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STATE OF RIO DE JANEIRO
THE FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON RECUPERATION OF THE GUANABARA BAY ECOSYSTEM

VOLUME 3
SUPPORTING REPORT I

I. Natural and Socioeconomic Conditions of the Guanabara Bay Basin
II. Runoff Load from the Basin
III. Hydrodynamic Conditions and Sedimentation in Guanabara Bay

MARCH 1994

KOKUSAI KOGYO CO., LTD. TOKYO

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PART I

NATURAL AND SOCIOECONOMIC CONDITIONS OF THE GUANABARA BAY BASIN

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NATURAL CONDITIONS

CHAPTER 1

NATURAL CONDITION

1.1 Land Utilization Survey in the Guanabara Bay Basin

1.1.1 Earth Satellite (LANDSAT) Data Used for the Survey

The earth satellite data used for the survey was from the LANDSAT TM (PATH217-ROW76). Two satellite images were taken of the same area 7 years apart. **Fig. 1-1** shows the coverage map of the LANDSAT data.

(1) Observation made on May 30th, 1984
(2) Observation made on Nov. 26th, 1991

1.1.2 Digital Image Analysis System Used for the Survey

Fig. 1-2 shows the configuration of the digital analysis system used for the survey.

1.1.3 Survey Items

The major survey items for the drafting of the land utilization maps are listed bellow. **Fig. 1-3** is a Flow Chart thereof.

(1) Preprocessing the data

(2) Preparation of false color images

(3) Primary land cover classification

(4) Confirmation by field surveys

(5) Preparation of land utilization zoning images based on the secondary land cover classification

(6) Calculation of land utilization zone areas based on administrative districts and basin zones.

(7) Summarization

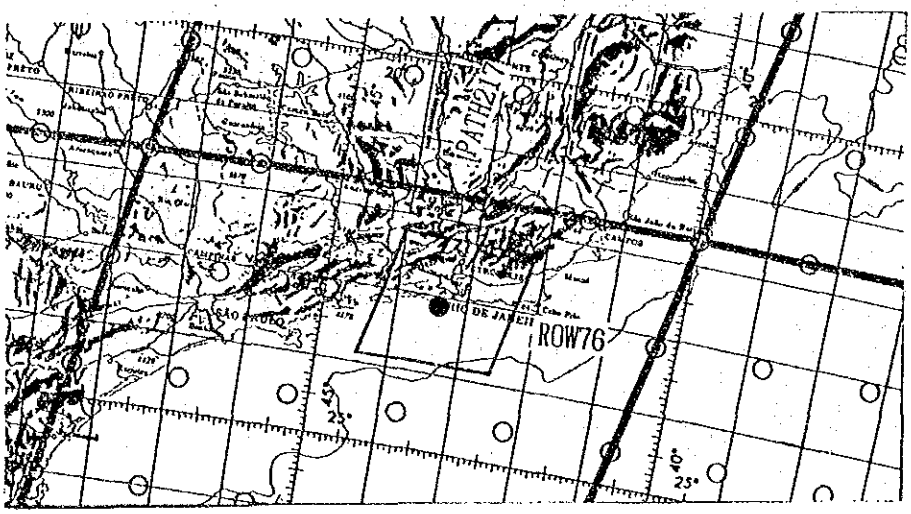


Fig. 1-1 Coverage map of the LANDSAT data

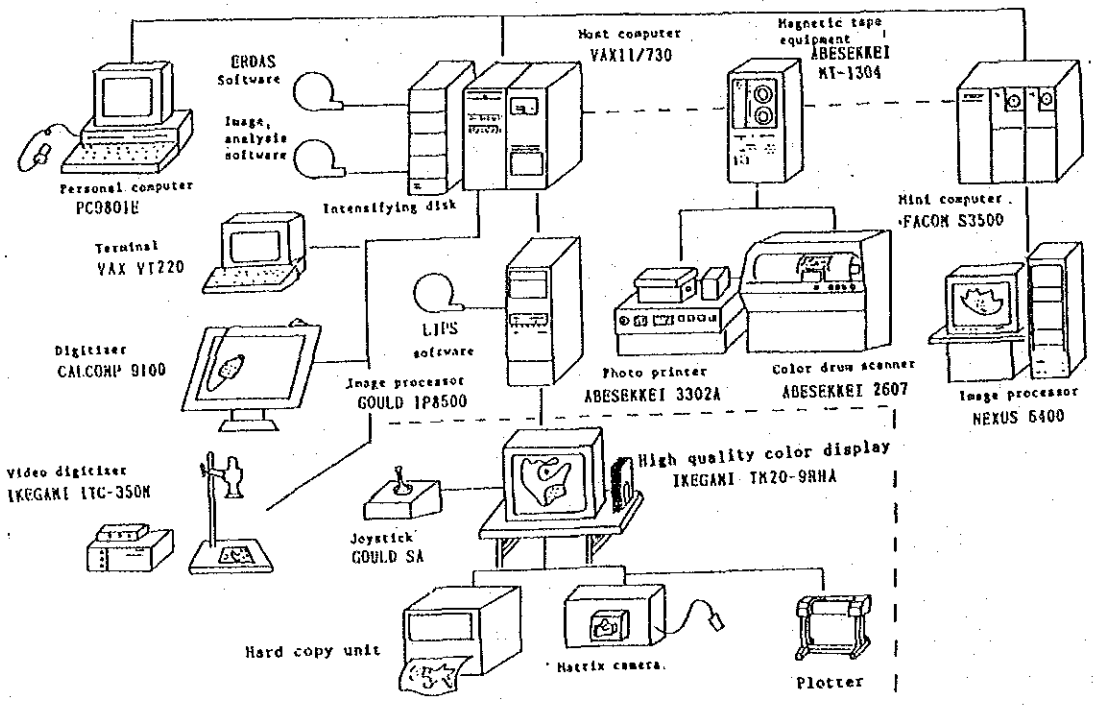


Fig. 1-2 Digital analysis system used for the survey

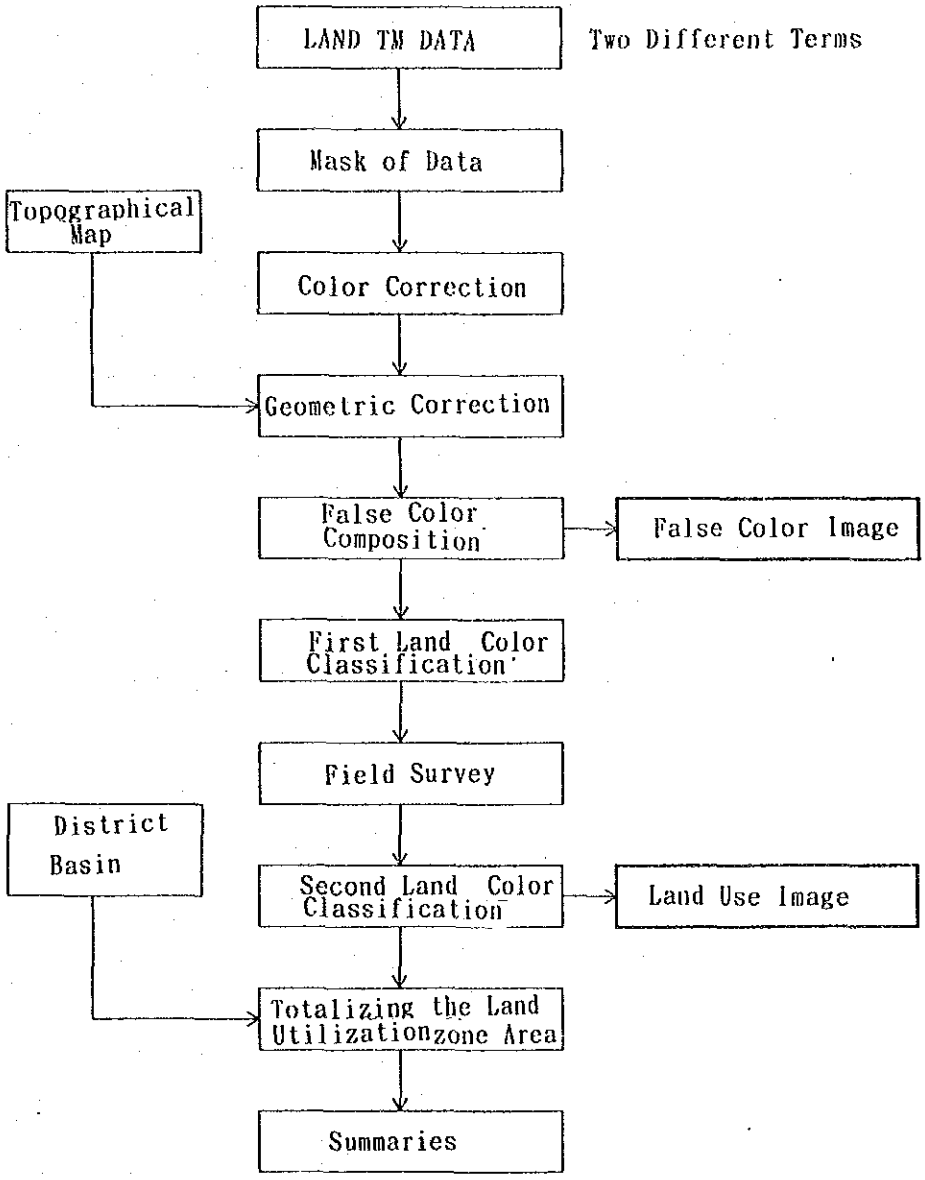


Fig. 1-3 Flow chart for Land utilization survey

1.1.4 Survey Methods

(1) Preprocessing the data

Data preprocessing entails the revision of the original data of the earth satellite, LANDSAT TM, prior to analysis. In this case, data pickup, color tone and geometrical revisions were performed.

Data pickup was carried out by selecting data pertaining to the survey area. Color tone revision was carried out by synchronizing the color tones of the two Landsat observations.

Geographical revision should be carried out for geometrical purposes to repair possible distortion in the original data. In this survey, topographical maps on a scale of 1:10,000 were used to identify points on the satellite images, these points are called ground control points (GCP).

Further, the geometrical revision carried out in this survey also included data conversion to 25 m x 25 m per 1 pixel based on the adjustments.

(2) Preparation of false color images

Like topographical maps, false color images are important for analysing survey areas. False color images are created by synthesizing the 3-band equivalent LANDSAT TM data whereby vegetation such as forests are colored red, grasslands in pink, villages in blue; these color variations enable the quick interpretation of the survey area.

In this survey, false color images of a scale of 1:100,000 were prepared for each of the 2 LANDSAT TM images.

(3) The Primary land cover classification

The land cover classification automatically categorizes the whole image in a statistical manner using the spectral characteristics of the earth satellite data. In this survey, the LANDSAT TM data revised through preprocessing were used and image categorization under the maximum likelihood categorization method was carried out. Maximum likelihood categorization sets up a training field (referred to as "teacher", it identifies areas by surface characteristics) through the use of existing land use and topographical maps, and subsequently automatically categorizes areas with similar spectral characteristics.

In this survey, firstly categories were established based on false color images of data collected prior to the field survey, and then primary land cover classification was carried out.

(4) Confirmation by field surveys

Fields surveys were done to confirm the accuracy of the data on the false color images and the results of the primary land cover classification.

(5) Preparation of land utilization zoning images based on secondary land cover classification

Once the classification categories and training fields were finalized based on the field survey results carried out, and through the maximum likelihood categorization method, secondary land cover classification was carried out.

Since the sole use of automatic categorization could lead to categorization errors, additional categorization and revisions will be made through false color image interpretation periodically before the different land utilization zoning images at a scale of 1:100,000 are drafted.

(6) Calculation of land utilization zones based on administrative districts and basin zones

The administrative districts and basin zones were overlaid on the land utilization zoning images to calculate the total areas of each land utilization category.

(7) Summarization

The aforementioned survey results were summarized into a report.

1.2 Land Use

1.2.1 Outline of Survey

(1) Purpose of Survey

Surveyed areas and Purpose are as follows.

OUTLINE OF GEOMORPHIC, GEOLOGY AND VEGETATION
To prepare an outline of the natural conditions and soil erosion.

DRAINAGE DIVISION
The drainage area is divided to calculate the population and the land use of each river basin.

LAND USE CLASSIFICATION
To survey the land use in the study area from current and past land use.

POPULATION DISTRIBUTION
The population of each basin is determined to calculate the water pollution loads.

FAVELA POPULATION
Favela population and distribution are determined to calculate the water pollution loads.

(2) Materials for the Survey

Survey items and materials are as follows.

GEOMORPHIC AND GEOLOGY

Topographic maps, scale 1:50,000,covering the study area are shown in **Fig.1.2-1.**

Ministerio do Exercito-Departmento de Engenharia e Comunicacões, Diretoria de Servico Geografico

1:400,000 Geographic Map of Rio de Janeiro State
Ambiental Engenharia Consultoria e Saneamento,(1992);
Estudo de impacto ambiental de programa de melhoria ambiental.
- Componentes saneamento basico da baia de Guanabara

False color images (path 217,row 76) of Landsat/TM in May 30th, 1984 and November 26th,1991

	MI-2715/3 MIGUEL PEREIRA	MI-2715/4 ITAIPAVA (1966)	MI-2716/3 TERESOPOLIS (1966)	MI-2716/4 NOVA FRIBURGO (1966)
MI-2744/2 PARACAMBI (1963)	MI-2745/1 CAVA (1963)	MI-2745/2 PETROPOLIS (1966)	MI-2746/1 ITABORAI (1969)	MI-2746/2 RIO BONITO (1964/66)
MI-2744/4 MI-2743/2 SANTA CRUZ (1982)	MI-2745/3 MI-2774/1 VILLA MILITAR (1982)	MI-2745/4 MI-2774/2 BAIA DE GUANABARA (1982)	MI-2746/3 MI-2774-A/1 MARICA (1962)	MI-2746/4 SAQUAREMA (1966)

Fig. 1.2-1 Topographic Maps on a Scale of 1:50,000 Covered the Study Area

VEGETATION

Ivan de Oliveira Pires,(1992);
Monitoramento de manguezais atraves de correlacão de dados da fitomassa e de radianicia TM/Landsat.
Exemplo: Apa-Guapimirim(RJ).

Governo do Estado do Rio de Janeiro,(1991);
Tombamento da Serra do Mar / Mata Atlantica

Maria Tereza Jorge Padua,(1983);
Os parques nacionais e reservas biologicas do Brasil,
Instituto Brasileiro de Desenvolvimento Florestal

False color images (path 217,row 76) of Landsat/TM taken May 30th, 1984 and November 26th,1991.

DRAINAGE SYSTEM AND DIVISION

Topographic maps, scale 1:50,000, covering the study area are shown in **Fig.1.2-1.**

LAND USE

Landsat/TM data (path 217, row 76) taken May 30th,1984 and November 26th, 1991

Ivan de Oliveira Pires,(1992);
Monitoramento de manguezais atraves de correlacão de dados da fitomassa e de radiancia TM/Landsat.
Exemplo:Apa-Guapimirim(RJ).

Ministerio de minas e energia,(1992)
Folha Rio de Janeiro (Edicão experimental),
Carta-imagem basica de sensores remotos orbitais,
Escala 1:100,000

POPULATION

Gerência do projeto censo 91, Fundacao instituto Brasileiro de geografia e estatistica(IBGE),(1992);
Censo 1991 com mapa municipal para fins estatisticos-90,
Inventario Municipal da Base Operational-Sintese, RJ.

POPULATION AND DISTRIBUTION OF FAVELA

Gerência do projeto censo 91, Fundacão instituto Brasileiro de geografia estatistica(IBGE), (1992),
Censo 1991 com mapa municipal para fins estatisticos-90,
Inventario Municipal da Base Operational-Sintese, RJ.

Instituto de planejamento municipal (IPLANRIO), (1991)
Population and area of favelas

Instituto de planejamento municipal (IPLANRIO), (1985)
Localizacão de favelas, loteamentos irregulares e conjuntos habitacionais de baixa renda no municipio do Rio de Janeiro, Escala 1:25,000

(3) Method and Process of Survey

OUTLINE OF GEOMORPHOLOGY,GEOLOGY AND VEGETATION

Outline of geomorphology, geology and vegetation was compiled from information and Landsat false color images. Soil erosion was studied from these data.

DRAINAGE SYSTEM AND DIVISION

The drainage system and division of the study area were investigated from the topographic maps (**Fig. 1.2-1**), scale 1:50,000, published by Diretoria de Servico Geografico Ministerio do Exercito. Aerial photographs from which the topographical maps were made, however, were taken between 1962 and 1982. Though the drainage system represented on these topographical maps is somewhat different from the present condition due to the difference in date, the drainage layout maps of the Guanabara Bay basin were made from these topographical maps.

As for the drainage system, areas were designated "valley" where the contours showed a valley with a narrow frontage (a) and a substantial length (b) on a topographical map ($a \leq b$). In a flat-hand near the middle and lower reaches of a stream, river systems were adopted those waterways which had been recorded on the topographical maps.

LAND USE CLASSIFICATION

Land use classification in 1984 and 1991 was investigated by analysis of the Landsat digital data. **Fig.1.3-1** shows the flow chart of analysis of the Landsat digital data.

POPULATION

Population of each river basin was calculated in proportion to the area of each district. The population including inhabitants of favelas in each district was based on the 1991 census which was conducted by IBGE (Fundacao Instituto Brasileiro de Geografia e Estatistica).

FAVELA POPULATION AND DISTRIBUTION

The favela population in each municipality was listed in the 1991 census. Favela population and distribution in Rio de Janeiro municipality in each basin were obtained from the data by IPLANRIO.

