995 to 26.5 in 1994.

Table-1.9 Financial Composition of Sergipe State

Unit: R$ million

Year	1994	1995	1996	1997	1998
Revenues	429.3	733.9	934.1	1,575.9	893.6
1. Current	326.2	643.7	729.8	861.9	802.6
1) Tax	139.6	262.2	313.3	372.5	330.0
2) Transfers from Federal Gov.	166.2	355.6	396.9	441.7	452.7
2. Capital*	103.1	90.2	204.3	714.0	91.0
1) Credit Operations	83.8	48.6	118.1	169.3	55.1
Expenditures	453.3	770.4	938.0	1,253.0	893.6
1. Current	312.0	700.4	719.2	843.8	687.3
1) Personnel	155.2	456.1	443.5	469.8	368.8
2) Financial	27.3	34.5	40.7	43.7	35.1
2. Capital	141.3	70.0	218.8	409.2	206.3
1) Investment	119.7	60.8	136.2	236.8	185.6
2) Repayment	14.6	9.0	82.4	172.4	20.5
Deficit/Surplus	-24.0	-36.5	-3.9	322.9	0.0
(% of Revenues)	-5.6%	-5.0%	-0.4%	20.5%	0.0%

Source: Balanco Geral, Governo de Sergipe, 1994,1995,1996 and 1997
Orcamento-Programa, Governo de Sergipe, 1998 (Original Budget)
* The amount of 1997 was mostly derived from the privatization of ENERGIPE, formerly owned by the state.

(2) Debt Situation

The state government finances were sustained by loans around 11% on average during the years from 1994 to 1998. Although the debt ratio has been declining obviously as shown in Table-1.10, the state has still owed loans equivalent to one year's net current revenue.

The debt payment, which means a total amount of repayment of loan and interest payment, is compared with net current revenue to measure its payment affordability (Debt Service Coverage Ratio), as shown in Table-1.10. In general, 25% of the ratio is considered a financial upper limit. The Sergipe state government has maintained constantly lower level of the ratio, except in 1997. It means that the state government financial condition is currently healthy in terms of debt service coverage ratio.

Table-1.10 Debt-to-Net Current Revenue Ratio and Debt Service Coverage Ratio

Unit: R$ 1,000 (1990-1992), R$ million (1993-1998)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Debt-to-Net Current Revenue Ratio									
A. Net Current Revenues	11.0	48.1	502.1	11.8	291.2	576.1	646.1	762.2	716.5
B. Debts	20.7	122.1	1613.1	44.7	383.8	569.0	684.2	746.4	737.8
C. Ratio (B/A)	188%	254%	321%	380%	132%	99%	106%	98%	103%
Debt Service Coverage Ratio									
A. Net Current Revenues	11.0	48.1	502.1	11.8	291.2	576.1	646.1	762.2	716.5
B. Debt Payment	2.0	3.1	23.5	1.4	41.9	43.5	123.1	216.1	55.5
C. Ratio (B/A)	18.2%	6.4%	4.7%	11.9%	14.4%	7.6%	19.1%	28.4%	7.7%

Source: Balanco Geral, Governo de Sergipe, 1994,1995,1996 and 1997
Orcamento-Programa, Governo de Sergipe, 1998 (Original Budget)
Note: Debts in 1998 is as of September. Net Current Revenue means total current revenue excluding an amount transferred to municipalities.

1.2 Topography, Geology and Land-use

Very old rocks of Precambrian age form geological flame of Sergipe State. Shield with flat geomorphic surface covers the state. Earth movements finished in Mesozoic age, then Sergipe State became geologically stable.

1.2.1 Topography

Geomorphological map is shown in Figure-1.1. Classification of landform in Sergipe State is outlined as shown in Table-1.11.

Table-1.11 Classification of Landform

Classification		Note
Plain along coast and near river mouth	Marine deposit	Distributes along the coast of the study area.
	Marine and fluvial deposit	Distributes near river mouth.
	Flood plain	Distributes down stream of rivers.
	Terrace	Distributes in border between coastal plain and plateau.
Flat plateau spreading inland	Plateau spreading in Cretaceous and Tertiary	Plateau surface is flat, rainfall carves and divide plateau into many small hills. Elevation is less than 150m.
	Plateau spreading in Precambrian	Inselbergs and pediments form this landscape. The ground surface is undulating. Elevation is 150-300m
Mountain rising from plateau	Mountain	Hard rock remains from erosion as mountain. Elevation is 300-600m.