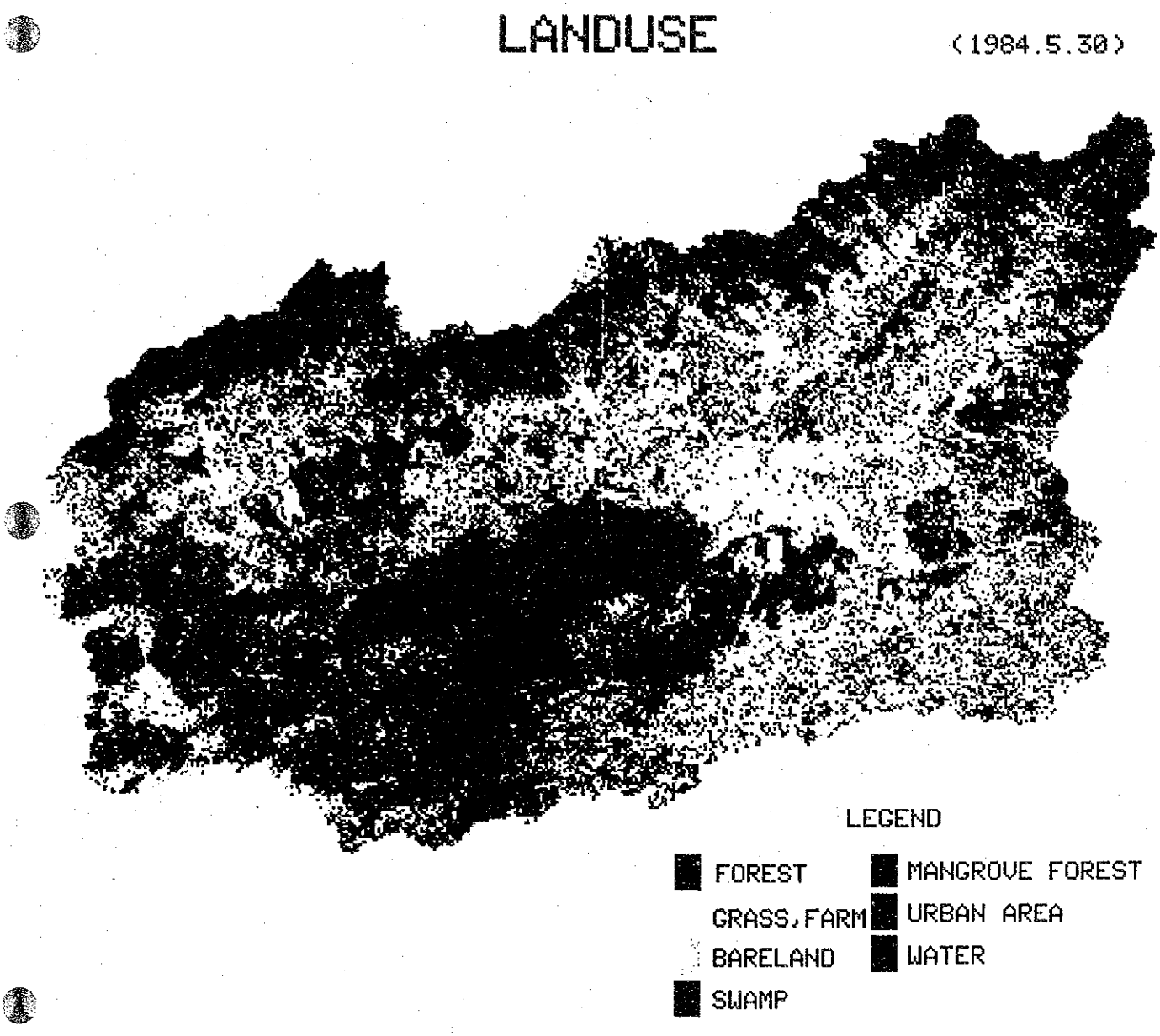


Fig. 1.3.1 Land Use Condition in 1984 interpreted from the LANDSAT/TM data

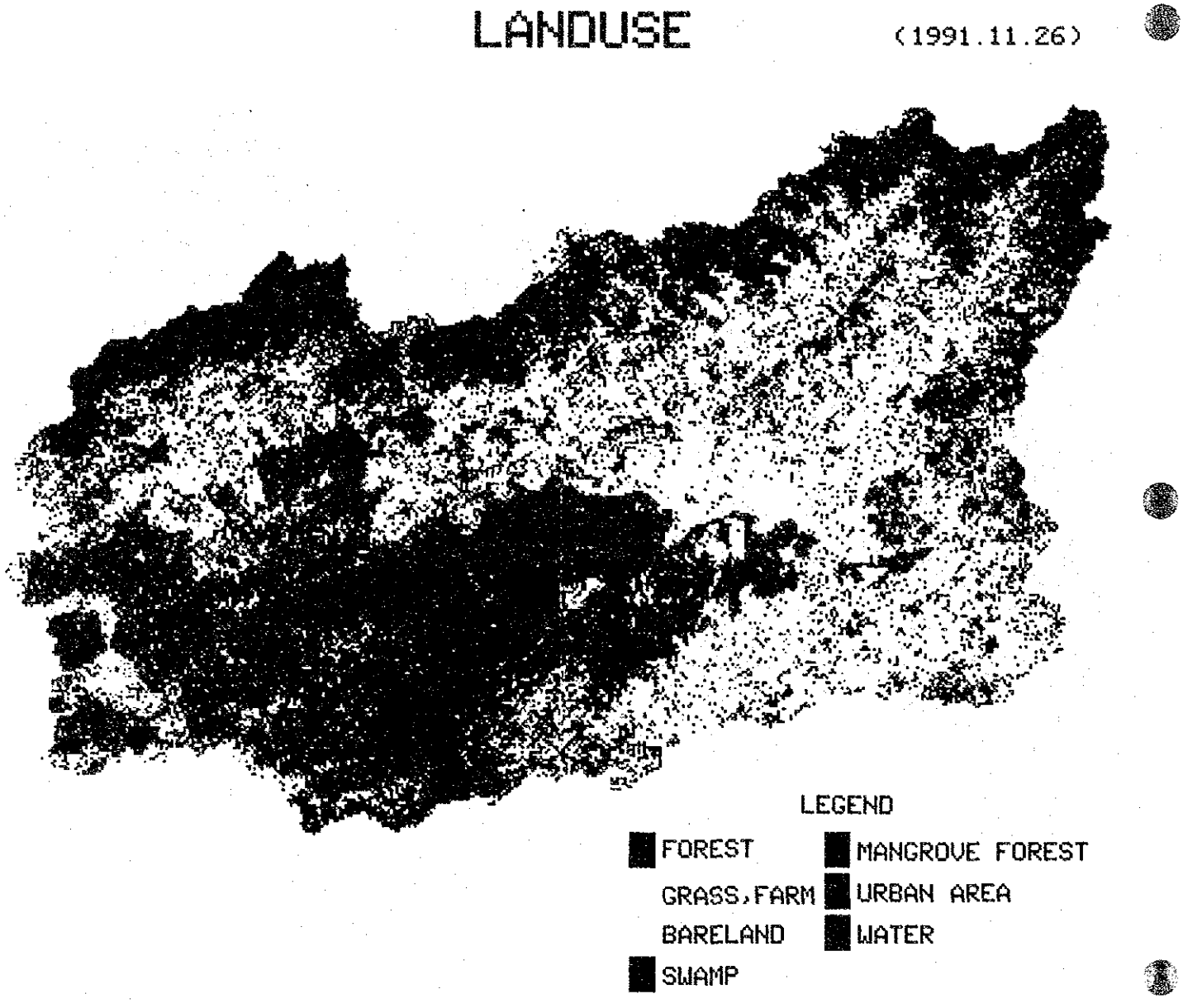


Fig. 1.3.1 Land Use Condition in 1991 interpreted from the LANDSAT/TM data

1.2.2. Results of Survey

(1) Outline of Geomorphology, Geology and Vegetation

OUTLINE OF GEOMORPHOLOGY

The northern edge of the Guanabara Bay basin is bordered by part of Serra do Mar which extends northeast. This mountains range has an altitude of 1,000 to 2,000 m and is about 5 to 7 km from the Atlantic coast.

The mountains have a strong influence upon the characteristics of the climate and vegetation in the study area, because they block the air current.

The southern study area is surrounded by coastal mountains: Serra do Bangu, Serra da Carioca and Serra do Mato Grosso whose heights range from 500 to 1,000 m.

The Rocky mountains that constrict the bay mouth area are generally a part of a mountainous area along the coastal line extending between these mountains which form two lines as they extend in an E-W direction. Because of this, the watershed on the east and west side of the Guanabara Bay basin is not always obvious.

Fig. 2.1-1 shows the geomorphological classification of the Guanabara Bay basin. On the north side of the study area, there are high mountains, Serra do Mar. On the south side, there are low mountains and hills. On the east and west side, there are mountains from south to north, hills and planes. The central basin is covered with gently undulating hills. Plains are found around the river and along the coast, and swamps are distributed in the estuary delta of Rio Iguacu and Rio Guapimirim.

OUTLINE OF GEOLOGY

Fig. 2.1-2, shows the Geological map of the Guanabara Bay basin. The Precambrian base covers a large area of the Guanabara Bay basin and consists of zonal gneisses and granitic gneisses, which contain subsidiary intercalated quarzites and marbles. This area is characterized by strong structural lineament, the dominant direction being WSW-ENE and SW-NE.

Alkali rocks of early Tertiary are isolated in the east and west sides of the basin. Surui Gganite is distributed to the north of Guanabara Bay.
Pleistocene sediments exist around Itaborai, and Holocene sediments are distributed over the river and coastal plains.

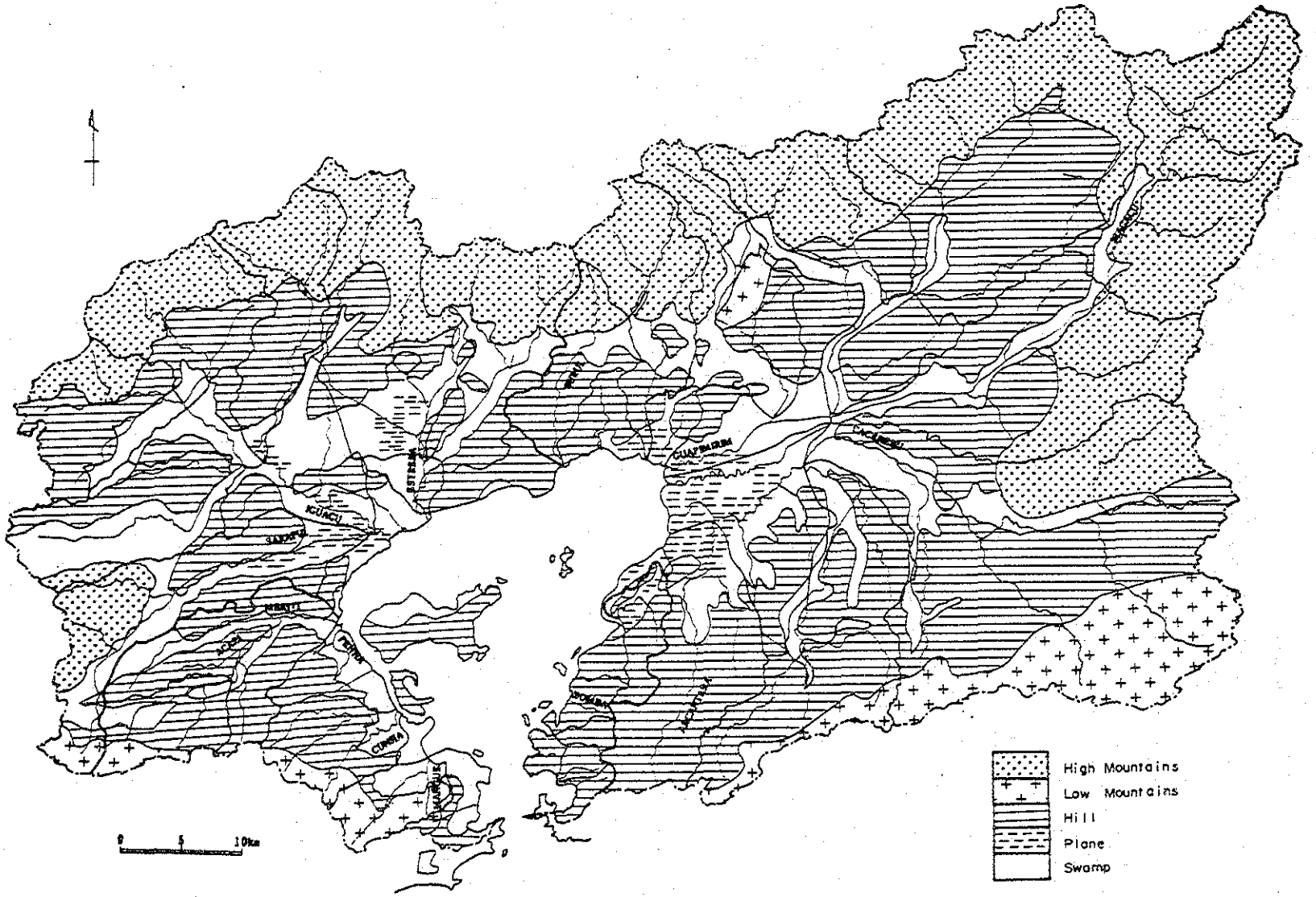


Fig. 2.1-1 Geomorphological Classification of the Guanabara

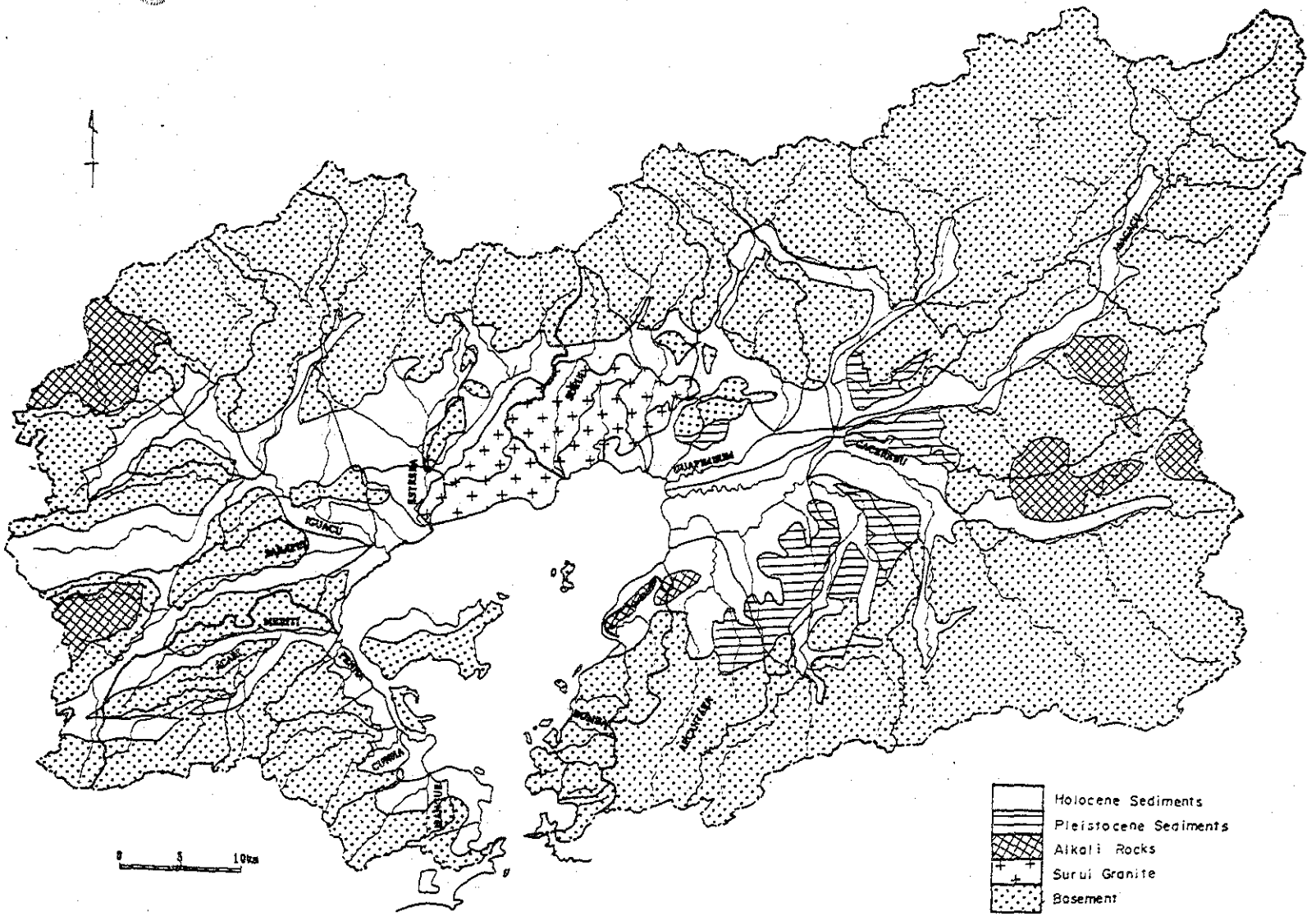


Fig. 2.1.- 2 Geology of the Guanabara Bay Basin

Quarternary sediments in Guanabara Bay basin are as follows.

Pre-Macacu Layer

The Pre-Macacu layers are constituted of alternating fine sediments, silt-clay with sand and sand-clay materials. They are interstratified with lenses, enrichment granule, generally clay.

Macacu Formation

The Macacu Formation is constituted by a succession of lenses and thin layers of consolidated and afossiliferous fine sediments, predominant sands.

Older Colluvium Sediments
Older Alluvial Sediments
Recent Colluvium Sediments
Fluvial-Marine Sediments

OUTLINE OF VEGETATION

Fig.2.1-3 shows the forest areas and environmental protection areas around Guanabara Bay. The largest one is in Serra dos Orgaos and also the Serra do Mar which are on the northern-margin of the basin. Another attractive forest is in Tijuca, which is isolated in the megalopolis. These mountain forests belong to the biogeographic region of Serra do Mar and are included in the Tropical Atlantic Morphoclimatic zone, and are largely designated as environmental protection areas. Though, at first glance, these forests look like the primary forests, actually they are the secondary forest with developed vegetal succession.

Since the forest of Serra do Mar has an annual precipitation of 2,200 mm and the relative humidity of 80 to 90% constantly through the year, the vegetation of the forests is extraordinary powerful and rich in species.

The Tijuca forest, was originaly destroyed by the cultivation of sugar cane and coffee from the 17th century. Finally, in 1961 ecological reforestation started, resulting in the current natural regeneration of the forest.

Another environmental protection area is around the mouth of the Rio Guapi-Mirim where a mangrove forest exists. In recent years, however, the area of forests have reduced due to deforestation and land development in adjacent areas. Though besides the above-mentioned forests, only few other forests are designated as the environmental protection area, generally speaking, the areas of the forest zones is rapidly diminishing.

(2) Drainage System and Division

Fig. 2.2-1 shows the drainage system of the study area and **Table 2.2-1** shows the drainage area.

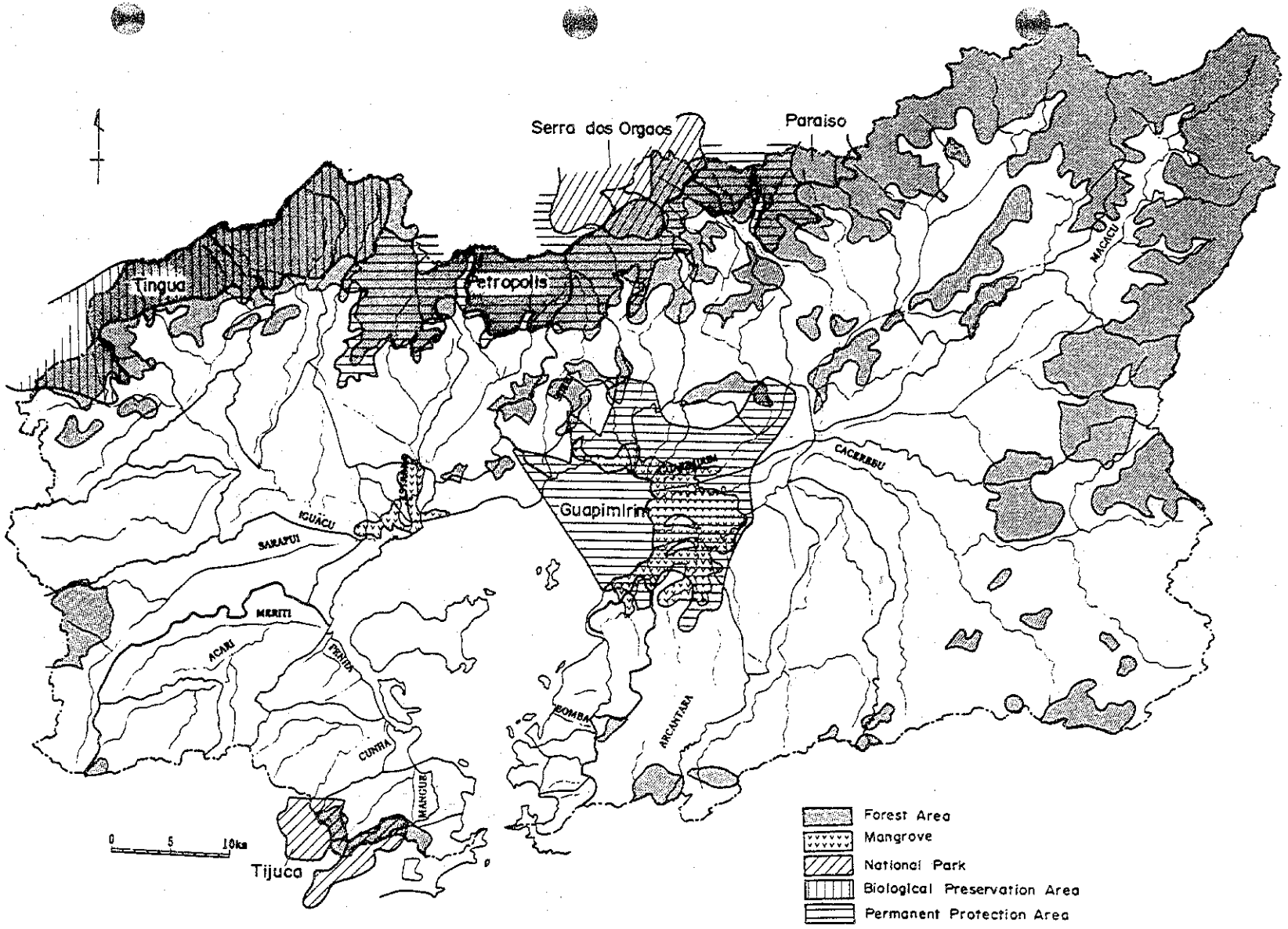


Fig. 2.1-3 Forest Area and Environmental Protection Area in the Guanabara Basin

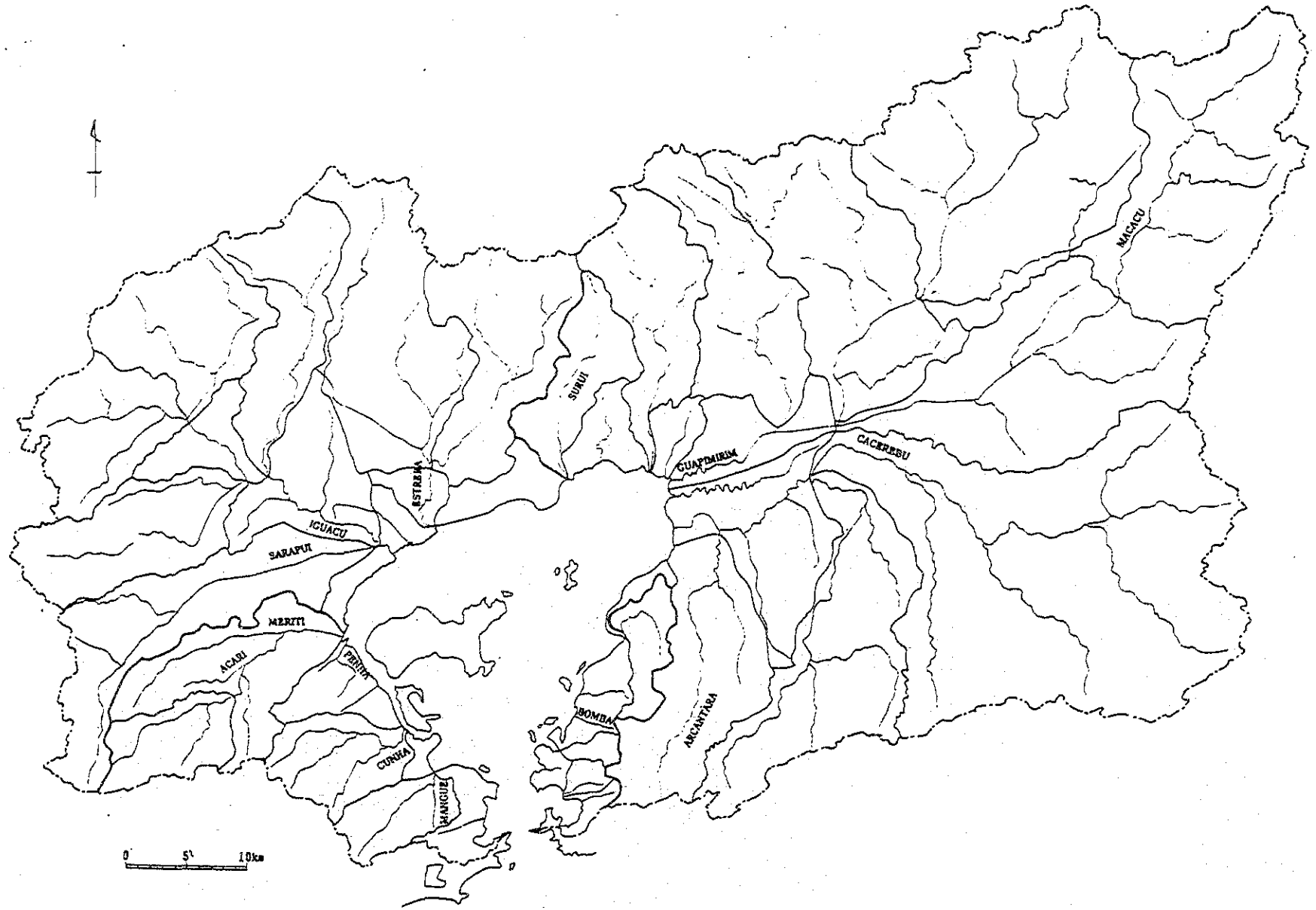


Fig. 2.2-1 Sub-basins in the Guanabara Bay Basin

Table 2.2-1 Area of River Basins in Study Area

Basin Code	Area(km²)	Basin Code	Area(km²)
1	9.4	16	342.5
2	7.4	16-1	17.5
3	7.8	16-2	139.0
4	7.9	16-3	186.0
5	26.2	17	755.3
6	30.8	17-1	122.9
7	6.4	17-2	104.4
8	144.6	17-3	115.7
9	846.7	17-4	103.1
9-1	110.9	17-5	116.7
9-2	191.4	17-6	165.5
9-3	544.4	18	27.0
10	1,253.1	19	164.5
10-1	53.1	19-1	106.6
10-2	246.7	19-2	57.9
10-3	256.0	20	35.7
10-4	215.4	21	63.6
10-5	349.5	22	6.6
10-6	132.4	23	42.8
11	18.3	24	26.0
12	111.4	25	38.2
13	27.8	26	5.4
14	68.8	27	1.7
15	28.9	28	1.3
		29	1.4
		Total	4,080.5

About forty-five (45) rivers flow into Guanabara Bay from the basin area. Rio Guapi-mirim, Rio Cacerebu and Rio Iguacu have large basin areas. The former two flow in from the eastern basin area forming a complex mesh-like route as they meander towards the swampy area downstream and divides its abundant flow into several river mouths, while Rio Iguacu flows in from the western basin area. The rivers that pass through the Rio de Janeiro municipality have a small basin area and steep slopes. These small and steep rivers often cause inundation because the urban areas occupying large parts of their basin increase the runoff ratio of rainfall.

(3) Land Use

ITEMS OF LAND USE CLASSIFICATION

The land use category is classified into seven (7) and are as follows.

Urban area: densely built-up, industry areas, residential areas, new town with surrounding open space, road, rail way, airport, harbor facilities, and artificial land;

Grassland : grassland, pasture land, farmland, orchards, studs;

Forest : density of forest crown cover above approximately 80%;

Mangrove : mangrove forest area;

Swamp : a permanently waterlogged area, without mangroves;

Bareland : rock surface area, beach sand area;

Water body : rivers, ponds, sea-surface;

AREA BY LAND USE CATEGORY

The present (1991) and past (1984) land use conditions were analyzed on the record of LANDSAT thematic mapper purchased from Instituto Nacional de Pesquisas (INRE).

Tables 2.3-1 and **2.3-2** show the area by land use category according to the area code. **Table 2.3-3** and **Fig. 2.3-1** show the land use of each river basin in 1991.

CHANGE OF LAND USE

The drainage area of Guanabara Bay basin amounts to about 4,000 km^2. The ratio of grassland, forest and urban area to the total study area were 35.3%, 33.4% and 19.5% respectively as of 1984. Those ratios altered to 39.1%, 31.1% and 21.6% respectively in 1991.Conspicuous changes were not found over the past seven years.

The change of the land use during a period from 1984 to 1991 was the increase of urban area by about 80 km^2, decrease of forests by 100 km^2 and the area of mangrove forest remained the same. Since the area of swamp decreased by about 100 km^2 during this period, patches of mangroves existing in this decreased area must also have diminished. During this period grasslands increased by about 150 km^2 and barelands only slightly decreased.

Table 2.3-1 Area by Land Use Category in 1984

(km2)

Area code	Urban	Forest	Mangrove	Swamp	Grass	Bareland	Water	Total
1NR	2.6	1.7	0.0	0.6	2.4	1.3	0.7	9.3
2NR	3.2	0.9	0.0	0.5	1.8	1.0	0.0	7.4
3NR	5.0	0.5	0.0	0.3	0.5	1.0	0.5	7.8
4NR	3.5	1.0	0.0	0.6	1.7	1.1	0.0	7.9
5NR	4.4	0.3	0.0	0.3	0.7	0.8	0.5	7.0
5SG	11.6	1.1	0.0	1.3	2.4	2.4	0.5	19.3
6SG	14.2	2.5	1.2	4.8	3.3	4.2	0.5	30.7
7SG	1.3	0.8	1.9	1.2	0.7	0.4	0.2	6.5
8NR	5.1	11.5	0.0	2.4	10.1	1.2	0.0	30.3
8SG	49.9	8.4	10.5	13.4	21.1	6.7	0.6	110.6
81B	0.0	0.0	3.1	0.6	0.0	0.0	0.1	3.8
9-1IB	26.5	0.2	7.1	10.4	9.5	1.7	0.6	56.0
9-1SG	10.2	0.5	0.3	1.3	3.2	0.4	0.0	15.9
9-1MG	0.1	0.0	19.0	9.6	9.3	0.5	0.6	39.1
9-2IB	34.8	9.5	0.0	7.2	64.7	2.3	0.2	118.7
9-2SG	2.0	11.4	0.0	5.2	42.0	1.3	0.0	61.9
9-2NR	0.3	5.0	0.0	0.6	4.8	0.1	0.0	10.8
9-3MG	0.0	0.0	0.0	0.3	1.3	0.0	0.0	1.6
9-3IB	23.4	78.8	0.0	18.1	219.7	5.6	0.1	345.7
9-3RB	5.3	81.9	0.0	11.1	94.1	4.7	0.1	197.2
10-1MG	2.2	3.5	6.2	4.2	34.8	1.8	0.6	53.3
10-2IB	0.5	8.0	0.0	2.9	35.3	0.6	0.0	47.3
10-2CN	4.4	72.8	0.0	8.1	110.7	3.2	0.1	199.3
10-3CN	2.6	181.6	0.0	7.5	61.4	2.8	0.1	256.0
10-4CN	0.5	37.2	0.0	6.0	48.6	2.4	0.1	94.8
10-4MG	1.4	62.6	0.0	3.0	51.1	2.5	0.1	120.7
10-5CN	1.3	221.4	0.0	8.9	111.7	5.7	0.3	349.3
10-6MG	6.6	49.8	0.0	4.9	64.9	6.2	0.1	132.5
11MG	3.5	2.4	2.8	1.0	8.0	0.6	0.0	18.3
12MG	2.7	60.6	1.4	2.4	38.6	5.7	0.1	111.5
13MG	1.0	4.6	5.3	2.6	13.0	1.2	0.1	27.8
14MG	2.6	31.5	0.7	3.3	28.5	2.0	0.2	68.8
15MG	4.5	7.0	0.2	4.7	10.2	2.1	0.2	28.9
16-1MG	0.0	0.4	0.5	1.5	2.6	0.4	0.0	5.4
16-1DC	3.7	0.3	3.4	2.5	0.3	1.9	0.2	12.3
16-2MG	12.8	60.0	0.1	8.3	39.0	3.1	0.1	123.4
16-2PP	1.2	12.2	0.0	0.4	1.2	0.8	0.0	15.8
16-3DC	36.2	65.5	0.7	12.8	26.0	4.6	0.7	146.5
16 3MG	5.8	2.7	0.0	1.3	4.2	0.8	0.0	14.8
16-3PP1	0.2	13.7	0.0	0.1	2.3	0.4	0.0	16.7
16-3PP2	0.0	7.5	0.0	0.0	0.1	0.0	0.0	7.6
17-1DC1	32.2	2.6	0.3	11.3	13.7	5.0	0.9	66.0
17-1DC2	2.1	1.9	0.0	0.5	12.9	0.7	0.0	18.1
17-1NI1	6.8	1.1	0.0	0.9	8.8	1.2	0.0	18.8
17-1NI2	2.9	2.7	0.0	0.3	13.4	0.6	0.0	19.9
17-2DC	5.9	64.1	0.0	2.5	29.8	2.0	0.1	104.4
17-3DC	0.8	35.4	0.0	0.0	16.4	0.8	0.0	53.4
17-3NI	3.3	43.0	0.0	0.2	15.5	0.4	0.0	62.4
17-4NI	19.7	38.4	0.0	4.7	36.6	3.6	0.1	103.1
17-5NI	76.4	6.5	0.0	6.0	21.7	6.0	0.1	116.7
17-6DC	16.2	0.1	0.1	4.8	2.0	4.7	0.3	28.2
17-6NI	26.9	22.4	0.0	2.7	14.0	3.4	0.0	69.4
17-6SJ	22.2	0.0	0.0	0.1	0.9	2.1	0.0	25.3
17-6NP	6.3	0.1	0.0	0.2	3.6	0.3	0.0	10.5
17-6RJ	15.2	2.2	0.0	1.9	10.8	1.9	0.0	32.0
18DC	8.6	0.1	3.3	7.2	0.5	5.0	2.2	26.9
19-1DC	7.4	0.0	0.3	0.2	0.3	1.2	0.4	9.8
19-1SJ	8.7	0.0	0.0	0.0	0.3	1.1	0.0	10.1
19-1NP	3.4	0.2	0.0	0.2	4.7	0.3	0.0	8.8
19-1RJ	57.3	1.1	0.4	1.9	10.9	6.3	0.2	78.1
19-2RJ	31.7	2.9	0.0	1.4	18.8	2.9	0.1	57.8
20RJ	29.1	0.2	0.0	1.0	1.4	3.2	0.9	35.8
21RJ	47.9	0.3	0.0	1.8	9.5	4.0	0.1	63.6
22RJ	4.9	0.0	0.0	0.1	0.0	0.5	1.0	6.5
23RJ	22.4	8.6	0.0	1.9	7.2	2.7	0.1	42.9
24RJ	14.9	2.9	0.0	1.1	2.3	3.0	1.6	25.8
25RJ	21.5	3.0	0.1	2.2	0.5	8.6	2.3	38.2
26RJ	3.0	0.0	0.0	0.7	0.3	0.5	0.9	5.4
27RJ	0.6	0.3	0.0	0.2	0.2	0.1	0.3	1.7
28SG	0.4	0.2	0.0	0.1	0.2	0.1	0.3	1.3
29NR	0.3	0.1	0.0	0.1	0.2	0.2	0.5	1.4
30RJ-S	1.1	0.3	0.0	0.2	0.2	0.6	182.4	184.8
31DC-S	0.0	0.0	0.0	0.9	0.0	0.1	21.2	22.2
32MG-S	0.2	0.1	1.2	0.4	0.1	0.2	68.9	71.1
33IB-S	0.0	0.0	0.2	0.1	0.0	0.0	12.9	13.2
34SG-S	0.3	0.3	0.1	0.2	0.0	0.2	28.2	29.3
35NR-S	0.4	0.1	0.0	0.0	0.1	0.3	25.9	26.8
Total	798.1	1,362.5	70.4	234.2	1,443.6	159.3	360.1	4,428.2