Sergipe State is divided into 6 main river basins. Every basin has the same geomorphological component from upstream to downstream, namely mountain area - flat plateau area - coastal plain. However, each geomorphological unit has different weight by basin. Basins in the northern part of Sergipe State have less mountain area, but basins in southern part have more mountain area. This fact is closely related to size of basin. Sao Francisco River Basin has less mountain area and more flat plateau. It results in milder slope than the other basins. On the other hand, Piaui River Basin and Real River Basin, have more mountain area. The other basins, Japaratuba, Sergipe, Vaza Barris River Basin, have intermediate characteristics between the formers. In these basins, however, Itabaiana Dome is notable with steep mountain dividing Sergipe Basin and Vaza Barris Basin.

1.2.2 Geology

Table-1.12 and Figure-1.2 show geology of Sergipe State. As shown in the figures, metamorphic rock of Precambrian distributes in 2/3 of inland area. Mesozoic system distributes in the other 1/3 area near the coast covering Precambrian rocks, and Tertiary system distributes covering Mesozoic system. Quaternary system distributes along the coast.

Each river basin has different geological unit. Representative geological unit by river basin is shown in Table-1.13.

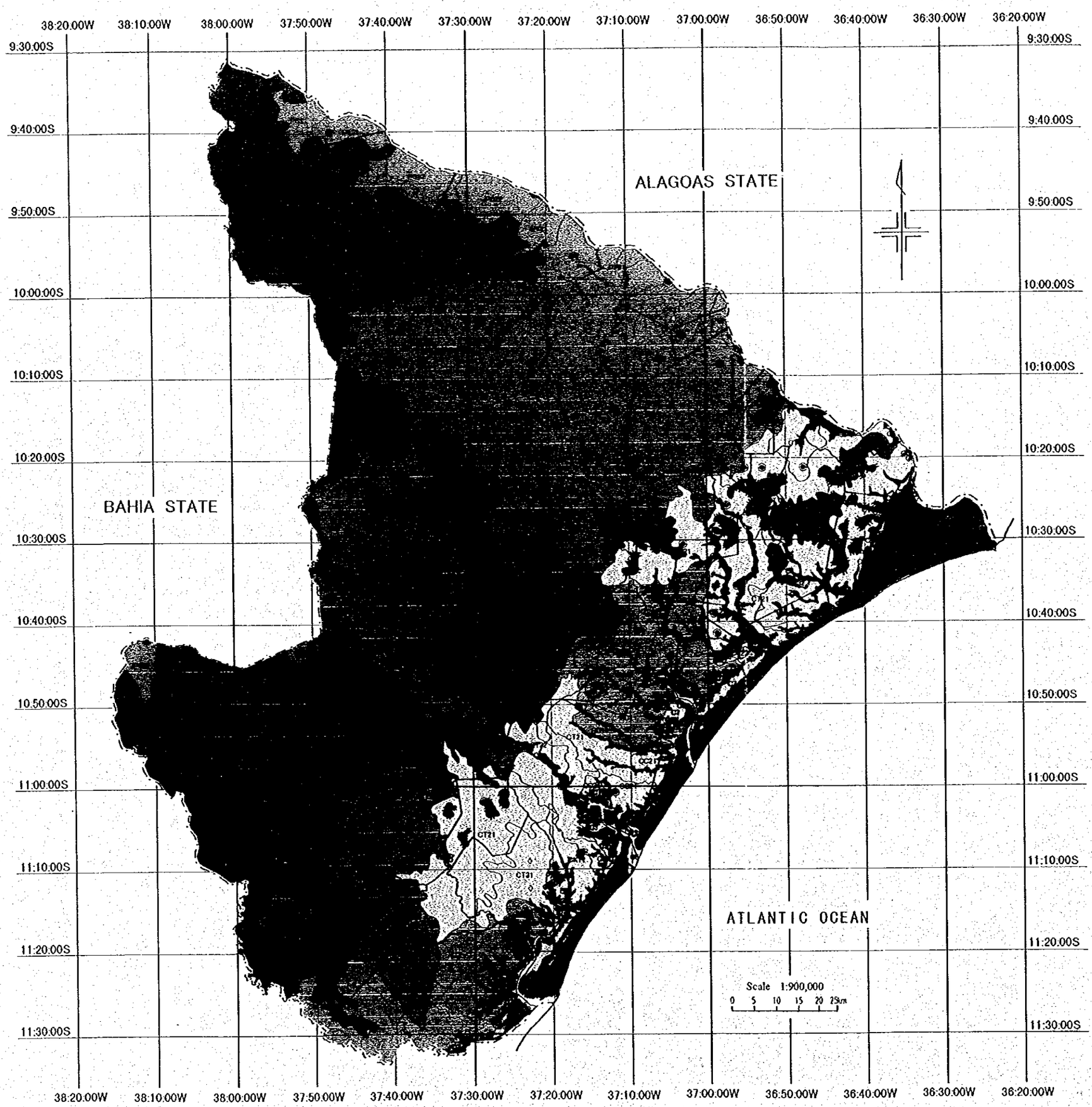
Table-1.12 Stratigraphy and Rock Faces of the Study Area