Table 2.3-2 Area by Land Use Category in 1991

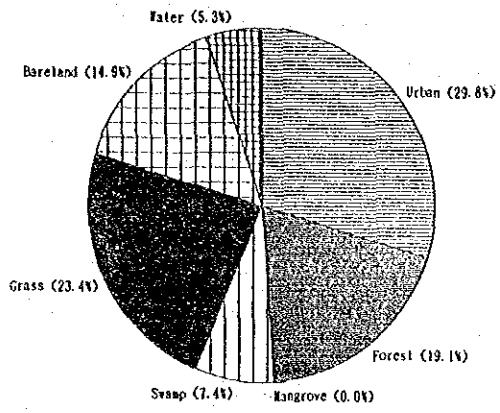
Basin code	Urban	Forest	Mangrove	Swamp	Grass	Bareland	Water	(km2) Total
1	2.8	1.8	0.0	0.7	2.2	1.4	0.5	9.4
2	3.5	0.3	0.0	0.4	2.5	0.7	0.0	7.4
3	5.4	0.1	0.0	0.3	0.7	0.9	0.4	7.8
4	4.3	0.3	0.0	0.3	2.2	0.8	0.0	7.9
5	18.4	0.2	0.0	0.6	3.7	2.6	0.7	26.2
6	17.2	1.7	1.2	4.3	4.1	2.1	0.2	30.8
7	1.8	0.5	1.9	1.1	0.8	0.1	0.2	6.4
8	66.1	14.7	13.6	6.7	36.1	7.3	0.1	144.6
9-1	39.1	1.4	26.3	17.9	22.1	3.7	0.4	110.9
9-2	42.5	16.9	0.0	0.5	123.4	7.8	0.3	191.4
9-3	35.6	116.9	0.0	1.8	377.9	12.2	0.0	544.4
10-1	2.6	3.0	6.2	3.6	35.8	1.5	0.4	53.1
10-2	5.3	79.9	0.0	0.3	157.0	4.2	0.0	246.7
10-3	3.4	180.9	0.0	1.6	68.4	1.7	0.0	256.0
10-4	3.2	102.0	0.0	1.9	106.0	2.3	0.0	215.4
10-5	2.0	211.0	0.0	1.8	130.5	4.1	0.1	349.5
10-6	6.7	52.2	0.0	2.9	65.8	4.8	0.0	132.4
11	4.0	1.1	2.7	0.8	8.9	0.8	0.0	18.3
12	3.5	60.3	1.4	1.0	40.1	5.1	0.0	111.4
13	1.2	3.2	5.3	2.5	15.1	0.5	0.0	27.8
14	3.3	29.8	0.7	1.4	32.6	1.0	0.0	68.8
15	6.3	5.8	0.2	2.7	12.9	1.0	0.0	28.9
16-1	4.3	0.3	3.9	4.6	3.5	0.9	0.0	17.5
16-2	16.7	68.8	0.1	4.0	46.8	2.6	0.0	139.0
16-3	48.0	84.4	0.7	10.3	37.8	4.2	0.6	186.0
17-1	49.3	4.7	0.3	11.6	50.8	6.0	0.2	122.9
17-2	6.4	59.8	0.0	3.0	33.9	1.3	0.0	104.4
17-3	4.5	75.6	0.0	0.7	33.8	1.1	0.0	115.7
17-4	22.1	37.3	0.0	1.4	38.8	3.5	0.0	103.1
17-5	84.2	2.7	0.0	0.7	22.1	7.0	0.0	116.7
17-6	91.9	26.5	0.1	9.3	27.6	10.0	0.1	165.5
18	11.1	0.1	3.3	9.0	0.7	2.4	0.4	27.0
19-1	80.2	1.6	0.7	1.5	13.4	9.2	0.0	106.6
19-2	32.5	3.5	0.0	0.8	16.7	4.4	0.0	57.9
20	30.9	0.0	0.0	0.5	1.2	2.7	0.4	35.7
21	47.8	0.5	0.0	1.3	8.9	5.1	0.0	63.6
22	5.6	0.0	0.0	0.1	0.1	0.4	0.4	6.6
23	22.3	10.5	0.0	1.8	5.2	3.0	0.0	42.8
24	15.9	3.3	0.0	1.3	2.0	2.3	1.2	26.0
25	24.9	3.1	0.1	0.9	0.7	6.8	1.7	38.2
26	3.4	0.0	0.0	0.2	0.4	0.6	0.8	5.4
27	0.7	0.2	0.0	0.1	0.2	0.2	0.3	1.7
28	0.4	0.2	0.0	0.0	0.3	0.1	0.3	1.3
29	0.4	0.2	0.0	0.0	0.3	0.1	0.4	1.4
Total	881.7	1,267.3	68.7	118.2	1,594.0	140.5	10.1	4,080.5
%	21.6	31.1	1.7	2.9	39.1	3.4	0.2	100.0

Table 2.3-3 Land Use of each River basin in 1991

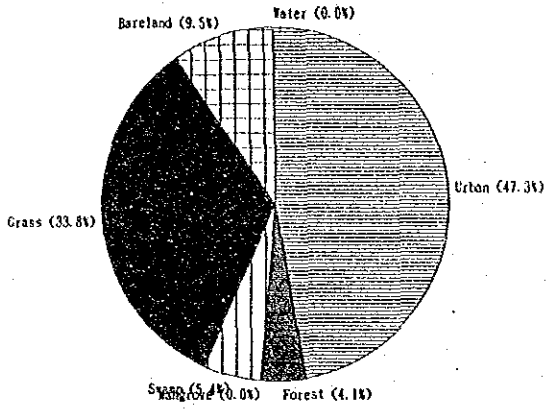
Basin No.		Name	Land Use							Basin Area
			Urban	Forest	Mangrove	Swamp	Grass	Bareland	Water	(km2)
	1	B.-CHARITAS	2.8	1.8	0.0	0.7	2.2	1.4	0.5	9.4
Eastern	2	CANAL CANTO DO RIO	3.5	0.3	0.0	0.4	2.5	0.7	0.0	7.4
Basin	3	B.-CATEDRAR	5.4	0.1	0.0	0.3	0.7	0.9	0.4	7.8
	4	B.-NORTE CENTRO	4.3	0.3	0.0	0.3	2.2	0.8	0.0	7.9
	5	RIO BOMBA	18.4	0.2	0.0	0.6	3.7	2.6	0.7	26.2
	6	RIO IMBOASSU	17.2	1.7	1.2	4.3	4.1	2.1	0.2	30.8
	7	B.-ITAOCA	1.8	0.5	1.9	1.1	0.8	0.1	0.2	6.4
Northeastern	8	RIO ALCANTARA	66.1	14.7	13.6	6.7	36.1	7.3	0.1	144.6
Basin	9	RIO CACEREBU	117.2	135.2	26.3	20.2	523.4	23.7	0.7	846.7
	10	RIO GUAPIMIRIM	23.2	629.0	6.2	12.1	563.5	18.6	0.5	1253.1
	11	CANAL DE MAGE	4.0	1.1	2.7	0.8	8.9	0.8	0.0	18.3
	12	RIO RONCADOR	3.5	60.3	1.4	1.0	40.1	5.1	0.0	111.4
	13	RIO IRIRI	1.2	3.2	5.3	2.5	15.1	0.5	0.0	27.8
	14	RIO SURUI	3.3	29.8	0.7	1.4	32.6	1.0	0.0	68.8
	15	B.-MAUA	6.3	5.8	0.2	2.7	12.9	1.0	0.0	28.9
Northwestern	16	RIO ESTRELA	69.0	153.5	4.7	18.9	88.1	7.7	0.6	342.5
Basin	17.1~5	RIO IGUACU	166.5	180.1	0.3	17.4	179.4	18.9	0.2	562.8
	17.6	RIO SARAPUI	92.1	26.5	0.1	9.3	27.6	9.8	0.1	165.5
	18	B.-CABO DO BRITO	11.1	0.1	3.3	9.0	0.7	2.4	0.4	27.0
	19	RIO S.J.DE MERITI	112.7	5.1	0.7	2.3	30.1	13.6	0.0	164.5
	20	RIO IRAJA	30.9	0.0	0.0	0.5	1.2	2.7	0.4	35.7
Western	21	CANAL DO CUNHA	47.8	0.5	0.0	1.3	8.9	5.1	0.0	63.6
Basin	22	B.-S.CRISTOVAO	5.6	0.0	0.0	0.1	0.1	0.4	0.4	6.6
	23	CANAL DO MANGUE	22.3	10.5	0.0	1.8	5.2	3.0	0.0	42.8
	24	B.-BOTAFOGO	15.9	3.3	0.0	1.3	2.0	2.3	1.2	26.0
	25	I. DO GAVANADOR	24.9	3.1	0.1	0.9	0.7	6.8	1.7	38.2
Island	26	I. DO FUNDAO	3.4	0.0	0.0	0.2	0.4	0.6	0.8	5.4
	27	I. DE PAQUETA	0.7	0.2	0.0	0.1	0.2	0.2	0.3	1.7
	28	I. DO ENGENHO	0.4	0.2	0.0	0.0	0.3	0.1	0.3	1.3
	29	I. DE S.CRUZ	0.4	0.2	0.0	0.0	0.3	0.1	0.4	1.4
		Total	881.9	1267.3	68.7	118.2	1594.0	140.3	10.1	4080.5

Fig. 2.3-1 Land Use of each River basin

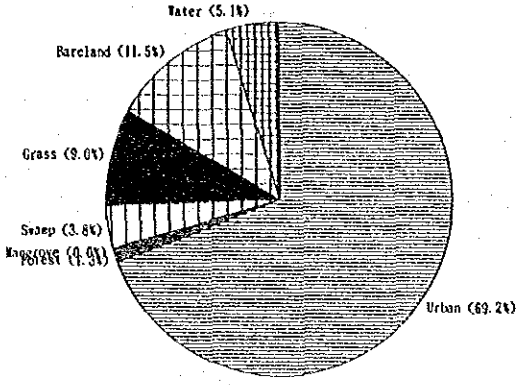
1 R.-CHARITAS



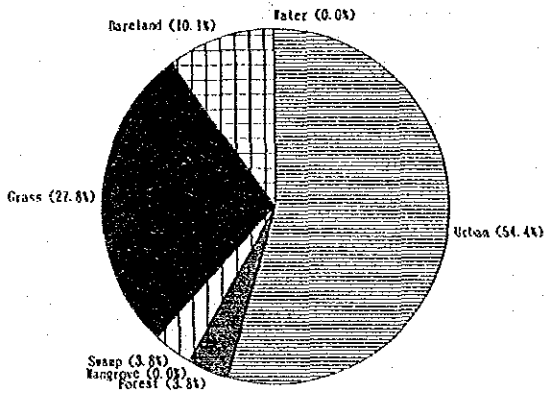
2 CANAL CANTO DO RIO



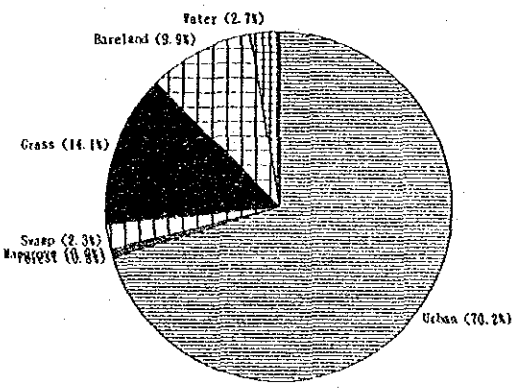
3 R.-CATEDRAR



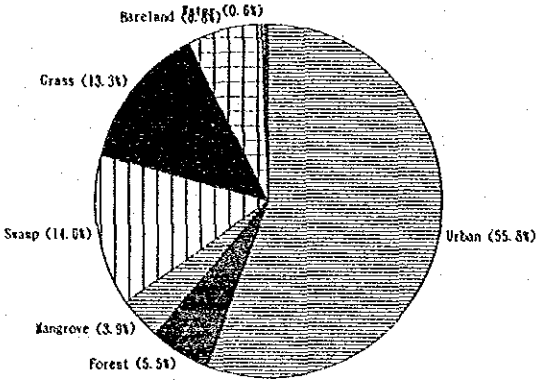
4 R.-NORTE CENTRO



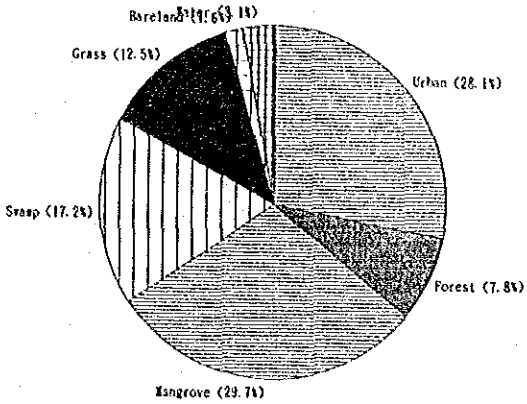
5 RIO BOMBA



6 RIO IMBOASSU



7 R.-ITACO



8 RIO ALCANTARA

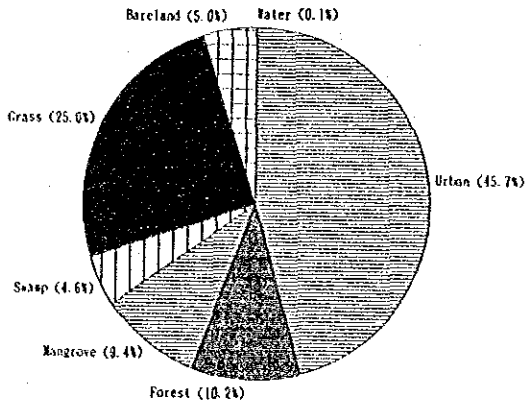
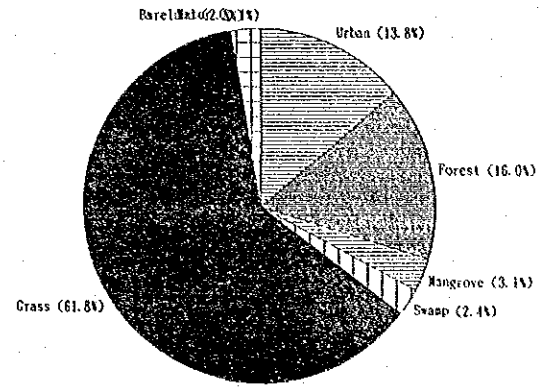
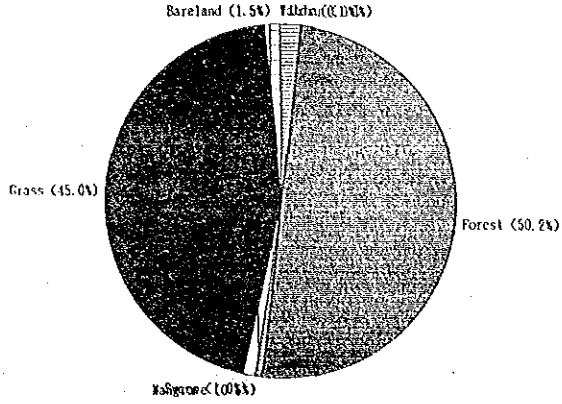


Fig. 2.3-1 Land Use of each River basin

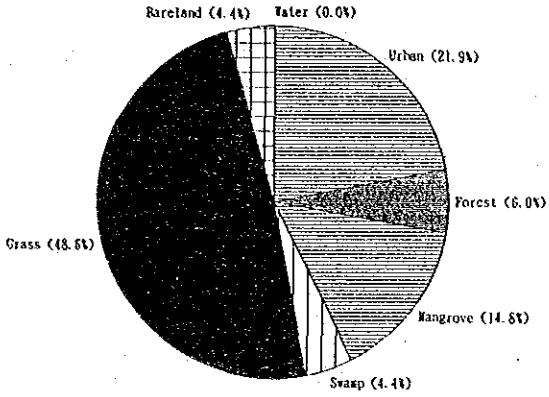
9 RIO CACEREBU



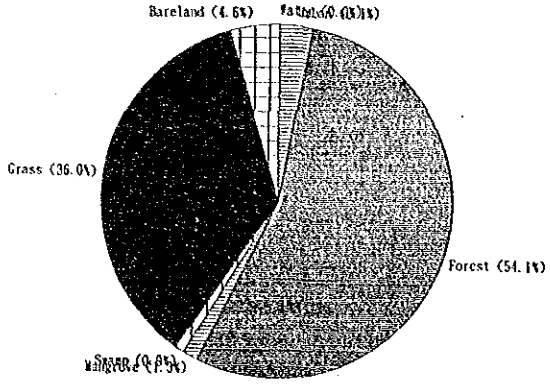
10 RIO GUAPIMIRIM



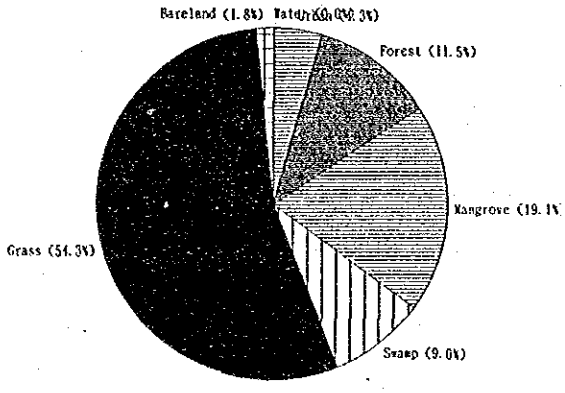
11 CANAL DE MAGE



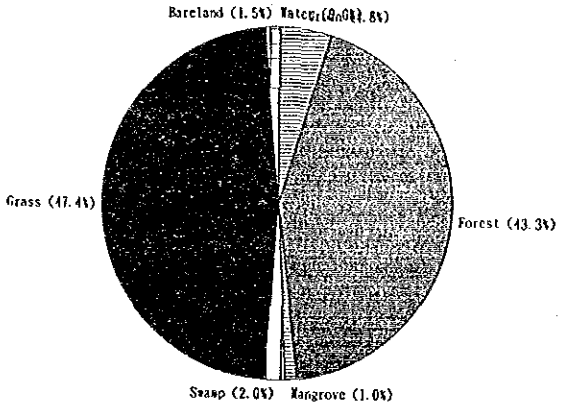
12 RIO ROUCADOR



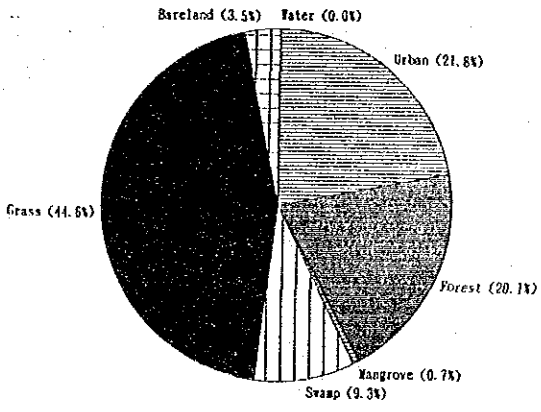
13 RIO IRIRI



14 RIO SURUI



15 R.-MAUA



16 RIO ESTRELA

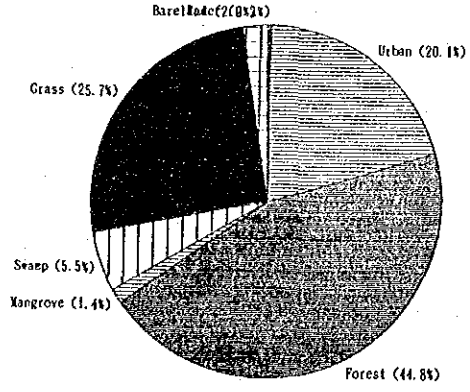
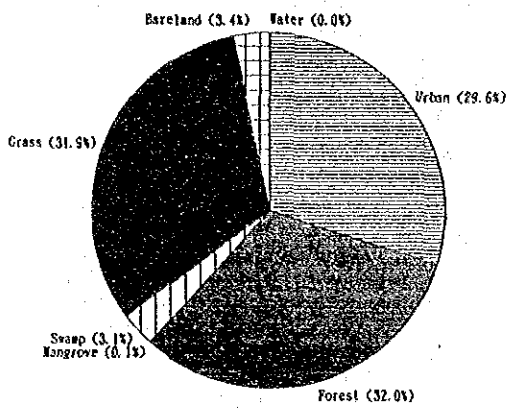
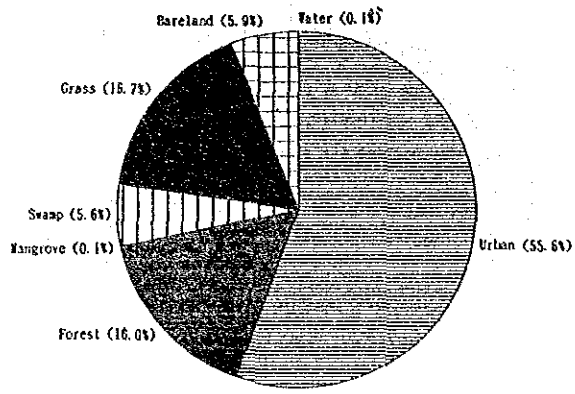