Age		Stratigraphy	Rock Faces
Cenozoic	Quaternary	Diluvium, Alluvium	Clay, silt, sand, gravel
	Tertiary	Barreiras Formation	Claystone, siltstone, sandstone, conglomerate
Mesozoic – Paleozoic	Cretaceous – Silurian	Tucano Basin	Limestone, sandstone, shale
		Sergipe Basin	Limestone, sandstone, shale
Late Proterozoic		Caninde Domain	Gabbro, amphibolite, metavolcanic rock, ultramafic rock
		Poco Redondo Domain	Granites, migmatite, gneiss
		Maranco Domain	Granites, metaconglomerate, phyllite
		Macurure Domain	Micaschist, quartzite, gabbro
Middle Proterozoic – late Proterozoic		Vaza-Barris Domain	Carbonate, phyllite, argillaceous rock
		Estancia Domain	Sandstone, argillaceous rock, conglomerate.
Archaean – early Proterozoic		Sao Francisco Craton	Gneiss, migmatite, granodiorite.
		Itabaiana Dome Craton	Migmatite.

Table-1.13 Geology of Basin

River Basin	Upper stream	Middle stream	Lower stream
Sao Francisco	Maranco Domain (3%) Poco Redondo Domain (6%) Caninde Domain (3%)	Macurure Domain (40%)	Quaternary (5%) Barreiras Formation (11%)
Japaratuba	Barreiras Formation (48%)		
	Macurure Domain(28%)	Sergipe Basin (12%)	Quaternary (12%)
Sergipe	Macurure Domain (26%)	Vaza-Barris Domain (24%) Itabaiana Dome (7%)	Quaternary (11%) Barreiras Formation (16%) Sergipe Basin (11%)
Vaza Barris	Vaza Barris Domain (51%)	Itabaiana Dome (11%)	Barreiras Formation(17%)
Piaui	Estancia Domain (20%)	Barreiras Formation(39%), Sao Francisco Craton (25%)	
Real	Estancia Domain (59%)		Barreiras Formation (9%) Sao Francisco Craton (18%)

Note: (%): Area of each geological unit represented by % against total basin area



THE STATE OF SERGIPE

GEOMORPHOLOGICAL MAP

Legend

- STATE BOUNDARY
- MUNICIPALITY BOUNDARY
- DRAINAGE BASIN
- MUNICIPALITY TOWN

COASTAL PLAIN

- Valley plain
- Swamp
- Flood plain
- Coastal sand dune (younger)
- Coastal sand dune (older)
- Lower marine terrace
- C7 Upper marine terrace
- Lower river terrace
- Upper river terrace
- C10 Alluvial fan