Fig. 2.3-1 Land Use of each River basin

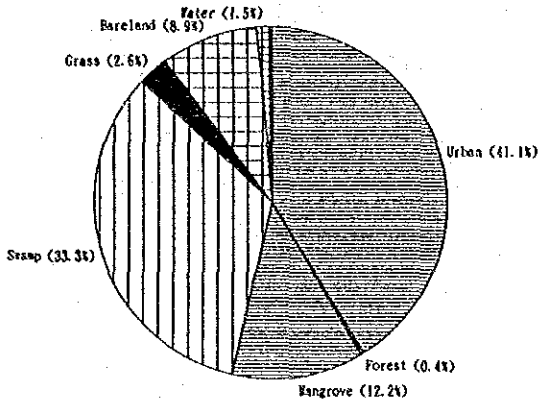
17.1-5 RIO IGUACU



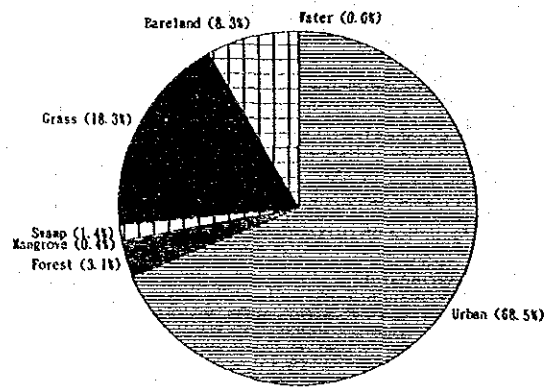
17.6 RIO SARAPUI



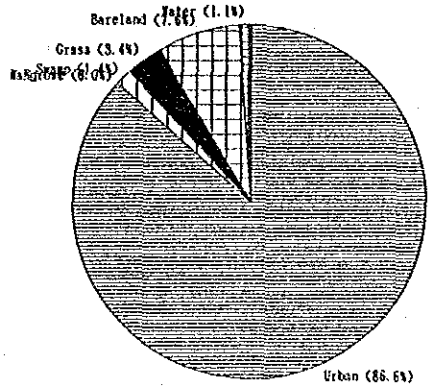
18 B.-CABO DO BRITO



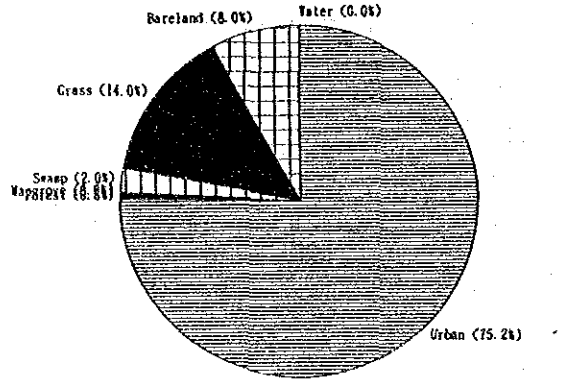
19 RIO S. J. DE MERITI



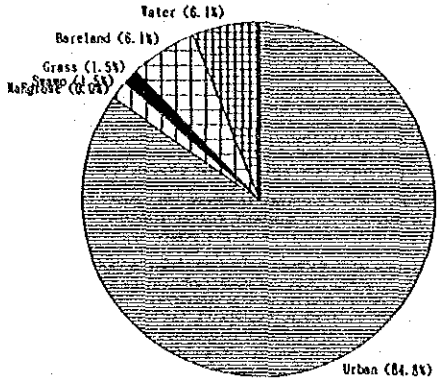
20 RIO IRAJA



21 CANAL DO CUNHA



22 B.-S. CRISTOVAO



23 CANAL DO MANGUE

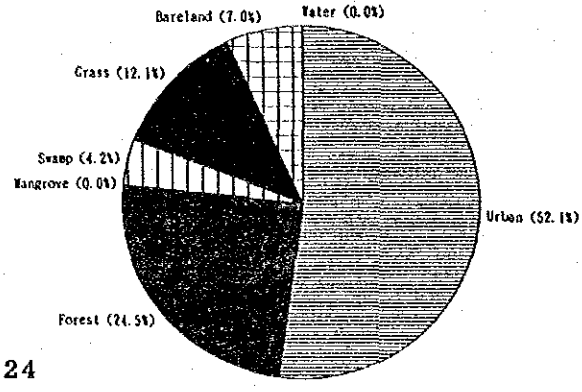
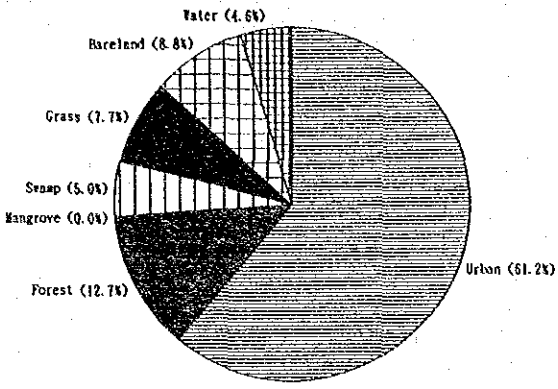
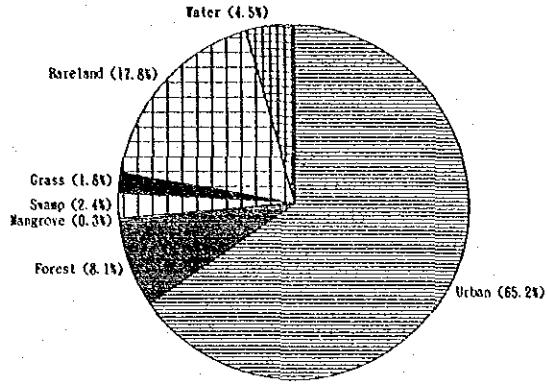


Fig. 2.3-1 Land Use of each River basin

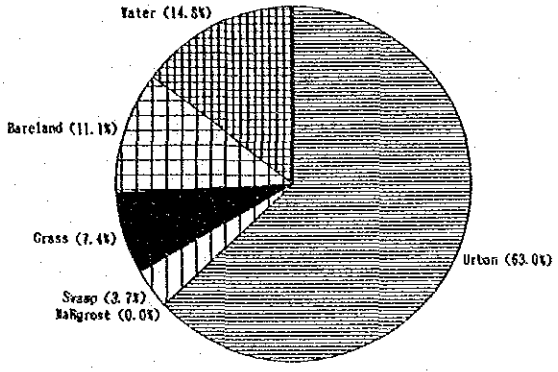
24 R.-BOTAFOGO



25 I. DO GAVIAO



26 I. DO FUNDAO



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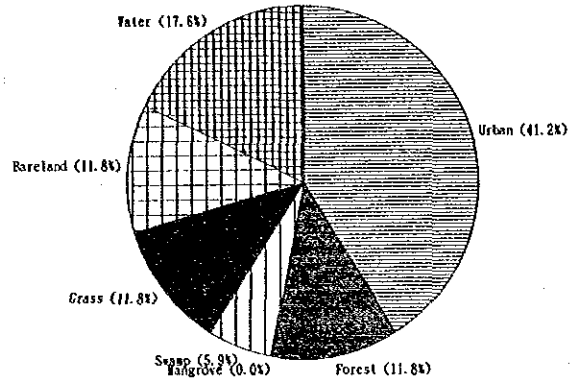
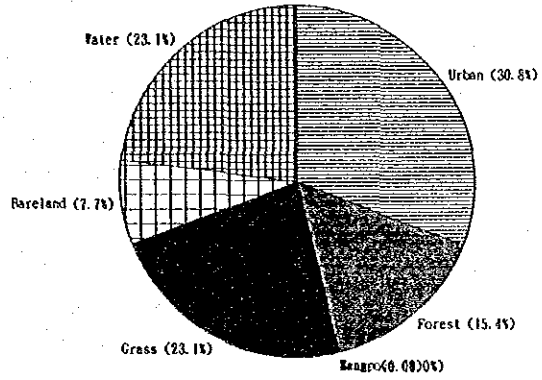
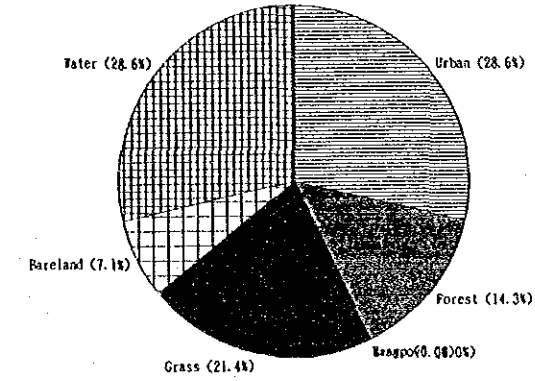


28 I. DO ENGENHO



29 I. DO S. CRUZ



Tables 2.3-4, 2.3-5 and **Fig. 2.3-2** show the land use in each district. In 1991 the largest urban area was located in the western district, amounting to 66% of the total urban area of study area and 45% of the area of the western district. The urban areas in the eastern and northern districts make up about 40% and 7% of the total urban area.

The largest forest area is located in the northern district and it amounts to about 940 km^2, that is, 75% of the total forest area in the study area and about 40% of the district. The forest areas in the western and eastern districts make up about 22% and 10% of the total forest area.

The largest mangrove area is located in the northern district in a swamp along the Rio Gapi-Mirim and Rio Macacu. The area is about 46 km^2, that is, 67% of the total mangrove area.

The distribution of mangrove is restricted within narrow limits in the coastal areas. Therefore, the mangrove area is very small, that is, less than 2% in the study area.

By 1984 the mangrove area in the study area had decreased on a large scale. In the swamp formed by the Rio Gapi-Mirim and Rio Macacu, the mangrove has been lost due to land development and felling to get fuel for the ceramic industry. Mud from the land developments flows into the swamps causing the aridity.

Fig. 2.3-3 and **2.3-4** are charts of the distribution of mangrove forests in 1938 and 1991. It shows that mangroves almost totally covered coastal areas around the northern part of Guanabara Bay.

Fig.2.3-5 shows the change in the coastal line from 1962 and 1992.

Fig. 2.3-6 shows the historical land use in the northern and eastern districts of the study area. At the end of the 18th century, sugar cane was cultivated widely in lowlands and hills, subsistence culture and coffee plantains existed in small areas and forests covered wide areas in the northern and southern mountain ranges. In the early 19th century, the forest area decreased and the area of sugar cane plantations enlarged. From the end of the 19th century to early 20 century, the greater part of sugar cane plantation and coffee plantation area were abandoned. Banana and citrus cultivation started. In the middle of the 20th century, the banana and citrus cultivation area enlarged and forests decreased.

(4) Population of the Study Area

DEMOGRAPHY OF STUDY AREA

Population data of the study area was obtained from the 1991 census by IBGE (Fundacao Instituto Brasileiro de Geografia e Estatistica). The census population includes favela population in

Table 2.3-4 Area by Land Use Category of Municipalities in 1984

(km2)

Municipality	Urban	Forest	Mangrove	Swamp	Grass	Bareland	Water	Total
Western District	538.2	305.9	8.6	71.3	283.3	78.6	12.5	1,298.4
Duque de Caxias	113.1	170.0	8.1	41.8	101.9	25.9	4.8	465.6
Nilopolis	9.7	0.3	0.0	0.4	8.3	0.6	0.0	19.3
Nova Iguacu	136.0	114.1	0.0	14.8	110.0	15.2	0.2	390.3
Rio de Janeiro	248.5	21.5	0.5	14.2	61.9	33.7	7.5	387.8
Sao Joao de Meriti	30.9	0.0	0.0	0.1	1.2	3.2	0.0	35.4
Eastern District	114.0	45.9	13.9	32.7	95.1	22.2	4.3	328.1
Niteroi	24.4	21.0	0.0	5.4	22.2	6.7	2.2	81.9
Sao Goncalo	89.6	24.9	13.9	27.3	72.9	15.5	2.1	246.2
Northeastern District	143.9	1,009.9	46.4	128.4	1,064.8	57.1	3.8	2,454.3
Cachoeiras de Macacu	8.8	513.0	0.0	30.5	332.4	14.1	0.6	899.4
Itaborai	85.2	96.5	10.2	39.2	329.2	10.2	1.0	571.5
Mage	43.2	285.1	36.2	47.1	305.5	26.9	2.1	746.1
Petropolis	1.4	33.4	0.0	0.5	3.6	1.2	0.0	40.1
Rio Bonito	5.3	81.9	0.0	11.1	94.1	4.7	0.1	197.2
Total	796.1	1,361.7	68.9	232.4	1,443.2	157.9	20.6	4,080.8

Table 2.3-5 Area by Land Use Category of Municipality in 1991

(km2)

Municipality	Urban	Forest	Mangrove	Swamp	Grass	Bareland	Water	Total
Western District	579.1	290.3	8.6	56.8	287.6	70.1	6.1	1,298.6
Duque de Caxias	127.5	154.4	8.1	43.0	115.6	15.6	1.3	465.5
Nilopolis	9.5	0.2	0.0	0.2	7.6	1.8	0.0	19.3
Nova Iguacu	149.7	110.6	0.0	4.6	109.6	15.7	0.0	390.2
Rio de Janeiro	260.5	25.1	0.5	8.8	53.8	34.7	4.8	388.2
Sao Joao de Meriti	31.9	0.0	0.0	0.2	1.0	2.3	0.0	35.4
Eastern District	136.2	32.1	13.8	14.1	109.7	19.3	2.8	328.0
Niteroi	28.5	18.5	0.0	2.2	25.2	6.2	1.6	82.2
Sao Goncalo	107.7	13.6	13.8	11.9	84.5	13.1	1.2	245.8
Northeastern District	166.4	944.9	46.3	47.3	1,196.7	51.1	1.2	2,453.9
Cachoeiras de Macacu	11.4	500.8	0.0	4.7	372.1	10.4	0.1	899.5
Itaborai	95.1	67.4	10.2	9.9	371.6	16.8	0.5	571.5
Mage	51.3	281.4	36.1	31.5	325.3	19.6	0.6	745.8
Petropolis	1.9	32.1	0.0	0.6	4.9	0.6	0.0	40.1
Rio Bonito	6.7	63.2	0.0	0.6	122.8	3.7	0.0	197.0
Total	881.7	1,267.3	68.7	118.2	1,594.0	140.5	10.1	4,080.5

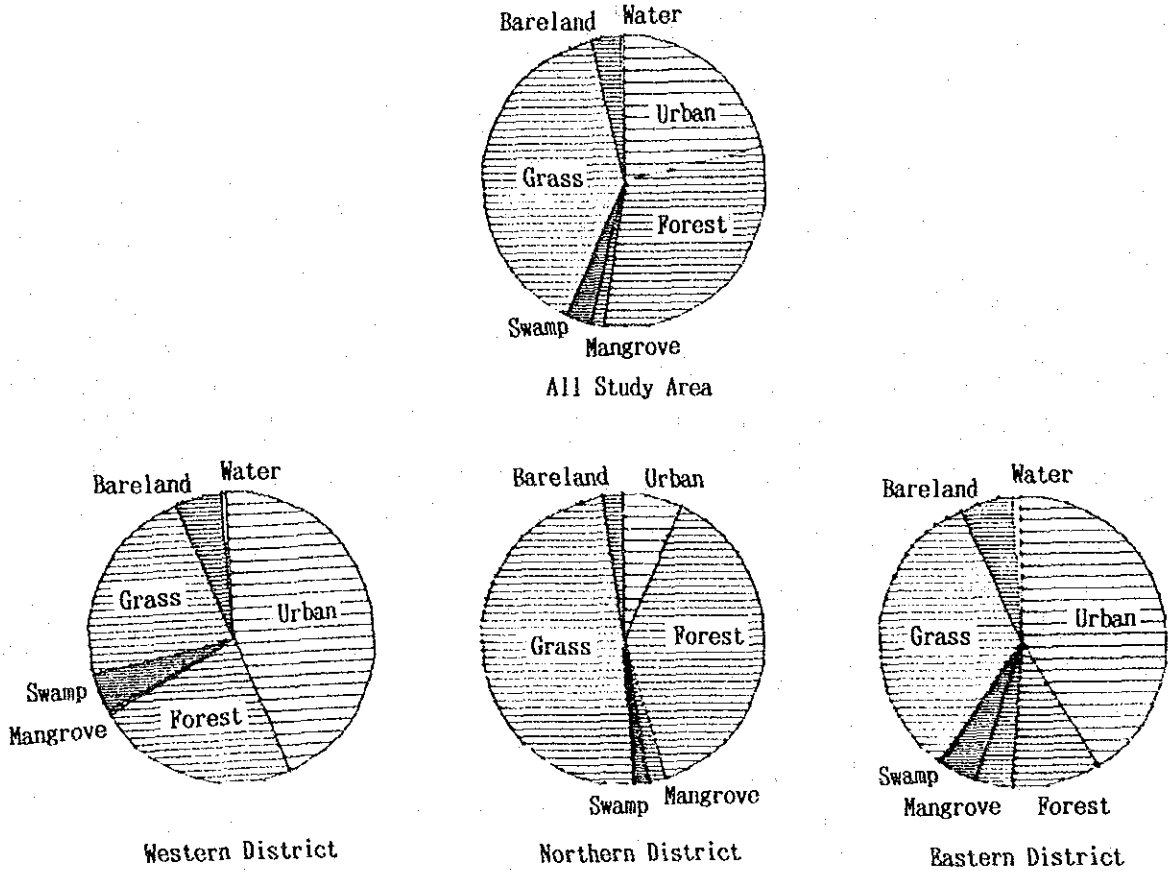


Fig. 2.3-2 Area by Land Use Category by Districts in 1991

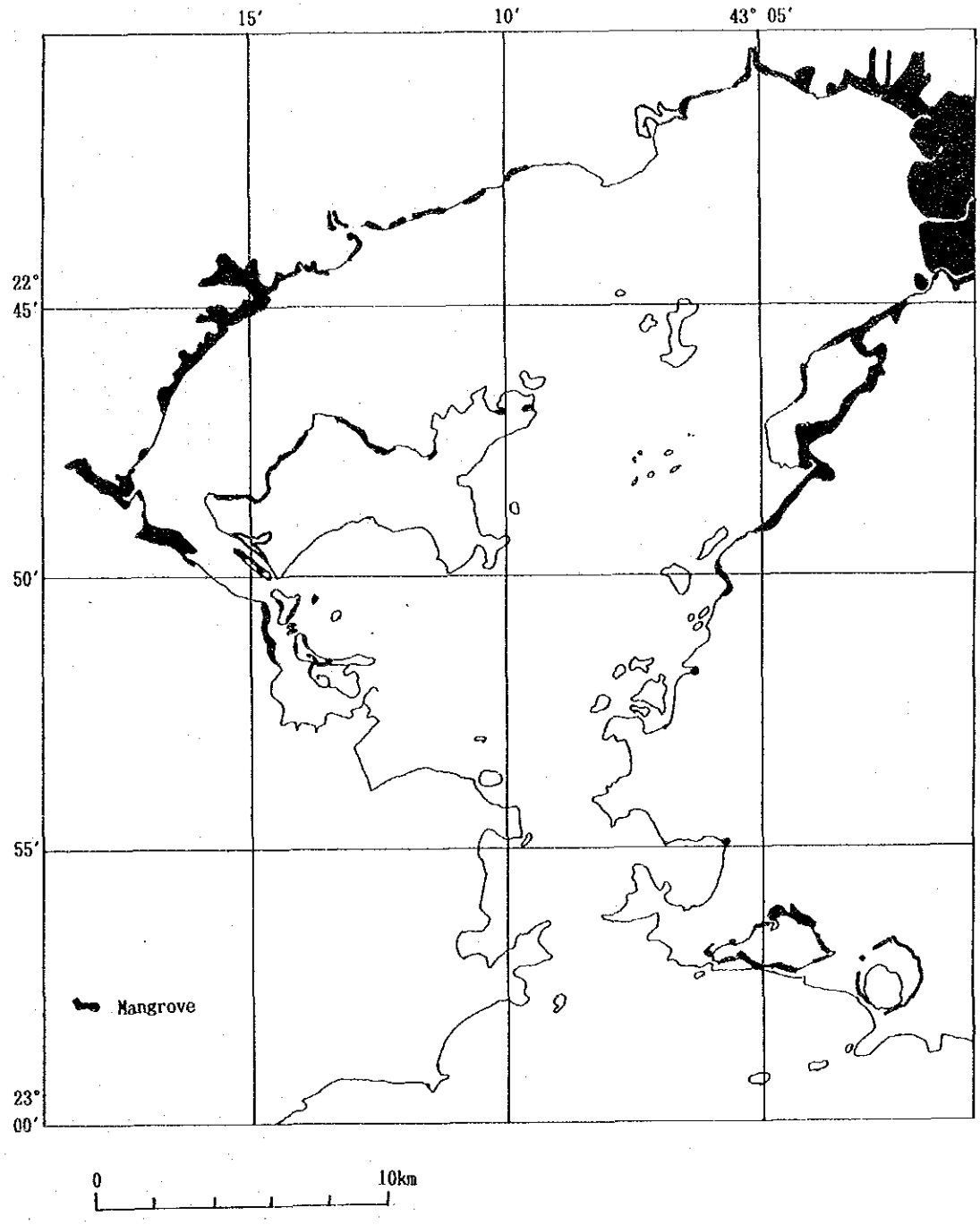


Fig. 2.3-3 Distribution of Mangrove Forest in 1938

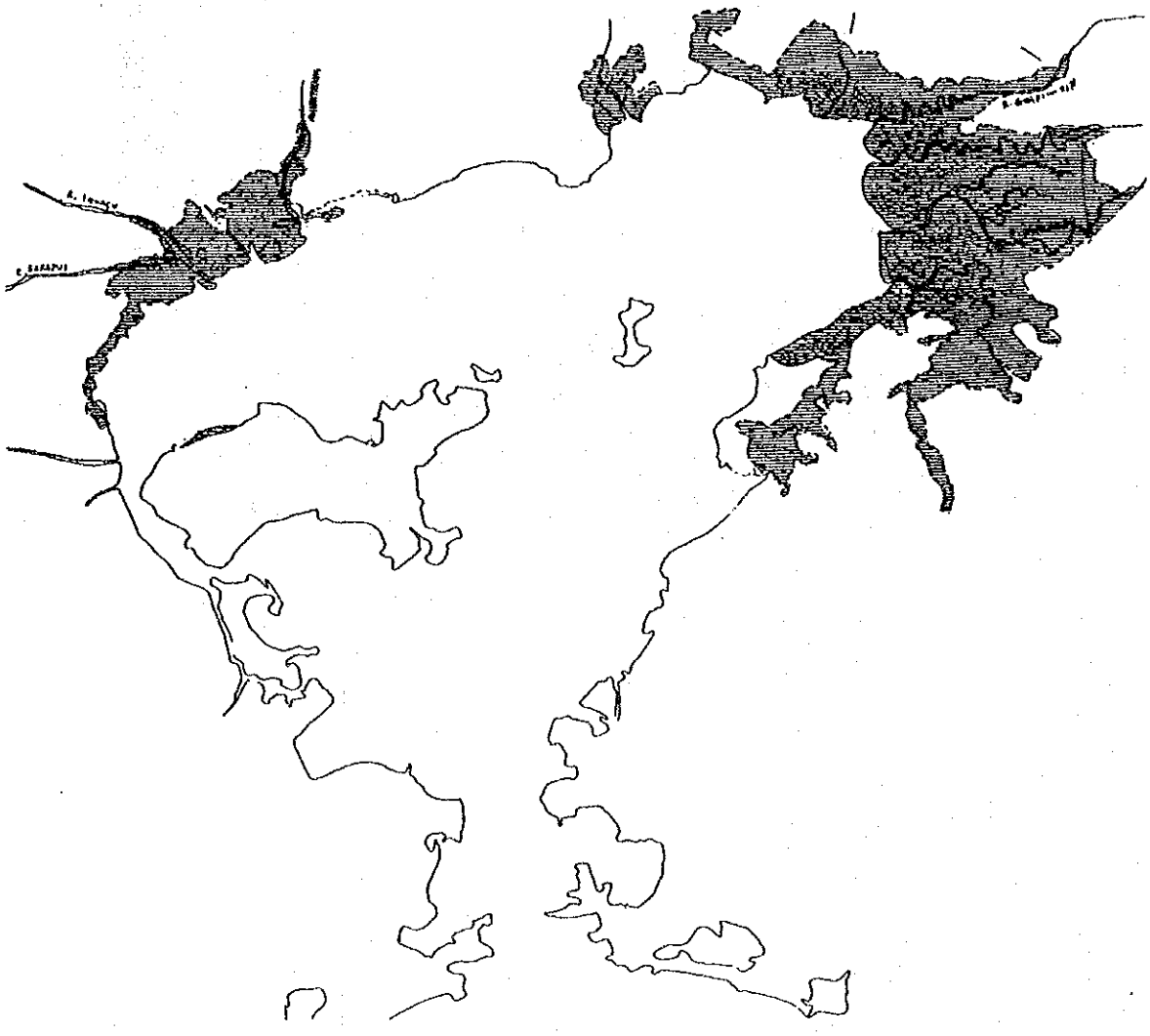


Fig. 2.3-4 Distribution of Mangrove Forest in 1991

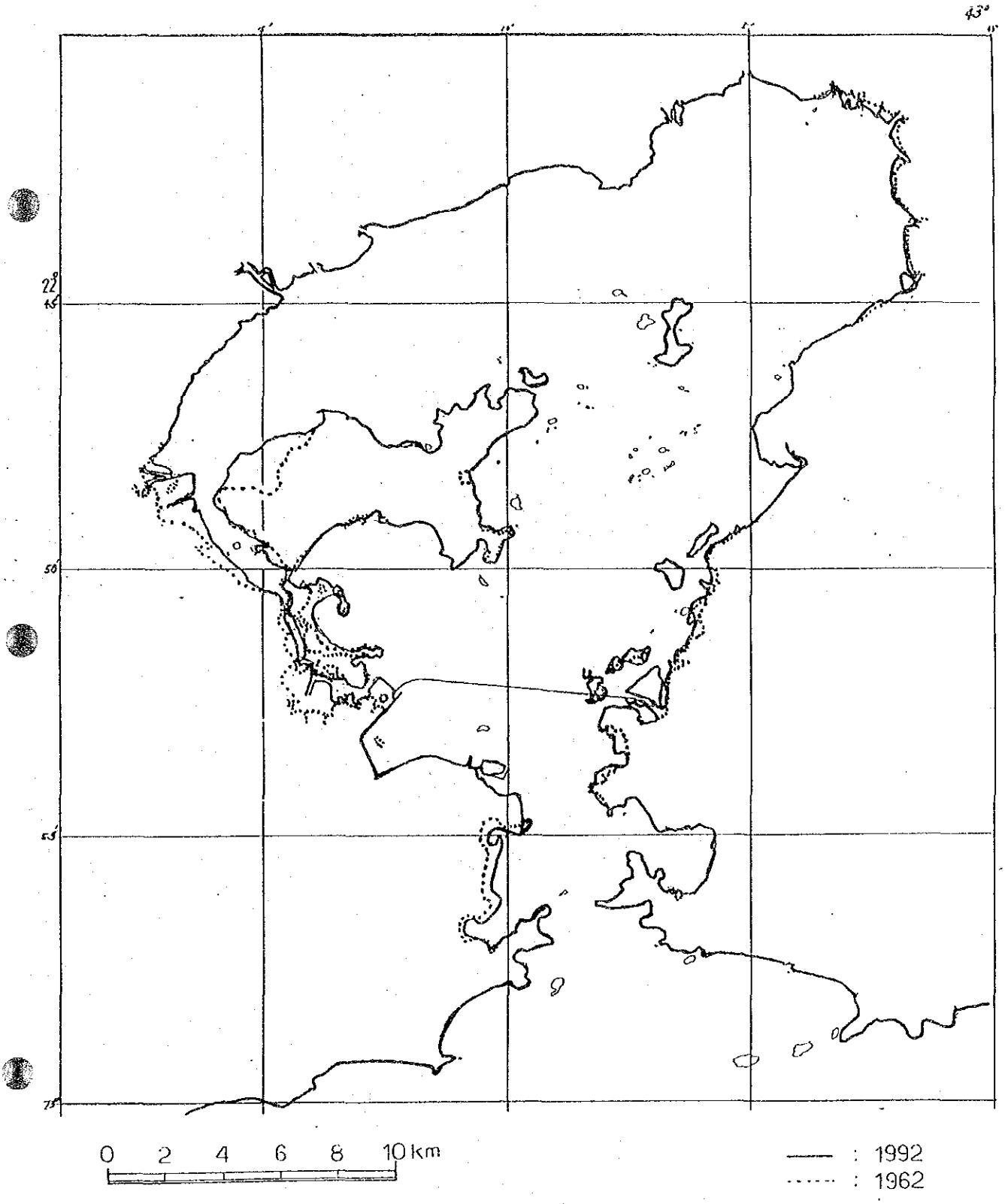
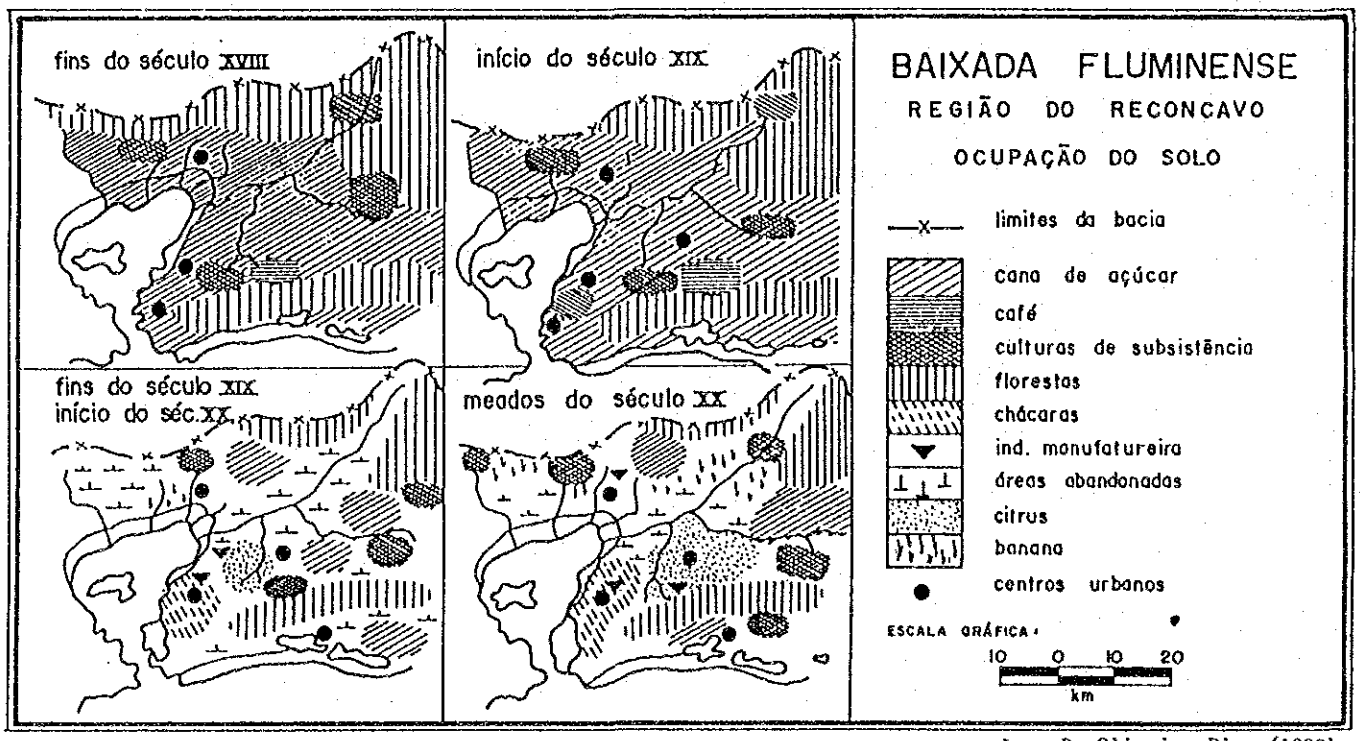


Fig. 2.3-5 Change in the Coastal Line from 1962 and 1992



Ivan De Oliveira Pires(1992)

Fig. 2.3-6 Historical Land Use in the Northern and Eastern Districts

each district and subdistrict, and also shows favela population and houses by Aglomerados Subnormais (favela in the census). **Table 2.4-1** shows the population of each municipalities.

FAVELA POPULATION BY MUNICIPALITY

There are many favelas in the study area and their population density, sanitation facilities, and collection ratio of solid wastes are largely different form other areas.

Table 2.4-1 shows the favela population of each municipality obtained from the 1991 demographic census. The largest favela population was about 880,000 in the Rio de Janeiro municipality, that is, 86% of the total favela population in the twelve municipalities.

Table 2.4-1 Favela Population by Municipality in 1991

Municipality	Municipal Population	Guanabara Bay Basin Population	Aglomerados Subnormais
Cachoeiras de Macacu	40,181	40,181	0
Duque de Caxias	65,338	665,338	51,179
Itaborai	161,398	161,398	0
Mage	191,249	191,249	8,968
Nilopolis	157,936	157,936	2,261
Nitero	435,658	369,933	24,843
Nova Iguacu	1,293,611	824,028	40,784
Petropolis	255,251	48,030	693
Rio Bonito	45,093	43,069	0
Rio de Janeiro	5,472,967	3,352,326	877,738
Sao Goncalo	778,820	778,820	0
Sao Joao de Meriti	424,689	424,689	13,726
12 Municipalities	9,922,191	7,056,997	1,020,192

* IBGE Census 1991
* Aglomerados Subnormais; Favela in IBGE Census 1991

FAVELA POPULATION AND AREAS IN RIO DE JANEIRO MUNICIPALITY

Table 2.4-2 shows the favela population and area in Rio de Janeiro municipality obtained from IPLANRIO (Instituto de planejamento municipal). It shows that favela populations in 1980 and 1991 number 570,928 and 799,549 respectively. The favela population increased by 40% during the ten year period.

The total favela area in the Rio de Janeiro municipality was 2,433 ha in 1991, that is only 6% of the total area of the municipality, however, the population is 19% of the total population of the municipality.

In the study area, the area of favelas is 4.5% and the population of favela is to 24%. Favela population density in the study area was 46,011 per km^2.

Table 2.4-2 Favela population and area in Rio de Janeiro municipality

Area Code	Number of Favelas	1980 Popula-tion	1980 House	1991 Popula-tion	1991 House	1991 Area (ha)
17-6RJ	21	8,148	1,835	33,34	37,574	77.93
19-1RJ	67	104,880	23,699	157,201	34,540	379.69
19-2RJ	36	13,554	3,062	27,469	5,749	80.52
20RJ	44	139,216	31,775	164,116	37,797	303.00
21RJ	104	154,806	35,440	205,864	45,964	444.97
22RJ	8	15,276	3,694	19,567	4,533	25.16
23RJ	48	88,359	20,128	113,093	24,583	285.04
24RJ	19	16,111	3,725	27,592	6,296	37.37
25RJ	22	30,578	6,750	51,304	12,074	104.06
26RJ	0					
27RJ	0					
Total	369	570,928	130,108	799,549	179,083	1,737.74

* House ; Number of houses
* Total favela of Rio de Janeiro Muninicipality by IPLANRIO
  Total number of favelas ; about 600
  Total favela population ; 1,045,721
  Total number of houses ; 233,997
  Total favela area ; 2,433.61ha

ALLOTMENT OF POPULATION TO THE BASINS

The allotment of population to each basins were calculated in proportion to the area of district (**Table.2.4-3**). The population including inhabitants of favela by district was based on the 1991 census.

Table 2.4-3 Area and Population by River Basins in Study Area(1991)

Basin Code	Area Code	Area (km^2)	Population	Basin Code	Area Code	Area (km^2)	Population
1	1NR	9.4	53,310		16-3	(186.0)	(194,171)
2	2NR	7.4	41,310		16-3DC	146.7	146,336
3	3NR	7.8	37,458		16-3MG	15.0	19,345
4	4NR	7.9	43,607		16-3PP1	16.7	19,521
5		(26.2)	(183,099)		16-3PP2	7.6	8,939
	5NR	7.1	33,396	17-1		(122.9)	(204,261)
	5SG	19.1	149,703		17-1DC1	66.0	99,453
6	6SG	30.8	138,636		17-1DC2	18.3	1,764
7	7SG	6.4	317,874		17-1NI1	18.7	92,011
8		(144.6)	(470,420)		17-1IN2	19.9	11,033
	8NR	30.4	149,822	17-2	17-2DC	104.4	19,388
	8SG	110.4	317,874	17-3		(115.7)	(12,243)
	8IB	3.8	2,724		17-3DC	53.4	995
9-1		(110.9)	(4,463)		17-3NI	62.3	11,248
	9-1IB	56.1	34,072	17-4	17-4NI	103.1	30,217
	9-1SG	15.8	39,193	17-5	17-5NI	116.7	427,266
	9-1MG	39.0	1,198	17-6		(165.5)	(1,012,275)
9-2		(191.4)	(151,365)		17-6DC	28.0	149,184
	9-2IB	118.6	55,165		17-6NI	69.5	252,253
	9-2SG	62.0	90,456		17-6SJ	25.3	299,425
	9-2NR	10.8	5,744		17-6NP	10.5	107,178
9-3		(544.4)	(110,373)		17-6RJ	32.2	204,235
	9-3MF	1.7	52	18	18DC	27.0	132,091
	9-3IB	345.7	67,252	19-1		(106.6)	(1,054,382)
	9-3RB	197.0	43,069		19-1DC	9.6	92,942
10-1	10-1MG	53.1	1,595		19-1SJ	10.1	125,264
10-2		(246.7)	(12,475)		19-1NP	8.8	50,758
	10-2IB	47.3	2,194		19-1RJ	78.1	785,418
	10-2CM	199.4	10,281	19-2	19-2RJ	57.9	438,076
10-3	10-3CM	256.0	18,577	20	20RJ	35.7	500,276
10-4		(215.4)	(10,311)	21	21RJ	63.6	414,522
	10-4CM	94.5	1,733	22	22RJ	6.6	60,011
	10-4MG	120.8	8,578	23	23RJ	42.8	500,876
10-5	10-5CM	349.5	8,983	24	24RJ	26.0	414,522
10-6	10-6MG	132.4	17,911	25	25RJ	38.2	153,903
11	11MG	18.3	8,458	26	26RJ	5.4	5,277
12	12MG	111.4	36,267	27	27RJ	1.7	3,254
13	13MF	27.8	10,684	28	28RJ	1.3	11,034
14	14MG	68.8	12,910	29	29NR	1.4	4,851
15	15MG	28.9	8,541	30	30RJ-S	184.8	
16-1		(17.5)	(24,216)	31	31DC-S	22.1	
	16-1MG	5.4	1,069	32	32MG-S	71.1	
	16-1DC	12.1	23,147	33	33IB-S	13.2	
16-2		(139.0)	(84,106)	34	34SG-S	29.4	
	16-2MG	123.2	64,536	35	35NE-A	26.8	
	16-2PP	15.7	19,570				
				Total		4,427.9	7,128,431
				(Land Area :		4,080.5 km^2)	
				(Water Area:		347.4 km^2)	

CM; Cachoeiras de Macacu
DC; Duque de Caxias
IB; Itaborai
MG; Mage
MI; Nova Iguacu
NP; Nilopolis
S; Guanabara Bay
NR; Niteroi
PP; Petropolis
RB; Rio Bonito
RJ; Rio de Janeiro
SG; Sao Goncalo
SJ; São João de Meriti

(5) Soil Erosion

The result of our field survey and the Landsat image show neither erosion nor outflow of soil on a large scale. At the ridge of the mountains, however, outcrops of hard rock were observed in large numbers. On the other hand, at the foot of the mountains and hilly districts, clayey zones resulting from violent weathering were observed in many places. Consequently, small gully erosions were found in the cutting slopes along roadways, soil pits for civil engineering and clay mines for pottery in the hilly districts, and a small outflow of earth and sand was observed. Gully erosion on a small scale was also observed in areas around the foothills.