COASTAL PLATEAU

- Erosion planation surface

Tabuler hill, interfluver and crest

- CC Convex top
- CK Peaked top
- CT Tabuler or planar top

SURFACE WITH CONTINGUBIA-SERGIPE RIVER AND REAL RIVER

Tabuler hill, interfluver and crest

- Convex top
- Peaked top
- Tabuler or planar top

INTERIOR PEDIPLAINE

- Pediplaine

Tabuler hill, interfluver and crest

- Convex top
- Peaked top
- Tabuler or planar top

OUTLIER

- Erosion planation surface

Tabuler hill, interfluver and crest

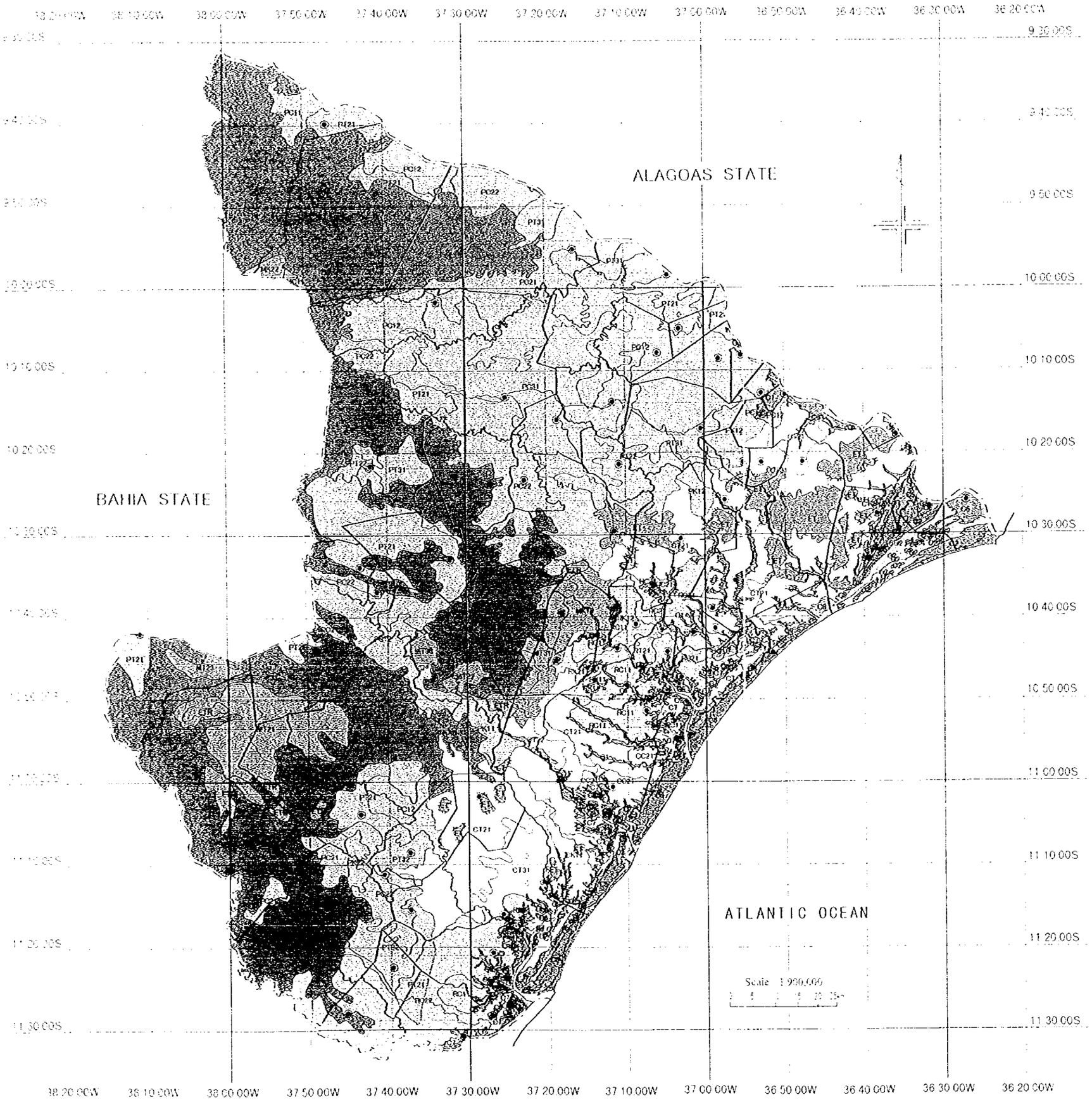
- Convex top
- Peaked top
- Tabuler or planar top

- Cliff (Erosion)
- Cliff (Dominant structure)
- Tor

Order of Great Dissection Forme

Intensity of deep Drainage	< 250 m	> 250 m ≦ 750 m	> 750 m ≧ 1,750 m
More Weak	11	21	31
Weak	12	22	32
Mediu	13	23	33