Some outflow of earth and sand was observed from cliffs along the river banks. The upper layer of the cliffs consisted of sedimentation (sand and mud) with a thickness of 2 to 3m and a lower layer of rounded gravels. On the side of concave banks, the sedimentary layer of the cliff easily eroded, and the small landslides with a high 2 to 3 m occurred often.

Earth and sand resulting from the erosion of the cliff was carried away by streamflow and the sand was separately deposited on the riverbed. Until a few years ago, these sands were dredged in large volumes for use as construction materials. At present, the dredging work being carried out has been scaled down.

On account of absence of data, the state of the erosion of the earth and sand caused by landslides and floods is unknown. However, judging from the natural environmental condition, it is unlikely a large amount of earth and sand is continuously flowing out. For example, the erosion of a large amount of earth and sand should occur at the northeast of Guanabara Bay where large rivers, Rio Guapi-Mirim and Rio Caceribu, flow in. However, in the neighborhood of these river mouths, mangrove forests have developed extensively showing that the natural land condition had remained unchanged for a long time. The growth of mangrove forests demands the following three conditions: extremely flat land with a large river, a shoaling beach where a large volume of mud sediments have deposited for a long time, and a sheltered area from sea wind and waves.

The sudden retreat of mangrove forests was observed at the northeast back zone of Guanabara Bay. This retreat occurred the result of appearance of dry land due to the supply of mud through the rivers, outflow of mud from clay mines for pottery near Itaborai and housing development sites in the neighborhood. The mangrove forest zone was diminishing partly due to deforestation. On the other hand, it was expected that mangrove forest might expand on the seashore where muds are being deposited. However, its rate of expansion is too small to measure.

Since the mangrove forests once vastly covered areas adjacent to river mouths and along the coasts (**Fig.2.3-3**), it is also unreasonable to consider that the outflow of such a vast amount of mud occurred over a short time period.

CHAPTER 2

SOCIOECONOMIC CONDITIONS

CHAPTER 2

SOCIOECONOMIC CONDITIONS

2.1 Selected Socioeconomic Conditions of the Guanabara Bay Basin

2.1.1 The Guanabara Bay Basin

The social conditions and economic activities prevailing in the Guanabara Bay basin are potential sources of pollution. Hence, analysis of the socioeconomic data can help to point out potential pollution problems in the Guanabara Bay.

The pollutant load flowing into the Guanabara Bay depends on the treatment applied to liquid effluents and wastes generated from domestic sources and economic activities. Accordingly, the study needs to focus initially on the existing distribution of population, production activities, social infrastructure and basic sanitation. Subsequently, an estimation of the future situation is necessary for the planning horizon, taking into account such modifying factors as development plans, legislation and environmental awareness of the community residents.

2.1.1.1 Administrative Organization

The Federative Republic of Brazil is administratively divided into 26 States, and a Federal District --Brasilia-- which is the capital city of the country. The 26 States are grouped into five Major Regions which are the Northern, Northeastern, Southeastern, Southern and Midwestern Regions. Within each State, the basic administrative unit is the Municipality, of which there are 4,490 in the whole country and 71 in the Rio de Janeiro State.

The Guanabara Bay Basin is located within the State of Rio de Janeiro, in the Southeastern Region, and straddles wholly or partly 12 Municipalities of the State. As compared to 43,305 km^2 of the Rio de Janeiro State, these 12 Municipalities add up to a total of 6,632 km^2, of which around 4,000 km^2 are estimated to comprise the Guanabara Bay basin as shown in **Table 1.1-1**

It should be noted that only the southern tip of Petropolis is included in the Guanabara Bay basin, but no population center exists in the area, thereby justifying its exclusion from the basin for all practical purposes. On the other hand, some Municipalities are undergoing a political process of subdivision into smaller but administratively independent Municipalities.

2.1.1.2 Data and Scope of Analysis

Secondary data pertaining to socioeconomic conditions are given by administrative units at the levels of Municipalities, State and Region. Since the Guanabara Bay basin encompasses less area than the Rio de Janeiro State, the data to describe the socioeconomic conditions of the basin were those pertaining to the basic administrative unit, that is, Municipalities.

Demographic Census presenting data on population and housing characteristics are taken at 10-year intervals in Brazil. Definitive data are available from Demographic Census taken in 1950, 1960, 1970 and 1980. The 1990 Census was delayed until 1991, but preliminary results concerning population by Municipality became available towards the end of 1992.

Population was examined as the source of domestic waste water, which was recognized to be a significant pollution source of the Guanabara Bay. In this regard, the population distribution within the basin was ascertained according to the latest population census. Another important point was to determine the past population growth trends, as an indication of possible population growth areas in the future.

Also examined were housing characteristics pertaining to domestic sanitation facilities, so that the effectiveness of waste water disposal systems could be taken into account. Domestic sanitation was analyzed using the 1980 Census, because data on housing characteristics from the 1991 Census are not yet available.

The 1985 industrial census data were used to determine the importance of each Municipality in reference to location, size and type of manufacturing existing in the Guanabara Bay basin. Rio de Janeiro is recognized to be the second industrial concentration of the country, and effluents from manufacturing plants are regarded as one of the major causes of pollution of the Guanabara Bay.

2.1.2 Demographic Characteristics

2.1.2.1 Population Distribution by Municipality

Preliminary results from the 1991 Demographic Census indicated an overall 1.87% population growth rate in Brazil between 1980 and 1991, well below the mean rate recorded during the previous decades. The low population growth rate reflected the quickly declining fertility rate, which was 6 children per woman during the 1960s, 4.5 during the 1970s, and less than 3 during the 1980s.

The latest demographic census showed an increasing wave of reverse migration, that is, from large metropolitan areas toward the inner States. The trend toward higher population growth rates outside the large cities was also observed within the Rio de Janeiro State. In this case, the likely explanation lies in the increasing cost of living in the large cities of Rio de Janeiro and Niteroi. Then, workers, who still find employment in large cities, face the need to live in more affordable rural settings at the expense of longer commuting time.

The population shift from Rio de Janeiro and Niteroi to rural Municipalities can be ascertained by comparing the proportion of population living in the Municipalities comprising the Guanabara Bay basin in 1980 and 1991, as shown in **Table 1.2-1**.

2.1.2.2 Urban-Rural Population Distribution

In November 1992, a set of preliminary results was obtained for the 1991 Demographic Census corresponding to the 11 Municipalities comprising the Guanabara Bay basin. This set of data showed that rural population comprised less than one per cent of the overall population, as shown in **Table 1.2-2**.

Another set of preliminary results for the 1991 Demographic Census was obtained in April 1993. The population in the Municipalities of the Guanabara Bay basin was lower in this newer set of preliminary results, which did not show the breakdown into urban and rural population.

2.1.2.3 Favela Population

In the Study Area, there are many favelas which have their own peculiar characteristics concerning population density, sanitation facilities and collection of solid wastes. Since these characteristics are quite different from those in other areas, the favela population was obtained from the 1991 Demographic Census and summarized as shown in **Table 1.2-3.**

2.1.2.4 Population Density

The population densities of the 11 Municipalities in 1991 are shown in **Table 1.2-4.** It can be seen that the two Municipalities outside Metropolitan Rio, that is, Cachoeiras de Macacu and Rio Bonito, had very low densities of less than 100 persons per sq.km, while very high densities of over 7,000 persons per sq.km. occurred in fully urbanized areas of Nilopolis and Sao João de Meriti.

Except for fully urbanized Municipalities, the overall population density is perhaps not very useful. However, a relatively low population density in a Municipality would imply presence of rural or unoccupied areas, where population growth is likely to occur in the future. A classification of population density per sq.km. of the Municipalities in the Guanabara Bay basin is shown in **Table 1.2-4.**

2.1.2.5 Population Growth: Past and Future

Details of population growth by Municipality between 1980 and 1991, according to preliminary census data obtained in April 1993, are shown in **Table 1.2-5.** A comparison between the population growth rates corresponding to the 1980s and the past three decades showed that the population growth rates have been continuously declining, except for Itaborai which had an upsurge during the 1970s (5.62%) and kept growing at a high 3.16% during the 1980s.

The above described pattern of population growth suggests that the urban areas around the city of Rio de Janeiro are saturated, implying high costs of living, thereby forcing population expansion into rural areas. Hence, population growth in the future is likely to be concentrated in those Municipalities with a significant proportion of rural population, namely, Itaborai, Rio Bonito and Cachoeiras de Macacu.

Expected population growth in Itaborai and Rio Bonito would be an overflow of the population growth that is expected to take place in Sao Goncalo because of the large urbanizations and housing developments that are being implemented and planned within its municipal boundaries. On the other hand, Cachoeiras de Macacu is completing establishment of an Industrial District, with eight industries committed as of October 1992, which is expected to attract people seeking employment.

2.1.3 Sanitation Infrastructure

As mentioned above, the following discussion on sanitation is based on the 1980 Census data, which is the latest census containing such data.

2.1.3.1 Water Supply

Indoor piped water supply was available in 80% of dwellings of the State in 1980, but wide variations occurred between Municipalities, ranging from 45% in Itaborai to 91% in Rio de Janeiro. Water supply systems were classified into public systems, wells/springs, and others. Water supply systems have an effect on the waste water generated and discharged from households or dwellings, especially if considered in conjunction with the types of toilet facilities.

Looking at the dwellings without indoor piped water supply, some of them showed water supplied by the public system. These are presumably yard taps. In the case of dwellings without indoor piped water supply, wells or springs were the predominant water sources.

Types of water supply systems by Municipality in 1980, expressed as percentage of dwellings, are shown in **Table 1.3-1.**

2.1.3.2 Sewer System

As already mentioned, important from the sanitation viewpoint are water supplied by indoor piping and facilities available in dwellings for the disposal of domestic waste water and human excreta. A critical issue in the sewer system in the Guanabara Bay basin concerns the final treatment of sewage. The issue stems

from the insufficient capacity of sewage treatment plants, even in cities with infrastructure of sewer networks such as Rio de Janeiro and Niteroi.

The 1980 Population Census divided toilet facilities into those used exclusively by the dwelling and those shared with other dwellings, as shown in **Table 1.3-2**, expressed in terms of percentage of dwellings. As expected, toilet facilities shared by several dwellings were more prevalent in rural Municipalities.

2.1.3.3 Sanitation and Water Pollution

From the water pollution viewpoint, attention should be paid to the following Municipalities.

* Dwellings without connection to public sewer systems

  Cachoeiras de Macacu
  Duque de Caxias
  Mage
  Sao Joao de Meriti

* High proportion of dwellings without toilet facilities

Cachoeiras de Macacu	23%
Itaborai	18%
Rio Bonito	28%

* High proportion of dwellings dependent on cesspools or septic tanks

Duque de Caxias	78%
Mage	49%
Nova Iguacu	44%
Sao Joao de Meriti	78%

* High proportion of dwellings dependent on simple pits

Cachoeiras de Macacu	20%
Itaborai	62%
Mage	24%
Rio Bonito	37%
Sao Goncalo	76%

It can be concluded from the above analysis that Municipalities requiring some kind of urgent sewer improvements are Cachoeiras de Macacu, Duque de Caxias, Itaborai, Mage, Nova Iguacu, Rio Bonito, Sao Goncalo and Sao Joao de Meriti, that is, eight of the eleven Municipalities in the Guanabara Bay basin.

2.1.4 Major Industries and Industrial Production

2.1.4.1 Industry Characteristics

In terms of economic activities causing pollution of water bodies, the industrial sector is likely to be one of the most significant factors in the Guanabara Bay basin.

Industrial data for Rio de Janeiro State in 1985 were analyzed in terms of selected criteria: (1) number of industries, (2) number of employees and (3) gross value of production. These data show that the Municipalities comprising the Guanabara Bay basin accounted for 74% of the number of industries, 77% of the number of employees, and 72% of the value of industrial production. In absolute figures, these Municipalities accounted for 12,492 out of 16,892 industrial firms, 405,344 out of 528,657 employees, and 78,724,100 out of 108,914,900 Million Cruzeiros worth of industrial production. Details by Municipality are shown in **Tables 1.4-1, 1.4-2, and 1.4-3** .

The large share of the Municipalities comprising the Guanabara Bay basin in the State industrial sector justifies drawing conclusions from industrial data available only for the State, with the understanding that they are equally valid for the said Municipalities. Further, the industrial sector is composed of the *mineral-extraction and the manufacturing subsectors*, the latter comprising 98% of the number of industrial firms and 99% of employees, thereby determining the overall characteristics of the whole industrial sector.

Small industrial firms, each employing less than 10 persons, comprised 61% of the total number of firms but accounted for only 7% of employees devoted to production. The medium size industries, each employing between 10 and 49 persons, were more even in terms of the share in the number of industrial firms (28%) and the number of employees (21%). Finally, large industrial firms, each employing 50 or more persons, accounted for 11% of firms and 72% of total employees in production. Very clearly seen here is the highly skewed industry size structure, in which a small number of large industrial firms dominate employment in the manufacturing sector in such a way that small firms have little influence on the overall picture.

2.1.4.2 Industry Types

Industry types were ranked by Municipality, according to the already mentioned three criteria consisting of (1) number of industries, (2) number of employees and (3) production values in 1985, and the resulting top industries are shown in **Tables 1.4-4, 1.4.5 and 1.4-6.**

The overall industry type characteristics for the Guanabara Bay basin are the following.

(1) Rank by number of industrial firms

Food processing
Clothing
Metallurgical
Chemical

(2) Rank by number of employees

Clothing
Metallurgical
Food Processing
Chemical

(3) Rank by value of production

Chemical
Food processing
Metallurgical
Textiles

With regards to pollution of water bodies, helpful data would be those relating to industrial water use as compared to other types of water use. The CEDAE data for the Guanabara Bay basin for November 1992 indicated that 80% of the water consumed in the month was for residential use, 11% for commercial use, 4% or 2,293,000 cubic meter for industrial use, and 5% for public facilities. The extremely low industrial use of water supplied by CEDAE suggests that manufacturing plants have developed their own sources of water supply.

As an alternative indicator, electricity consumption in 1990 showed the following distribution.

Residential use	30%
Commercial use	17%
Industrial use	40%
Other uses	13%

Electricity consumption for industrial use varied widely among Municipalities, being highest in Duque de Caxias with 47%, Itaborai with 42%, Rio de Janeiro and Mage with 33%, while the low consuming end was comprised by Cachoeiras de Macacu with 2% and Nilopolis with 4%. Further, within the industrial sector, major electricity consuming industry types were metallurgicals 55%, followed by chemicals 10% and food processing 6%.

2.1.4.3 Pollution from Industrial Sources

A comparative analysis of the industrial sector by Municipality between 1980 and 1985 give the impression of an economic sector in decline. However, in the interpretation of these results, careful consideration should be given to the difficulties faced by the Brazilian economy during the 1980s.

Important to note from the viewpoint of pollution in the Guanabara Bay are the strength and widespread distribution of chemical industries, among which the sheer size and complexity of REDUC (oil refinery of Duque de Caxias) is a motive for concern. Other important industries appear to be metallurgical, clothing (apparel), textiles, and food processing. The concentration of about half of industrial establishments in Rio de Janeiro Municipality is also a matter of concern. Food processing industries, particularly fish canneries, although mostly localized in Niteroi and Sao Goncalo, are known to discharge untreated organic wastes.

Fortunately, FEEMA has been working for several years with 52 large industries which are presumed to be responsible for 80% of organic industrial pollution in the Guanabara Bay. A monitoring program has been conducted, and FEEMA has been successful in convincing most of the industries to initiate treatment of industrial effluents. Continuation and expansion of this program is strongly encouraged.

2.1.5 Rio de Janeiro State and City Finances

The relative importance attached to environmental matters by the Rio de Janeiro State and the Municipalities comprising the Guanabara Bay basin can be gleaned from the examination of budgets appropriations. The amount appropriated for environmental programs and its trend, as compared with the budget total, can give a useful indication on the possible commitment of State and local authorities to environmental improvement.

Budget data were examined at the State and Municipal levels in relation to expense appropriations for the respective Secretariats of the Environment. These data were available only for the State and the Municipality of Rio de Janeiro. Data on expense appropriations for broad expenditure groups were available for every Municipality, but none of the groups referred to the environment.

2.1.5.1 Rio de Janeiro State Finances

The State government is organized under the classical division of power into three branches: Legislative, Judicial and Executive. However, expense appropriations for the Executive Branch during the three years of the available data accounted for 94% of the State expense budget. Within the Executive Branch, the Secretariat for the Environment had expense appropriations since 1987, but they amounted to very low proportions of the budgets for the State and the Executive Branch, as shown in the table below.