Figure-1.1 Geomorphological Map in Sergipe State by Satellite Image Analysis



THE STATE OF SERGIPE

GEOMORPHOLOGICAL MAP

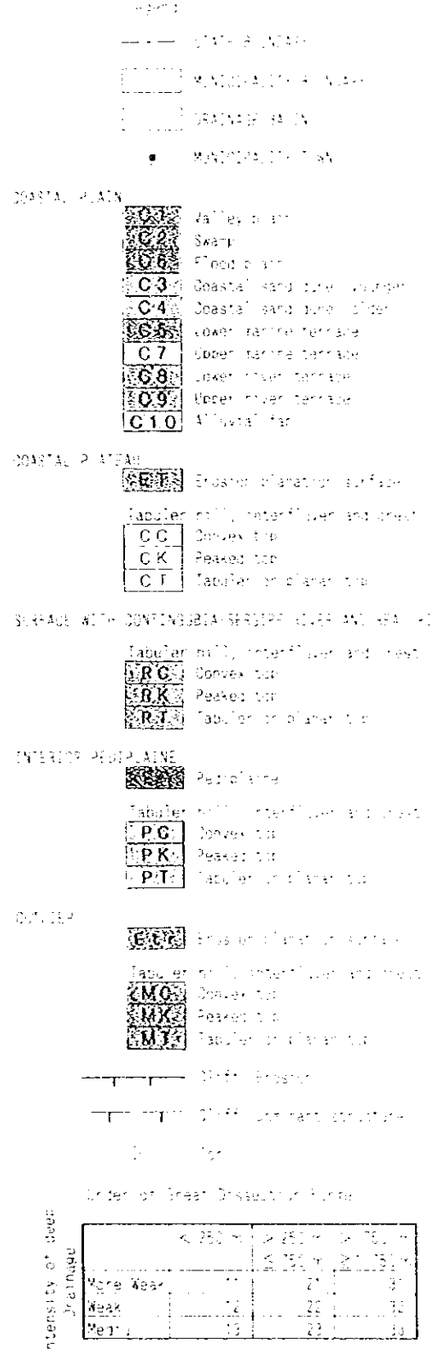
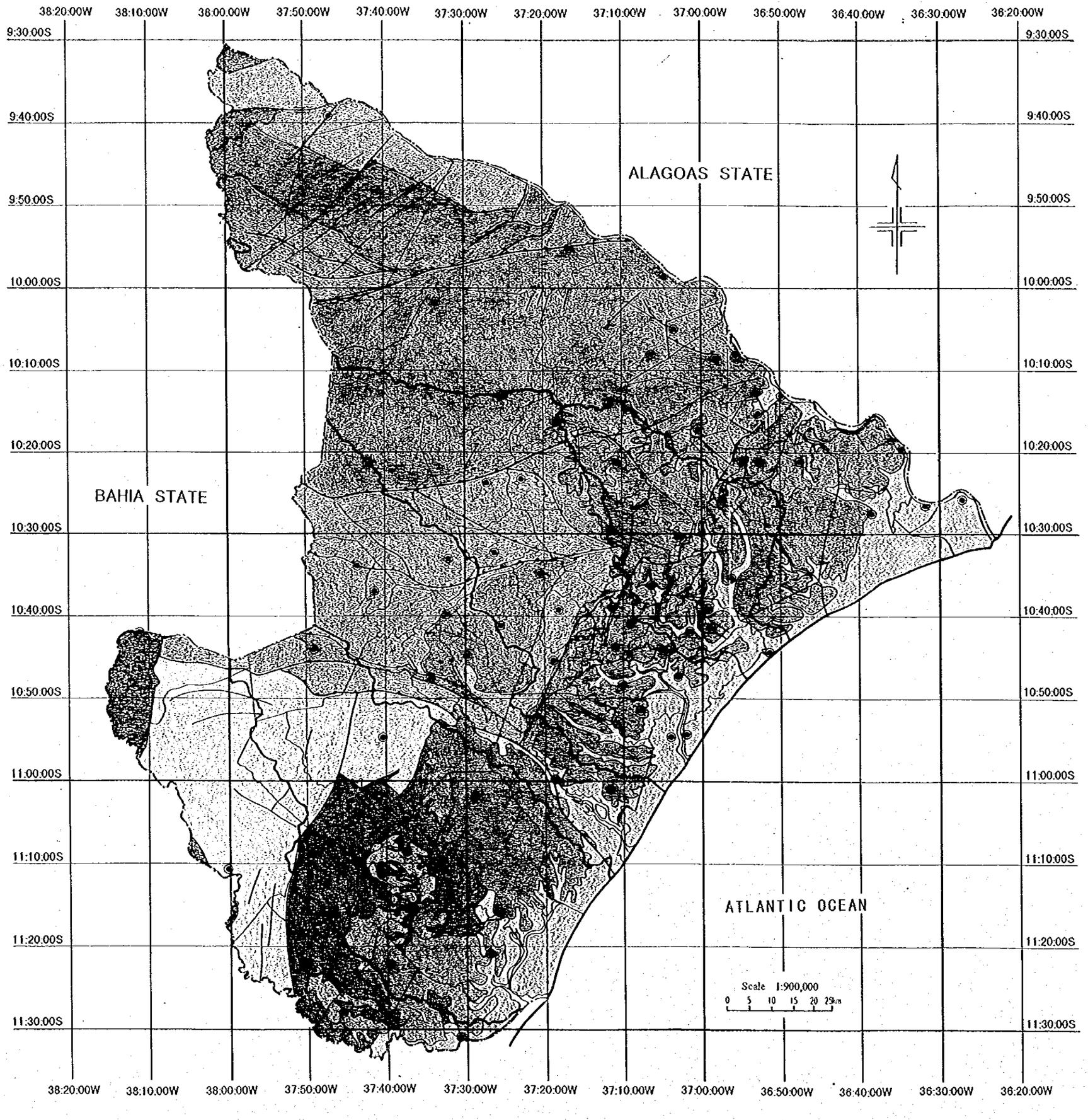


Figure-1.1 Geomorphological Map in Sergipe State by Satellite Image Analysis



THE STATE OF SERGIPE
GEOLOGICAL MAP

LEGEND

- STATE BOUNDARY
- MUNICIPALITY BOUNDARY
- DRAINAGE BASIN
- MUNICIPALITY TOWN
- QUATERNARY SYSTEM
- TERTIARY SYSTEM

BASIN SEDIMENTS

- BASIN OF SERGIPE
- BASIN OF TUCANO

SERGIPANA FOLDING ZONE

- ESTÂNCIA DOMAIN
- VAZA-BARRIS DOMAIN
- MACURURÉ DOMAIN
- MARANCÓ DOMAIN
- POÇO REDONDO DOMAIN
- CANINDÉ DOMAIN

BASEMENT GNEISS

- CRATON OF SÃO FRANCISCO
- DOMES OF ITABAIANA
- GEOLOGICAL BOUNDARY
- FAULT
- EXTENSION FAULT
- CONTRACTION FAULT

Figure-1.2 Geological Map in Sergipe State by Satellite Image Analysis

1.3 Climate

1.3.1 General Climatic Conditions

The climate in Sergipe State is divided into three distinct regions according to temperature and rainfall, namely: 1) the tropical humid region with the high temperature and high humidity along the coast (Leste), 2) the tropical sub-humid region or the intermediate drier region (Agreste), and 3) the semi-arid region of the interior (Semi-Arido). These three climatic regions are the basis of the meso-region division of the state, namely: 1) the coastal Leste, 2) the intermediate Agreste, and 3) the interior Sertao regions. Although Sergipe is the smallest state in Brazil with an area of just 22,050 km^2, its climate varies considerably from the Atlantic coast to the inland Sertao area. In the 20-40 km wide Leste belt along the coast, annual rainfall is abundant at about 1200-1600 mm/year and the average temperature is 25°C $\pm$ 5°C throughout the year. In comparison, the Semi-Arido belt covering approximately one third of the state has much less rainfall, around 500-800 mm/year, and slightly higher temperatures with a wider daily range. The intermediate Agreste region has around 800-1200 mm/year rainfall and similar annual average temperature of around 25°C.

1.3.2 Meteorological Observation Network

The principal agency responsible for the collection and analysis of meteorological data in Brazil is INMET, the National Institute of Meteorology. In Sergipe State, INMET operates 3 meteorological stations with the full range of instruments necessary for climatological monitoring. These are located at Propria, Aracaju and Itabaianinha and have records of daily data since 1972.

Within Sergipe State, EMDAGRO operates a meteorological station at its experimental research facility at Boquim and there is also a station at Aracaju airport. COHIDRO has meteorological stations at each of its four irrigation projects at California, Jacarecica, Piaui and Jabiberi and there is also a new station at Neopolis operated by ASCONDIR. CODEVASF operates two meteorological stations at its irrigation projects at Cotinguiba and Betume in the Sao Francisco river basin. The location of these stations is illustrated in Figure-1.3. Availability of data for each of the stations is shown in Table-1.14.

Table-1.14 Availability of Meteorological Data

Station Name	Operator	Data Period	
		From	To
Daily Data			
Boquim (Exp. Stn)	EMDAGRO	Jan-75	Jul-98
Aracaju Airport	AERONAUT.	Jan-85	Dec-97
California	COHIDRO	Jan-89	Oct-97
Jabiberi	COHIDRO	Jan-89	Dec-97
Jacarecica	COHIDRO	Apr-89	Dec-97
Piaui	COHIDRO	Jun-89	Jan-98
Monthly Data			
Cotinguiba Pindoba	CODEVASF	Jan-90	Jun-96
Betume	CODEVASF	Oct-93	Feb-96
Aracaju	INMET*	Jan-93	Dec-97
Itabaianinha	INMET*	Jan-93	Dec-97
Propria	INMET*	Jan-93	Jun-97

* It was not possible to obtain the daily data but monthly data for the last five years.

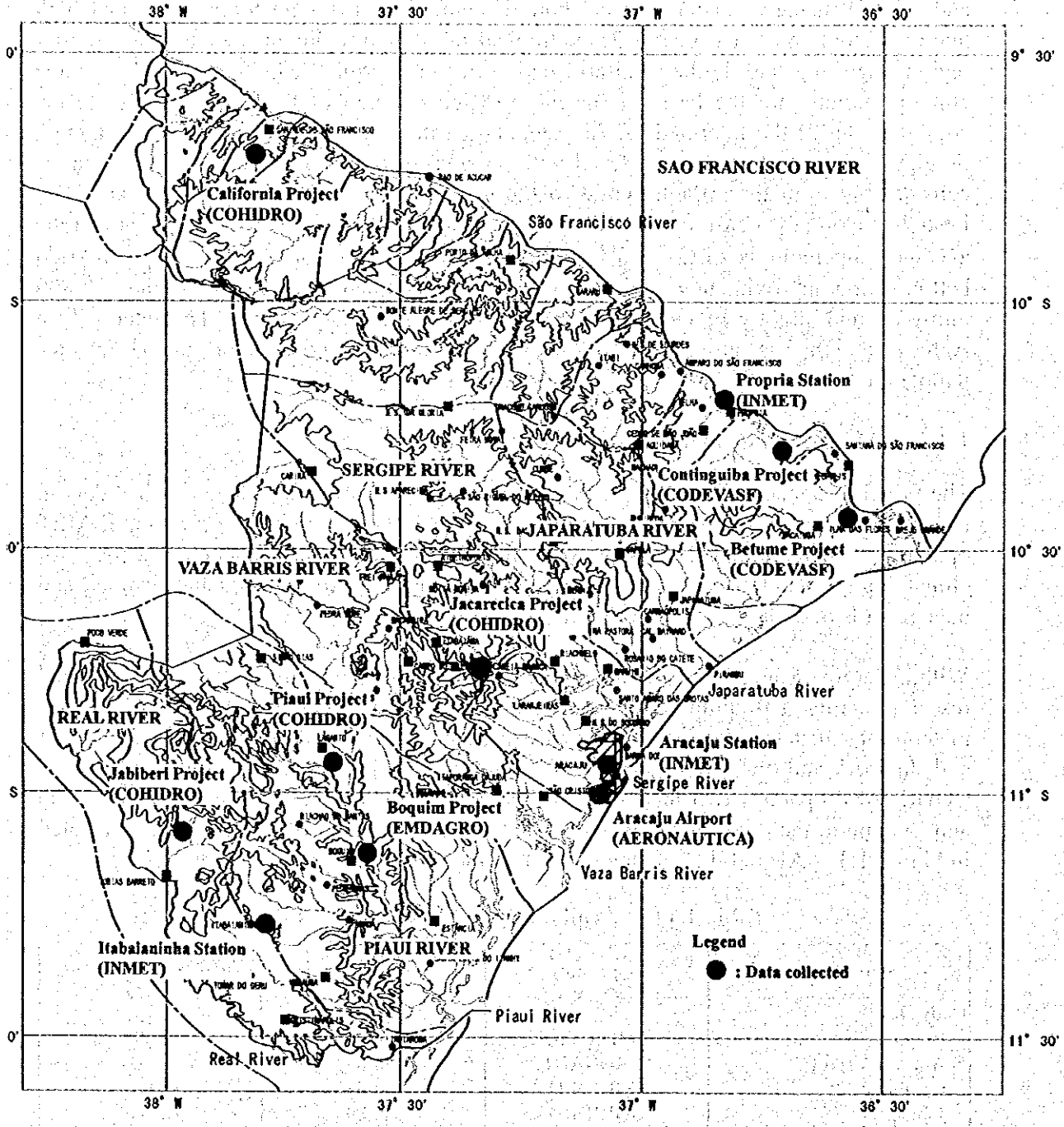


Figure-1.3 Location of Meteorological Stations

1.3.3 Meteorological Characteristics

Daily data was obtained for the following parameters – maximum & minimum temperature, rainfall, evaporation, relative humidity, wind speed and solar radiation (in the form of number of sunshine hours). Monthly variation for Boquim in the Leste region, Piaui in the Agreste region and California in the Semi-Arid region are compared in Figure-1.4. The climatological characteristics of the three regions are described below:

(1) Leste Region – Boquim Station (EMDAGRO)

As illustrated by the data for Boquim, the Leste region is characterized by comparatively high rainfall (average annual total =1,355 mm/year) and high relative humidity (annual average of 80%). Rainfall is clearly divided into a rainy winter season from April to July and a dry summer season from October to January. Pan evaporation is somewhat lower than the interior regions of the state at just over 1,000 mm/year, with higher evaporation in the summer than in the winter. Average mean temperature is around 25°C, ranging from just over 26°C in the summer months of December to March to less than 23°C in the winter months of June to September. Daily temperature range is approximately ± 5°C with an annual average minimum temperature of around 20°C and an average maximum of just over 29°C. Wind speed is higher than in the inland areas, but winds are still moderate throughout the year varying between 2 and 3 m/s. Average sunshine hours are fairly constant through the year at between 4 and 5 hours/day. In comparison, the average wind speed at the coast is considerably higher, as indicated by the data for Aracaju airport where average wind speeds vary between 6 and 8 m/s. Average sunshine hours at Aracaju (INMET) vary between 6.4 hours/day in the winter and over 9 hours/day in the summer with an annual average of 7.7 hours/day.

(2) Agreste Region – Piaui Station (COHIDRO)

The Piaui Irrigation project station shows typical conditions in the Agreste region, although data is very similar for the other COHIDRO stations at Jacarecica and Jabiberi. Rainfall is somewhat lower than in the Leste region at around 1,000 mm/year and the monthly distribution is similar. Temperatures are also similar with an annual average of 25°C, average minimum temperature of around 20°C and an average maximum of over 29°C. In comparison, however, evaporation is considerably higher at almost 2,000 mm/year. Average humidity is lower at about 70% and wind speeds are also less at between only 1 and 2 m/s. The number of sunshine hours varies between 5 hrs/day in the winter and over 8 hours/day in the summer with an annual average of 6.8 hours/day.

(3) Semi-Arido (Sertao) Region – California Station (COHIDRO)

The Semi-Arido region of the interior of Sergipe State is considerably drier than the coastal region and this fact is illustrated by the data for the California Irrigation project near to Xingo dam. Annual average rainfall is less than 700 mm/year with average monthly rainfall in the summer months of less than 30 mm. Temperatures are also higher with an annual average of 26°C, average minimum temperature of around 20°C and an average maximum of 32°C. Evaporation is again high at over 2,100 mm/year and relative humidity is lower than the other regions at an average of 65%. Wind speeds are light at between 1.5 and 2.2 m/s and the number of sunshine hours is high at an average value of over 7 hours/day.

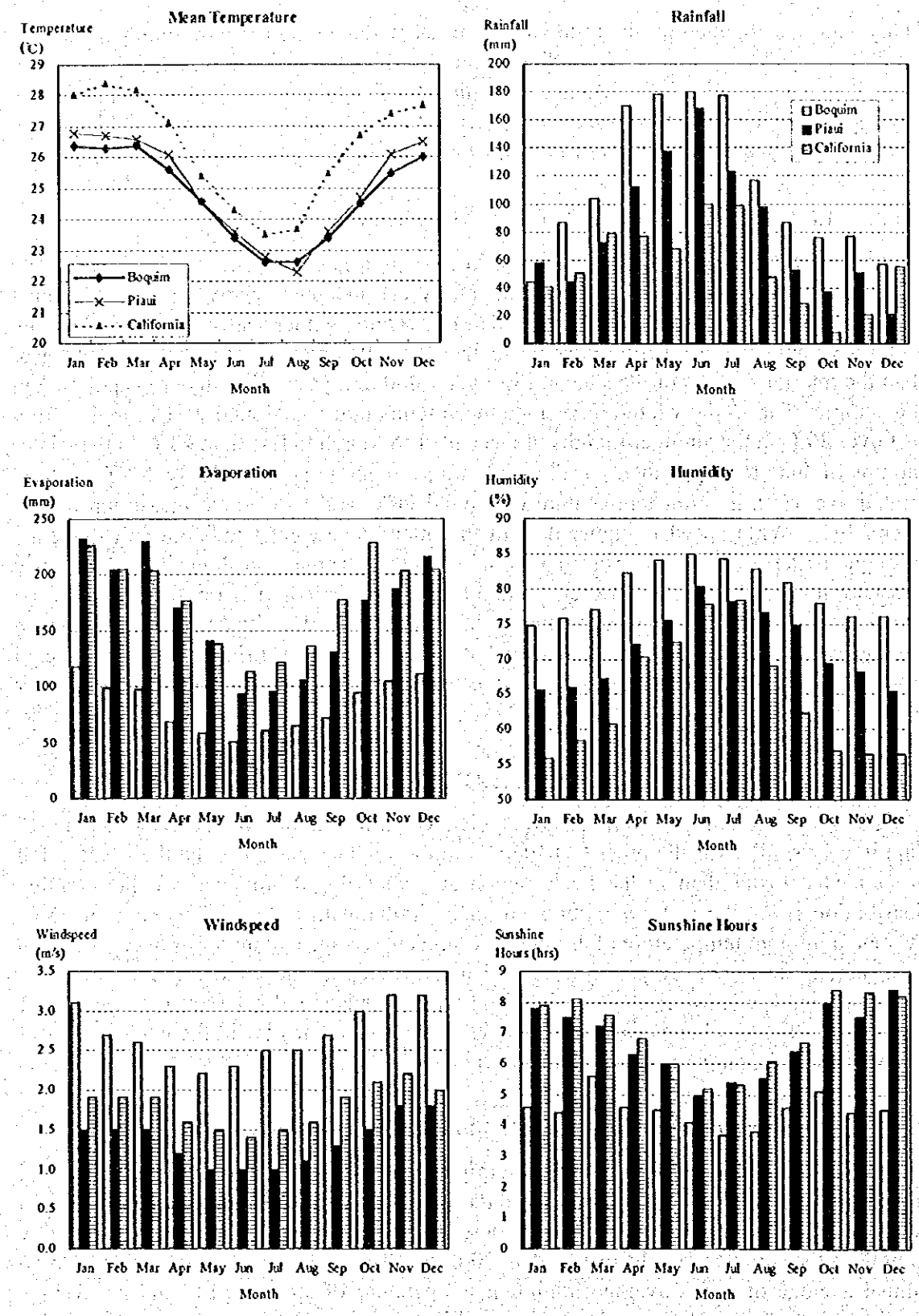


Figure-1.4 Monthly Variation of Meteorological Data – Boquim, Piaui and California