Budget Item	Budget Amount (Million Cz$)		
	1987(1)	1988(1)	1989(2)
R.J. State	110,423	908,270	11,351
Legislative	2,805	17,164	321
Judicial	4,868	32,095	328
Executive	102,750	859,011	10,702
Environmental Secretariat	123	12,216	163
% of State	0.11	1.34	1.44
% of Executive	0.12	1.42	1.52

(1) Million Cruzados
(2) Million Cruzados Novos

More recent data are expected to show large increases in environmental budgets, in light of the tremendous importance granted lately to the environment, which culminated with the U.N. sponsored Conference on Conservation and Development, or the Earth Summit, held in Rio de Janeiro in June 1992 with the attendance of world political leaders and environmental experts.

According to FEEMA, the 1992 budget appropriations for the different government agencies of the Rio de Janeiro State, calculated at the exchange rate of Cr$8,460 per US$1.00, amounted to the following.

Government Agency	1992 Budget (US$)
SEMANP	1,111,000
IEF	1,832,000
FEEMA	5,447,000
SERLA	15,279,000
FECAM	1,709,000
TOTAL	25,377,000

In the appropriated 1992 budget, the structure of expense categories was quite different for every government agency, as can be seen below.

Government Agency	Current Expenses (%)	Capital Expenses (%)
SEMANP	99.6	0.4
IEF	43.0	57.0
FEEMA	87.6	12.4
SERLA	24.6	75.4
FECAM	0.6	99.4
TOTAL	41.1	58.9

2.1.5.2 Rio de Janeiro City Finances

The budget for the City of Rio de Janeiro showed appropriations for the Municipal Secretariat for Urban and Environmental Matters only starting in 1989. Similar to the State, the amounts appropriated in 1989 and 1990 were small, not reaching half a percent of the total municipal budget. However, while the 1989 expense budget was assigned to Housing and Urbanization, the 1990 expense budget was assigned to Education and Culture, presumably environmental education.

The total and environmental budgets appropriated by the City of Rio de Janeiro in 1989 and 1990 are shown in the following table.

Budget Item	Budget Amount (Million Cr$) 1989	1990
R.J. Municipality	3,869	123,220
Urban and Environmental Secretariat	18	608
% of Total	0.48	0.49

Table 1.1.1 Area of Municipalities Included in the Guanabara Bay Basin

Municipalities wholly included in the basin	Area (km^2)
Cachoeiras de Macacu	1,055
Duque de Caxias	442
Itaborai	526
Mage	718
Nilopolis	22
Sao Goncalo	228
Sao Joao de Meriti	34
Sub-total	3,025

Municipalities partly included in the basin	Area (km^2)
Niteroi	130
Nova Iguacu	764
Petropolis	1,080
Rio Bonito	462
Rio de Janeiro	1,171
Sub-total	3,607
12 Municipalities	6,632
Guanabara Bay basin	4,000
Rio de Janeiro State	43,305

Table 1.2.1 Proportion of the R.J.State Population in the Guanabara Bay Basin Municipalities

Municipalities	% of State Population	
	1980	1991
Cachoeiras de Macacu	0.3	0.3
Duque de Caxias	5.1	5.3
Itaborai	1.0	1.3
Mage	1.5	1.5
Nilopolis	1.3	1.3
Niteroi	3.5	3.3
Nova Iguacu	9.7	10.2
Rio Bonito	0.4	0.4
Rio de Janeiro	45.1	42.4
Sao Goncalo	5.4	5.9
Sao Joao de Meriti	3.5	3.4

Table 1.2.2 Urban and Rural Population of Municipalities

Municipality	Population		
	Total	Urban	Rural
Cachoeiras de Macacu	40,181	32,016	8,165
Duque de Caxias	665,338	661,671	3,667
Itaborai	161,398	145,933	15,465
Mage	191,249	171,921	19,328
Nilopolis	157,936	157,936	------
Niteroi	435,658	435,658	------
Nova Iguacu	1,293,611	1,290,289	3,322
Rio Bonito	45,093	27,147	17,946
Rio de Janeiro	5,472,967	5,472,967	------
Sao Goncalo	778,820	778,820	------
Sao Joao de Meriti	424,689	424,689	------
11 Municipalities	9,666,940	9,599,047	67,893

Table 1.2.3 Favela Population by Municipality

Municipality	Municipal Population	G.B. Basin Population	Favela Population
Cach. de Macacu	40,181	40,181	0
Duque de Caxias	665,338	665,338	51,179
Itaborai	161,398	161,398	0
Mage	191,249	191,249	8,968
Nilopolis	157,936	157,936	2,261
Niteroi	435,658	369,933	24,843
Nova Iguacu	1,293,611	824,028	40,784
Rio Bonito	45,093	43,069	0
Rio de Janeiro	5,472,967	3,352,326	877,738
Sao Goncalo	778,820	778,820	0
S.J. de Meriti	424,689	424,689	13,726
Total	9,666,940	7,008,967	1,019,499

Table 1.2.4 Population Density of Municipalities

Classification	Person/sq.km
Very low-density Municipalities	
Outside Metropolitan Rio	
Cachoeiras de Macacu	38
Rio Bonito	97
Low-density Municipalities	
Northeast	
Mage	267
Itaborai	307
Medium-density Municipalities	
Northwest	
Nova Iguacu	1,684
Duque de Caxias	1,504
High-density Municipalities	
West	
Rio de Janeiro	4,557
East	
Niteroi	3,201
Sao Goncalo	3,280
Very high-density Municipalities	
West	
Sao Joao de Meriti	12,501
Nilopolis	7,174

Very low:<100; Low:100-999;
Medium:1,000-2,999: High:3,000-5,000
Very high:>5,000

Table 1.2.5 Population Growth between 1980 and 1991

Municipality	Population		
	1980	1991	Growth (%)
Cach. de Macacu	35,867	40,195	1.04
D. de Caxias	575,814	665,643	1.31
Itaborai	114,540	161,274	3.16
Mage	166,602	191,359	1.27
Nilopolis	151,588	157,819	0.37
Niteroi	397,123	416,123	0.43
Nova Iguacu	1,094,805	1,286,337	1.48
Rio Bonito	40,036	45,093	1.09
Rio de Janeiro	5,090,700	5,336,179	0.43
Sao Goncalo	615,352	747,891	1.79
S.J. de Meriti	398,826	425,038	0.58
11 Municipalities	8,681,253	9,472,951	0.80

Table 1.3.1 Types of Water Supply Systems

Unit: % of dwellings

State and Municipality	Public System	Well/ Spring	Others	Total
Rio de Janeiro State	69(4)	10(12)	1(4)	80(20)
Cachoeiras de Macacu	45(4)	15(30)	2(4)	62(38)
Duque de Caxias	37(7)	22(26)	2(6)	61(39)
Itaborai	21(3)	22(51)	1(2)	44(56)
Mage	34(3)	22(36)	1(4)	57(43)
Nilopolis	85(4)	3 (4)	1(3)	89(11)
Niteroi	70(3)	9(10)	2(6)	81(19)
Nova Iguacu	38(5)	23(28)	2(4)	63(37)
Rio Bonito	40(2)	17(38)	-(3)	57(43)
Rio de Janeiro	88(4)	2 (2)	1(3)	91 (9)
Sao Goncalo	60(4)	12(15)	3(6)	75(25)
Sao Joao de Meriti	62(9)	10(11)	2(6)	74(26)

No parentheses: with indoor pipe
In parentheses: without indoor pipe

Table 1.3.2 Toilet Facilities

Unit: % of dwellings

State and Municipality	Public Sewer	Cess-pool	Simple Pits	Others	Total
R.J. State	53(3)	15 (2)	11(1)	6 (9)	85(15)
Cach. de Macacu	--	7(--)	19(1)	47(26)	73(27)
Duque de Caxias	--	68(10)	8(1)	5 (8)	81(19)
Itaborai	9(1)	2(--)	59(4)	3(22)	73(27)
Mage	--	46 (3)	22(2)	14(13)	82(18)
Nilopolis	66(4)	16 (2)	3(1)	3 (4)	89(11)
Niteroi	65(2)	14 (1)	7(1)	3 (7)	89(11)
Nova Iguacu	30(3)	39 (4)	9(1)	7 (7)	85(15)
Rio Bonito	25(1)	--	36(1)	5(32)	66(34)
Rio de Janeiro	78(5)	2(--)	5(1)	4 (5)	89(11)
Sao Goncalo	8(1)	1(--)	70(6)	6 (8)	85(15)
S.J. de Meriti	--	68 (9)	9(2)	7 (5)	84(16)

No parentheses : exclusive use of the dwelling
In parentheses : shared use by several dwellings

Table 1.4.1 Number of Industrial Firms by Municipality

State and Municipality	No. of Industries	%
Rio de Janeiro State	16,892	100.0
Cachoeiras de Macacu	40	0.2
Duque de Caxias	807	4.8
Itaborai	179	1.1
Mage	144	0.9
Nilopolis	126	0.7
Niteroi	498	2.9
Nova Iguacu	619	3.7
Rio Bonito	80	0.5
Rio de Janeiro	8,959	53.0
Sao Goncalo	594	3.5
Sao Joao de Meriti	446	2.6

Table 1.4.2 Number of Employees in the Industrial Sector by Municipality

State and Municipality	No. of Employees	%
Rio de Janeiro State	528,657	100.0
Cachoeiras de Macacu	248	0.1
Duque de Caxias	23,302	4.4
Itaborai	3,007	0.6
Mage	5,075	1.0
Nilopolis	1,207	0.2
Niteroi	15,729	3.0
Nova Iguacu	16,657	3.2
Rio Bonito	1,195	0.2
Rio de Janeiro	320,820	60.7
Sao Goncalo	12,536	2.4
Sao Joao de Meriti	5,568	1.1

Table 1.4.3 Gross Value of Industrial Production by Municipality

State and Municipality	Production Value (Billion Cr$)	%
Rio de Janeiro State	108,914.9	100.0
Cachoeiras de Macacu	10.8	-----
Duque de Caxias	20,513.6	18.8
Itaborai	188.5	0.2
Mage	349.5	0.3
Nilopolis	53.8	-----
Niteroi	1,279.2	1.2
Nova Iguacu	3,695.9	3.4
Rio Bonito	80.4	0.1
Rio de Janeiro	50,167.1	46.1
Sao Goncalo	1,507.1	1.4
Sao Joao de Meriti	878.2	0.8

Table 1.4.4 Rank of Industry Types by Number of Firms

Municipality	Ranking
Cachoeiras de Macacu	Unknown industry types
Duque de Caxias	Food processing, clothing, chemical
Itaborai	Food processing, chemical, beverage
Mage	Food processing, textile, mechanic.
Nilopolis	Food processing, clothing, chemical
Niteroi	Food processing, transp., printing
Nova Iguacu	Food processing, metal., chemical
Rio Bonito	Unknown industry types
Rio de Janeiro	Clothing, metal, printing
Sao Goncalo	Food processing, metal., chemical
Sao Joao de Meriti	Clothing, food processing, plastics

Table 1.4.5 Rank of Industry Types by Number of Employees

Municipality	Ranking
Cachoeiras de Macacu	Unknown industry types
Duque de Caxias	Chemical, clothing, textiles
Itaborai	Chemical, food processing, various
Mage	Textiles, paper, mechanical
Nilopolis	Food processing, chemical, various
Niteroi	Transp., food process., printing
Nova Iguacu	Metal., food process., chemical
Rio Bonito	Unknown industry types
Rio de Janeiro	Clothing, food process., printing
Sao Goncalo	Food process., metal., chemical
Sao Joao de Meriti	Clothing, plastics., food process

Table 1.4.6 Rank of Industry Types by Value of Production

Municipality	Ranking
Cachoeiras de Macacu	Unknown industry types
Duque de Caxias	Chemical, textiles, food process.
Itaborai	Chemical, food process., various
Mage	Textiles, paper, mechanical
Nilopolis	Food process., chemical, various
Niteroi	Transp., food process., textiles
Nova Iguacu	Chemical, metal., food process.
Rio Bonito	Unknown industry types
Rio de Janeiro	Chemical, metal., food process.
Sao Goncalo	Food process., chemical, metal.
Sao Joao de Meriti	Plastics, food process., clothing

2.2 Development Plans and Environmental Projects in the Guanabara Bay Basin

2.2.1 Regional Development Plans

2.2.1.1 Rio de Janeiro State Development Plan

The latest development plan for the State of Rio de Janeiro is "The 1992-1995 Multi-year Government Plan", or "Plano Plurianual de Governo 1992/1995", in which the role of the State Government is defined as the provider of essential services. The Plan delineates the overall strategy and 14 sectoral plans. The Plan emphasizes environmental quality to be achieved through improved provision of social and sanitation infrastructures, education campaigns in the formal and informal school systems, promotion of non-polluting industries, and paying attention not only to technical solutions but also to social and cultural considerations in the application of environmental improvement schemes.

A violation of environmental laws is regarded as an environmental crime, which is to be dealt with by a coordinated action from the police, military police, civil defense and environmental organizations. Eventually, a specific environmental crime prevention force is to be created. However, prevention of environmental degradation is to rely more heavily on increased awareness of the population, which is to be achieved by a continued education campaign, targetting the children and youth in the formal school system as well as the general adult people through informal education programs.

The 1989 State Constitution declared Guanabara Bay as an Area of Permanent Preservation and also as an Area of Relevant Ecologic Interest. As such, measures to improve the quality of the Guanabara Bay ecosystem have been proposed and are being implemented or nearing implementation in the form of different projects. Of these, the Rio Reconstruction Project was formulated to deal with the aftermath of the flood of February 28th, 1988, funded by the World Bank and including such components as dredging, reforestation and solid wastes disposal. This project is nearing completion.

Another project to be jointly funded by the Inter-American Development Bank (BID) and the Overseas Economic Cooperation Fund (OECF) of Japan includes such components as sewer works, dredging,

reforestation, protection of mangrove forests and improvements in solid wastes disposal in every Municipality surroundig the Guanabara Bay. This Projecct is known as the Basic Sanitation Program for the Guanabara Bay Basin, and as of December 1992 was in the final stages of negotiation with BID.

Other environmental improvement measures refer to urbanization of slums ("favelas") and expansion of sewer treatment plants. Two large favelas, Rocinha and Vidigal, are to be urbanized with provision of basic sanitation, electrification, health care facilities, and above all, road pavement which would permit better traffic conditions, thereby facilitating evacuation of solid wastes. The Plan also proposes construction or expansion of 15 sewer treatment plants along the bay shore, which would increase sewage treatment capacity from 11.4 cu.m./s to 17.9 cu.m./s, with an expected 35% reduction in the organic load flowing into the Guanabara Bay.

The Development Plan gives the Guanabara Bay a high potential as a component of metropolitan mass transportation. An expanded boat service for passengers would have the added benefit of helping the idle State naval industry. The bottleneck of the Rio-Niteroi bridge will likely be ameliorated by a mass water transportation linking the eastern and western shores of the Guanabara Bay.

On the other hand, for promoting tourism, water transportation is believed to be attractive to revive the historical "Emperor's route", that is, by boat from Rio de Janeiro to Maua Beach in Mage, and by railroad from Maua Beach to Petropolis. Either as a leg in commuting or as a tourist transportation, it seems obvious that water transportation in the Guanabara Bay will have a higher demand if the bay water were cleaner and more pleasant.

An estimated 60% of foreign tourists to Brazil come to Rio de Janeiro, which is presumed to have a receptive capacity of 5,000,000 tourists per year. Tourism is estimated to generate 6% of the State gross domestic product and to employ 300,000 persons. The drawback is thought to be tourist attractions being concentrated in the city. In this regard, water transportation is believed to be capable of giving diversity to alternative tourist destinations within the Rio de Janeiro State. Historical, cultural and ecologic attractions are to be emphasized for tourism promotion, stressing the concept of conservation being compatible with development.

In the industrial sector, incentives are to be given to those using technology friendly to the environment, either by modernizing and modifying production processes of traditional industries (naval, mechanical, textiles, plastics, ceramics, chemicals), or by setting up non-polluting industries in the fields of high technology, biotechnology, new materials, fine ceramics and information systems.

The types of agroindustry in the State are presently restricted to sugar, meat and dairy. The Development Plan calls attention to the State potential in concentrated fruit juice, dehydrated and preserved foodstuff, and farm inputs such as feed, fertilizer and agrochemicals. The development of these high potential products would require increasing production of traditional fruit species (citrus, banana, passion fruit, pineapple, guava), in addition to the introduction of new species (fig, peach, grape). The final goal is diversification, and increased yield and processing of fruit, vegetable and dairy products.

2.2.1.2 Municipal Development Master Plans

Municipal authorities in the Rio de Janeiro State have to formulate a "Plano Diretor", that is, a Master Plan for the development of the Municipality. Some Municipalities in the Guanabara Bay basin have already completed their Master Plans, while some others are in the process of Master Plan preparation, and some Municipalities are yet to start preparation of their Master Plans. Usually, these Master Plans take the form of Municipal Laws, and the degree of detail varies from zoning and related laws to quite detailed plans, complete with background information. Municipal authorities often hire consultants to prepare these Master Plans.

(1) Rio de Janeiro

The Development Master Plan, formulated in 1991 with a 5-year planning horizon, is understood to be a set of guidelines and executive orders designed to regulate urban development by guiding public and private actions. The objectives of the Master Plan are: (1) to pursue an orderly growth of the city, seeking a balanced and just distribution of basic sanitation, road, transportation and other urban services; (2) to promote urban development compatible with environmental protection; and (3) to set up mechanisms for community participation in the planning and implementation of urban projects.

The Master Plan emphasizes control of air and water pollution which may be caused by existing or future industries. Likewise, the Master Plan encourages expansion of mass water transportation in the Guanabara Bay.

Specific environmental measures include pollution control programs based on standards yet to be set up and followed by monitoring; protection of slopes and floodplains based on controlled urbanization, farming, drainage, dredging and reforestation; and environmental education. Simultaneously, improvements are to be pursued in sewer services, by gradually eliminating the commonly used combined sewer/drainage system, and by requiring mandatory treatment of sewage prior to discharge into water bodies or storm sewers. Water supply network is to be expanded only if accompanied by adequate sewer systems. Land developers are to be required to build proper drainage systems.

Improved solid wastes disposal management is to begin with a public education campaign pursuing people's participation in the classification of solid wastes (burnable/non-burnable) at the generation point. This would facilitate recycling and composting, while reducing the amount of solid wastes for final disposal. In addition, solid wastes collection service is to be expanded into low income areas, and special treatments are to be required for pathogenic and toxic wastes.

Finally, development is to be compatible with environmental protection, favoring non-polluting, labor-intensive and export-oriented industries. Agriculture is to favor high valued products which can also be industrialized. Security, transportation and information services are to be improved as a way to promote tourism.

(2) Niteroi

The Development Master Plan, formulated in 1992, is to direct urban development in pursuance of improved quality of life for the people, under the criteria of ecology and social justice. Then, the people will be able to exercise their rights to housing, public transportation, basic sanitation, electricity, health, education, security, culture and recreation. At the same time, environmental, architectural and cultural assets are to be protected, preserved and restored.

The strategic objectives of the Master Plan are compatibilization of land use and environmental protection; improvement of environmental quality through rational use of natural resources, recovery of degraded areas, and preservation of natural scenery; promotion of economic development in the services and non-polluting industries, with due regard to local traditions and attitudes; promotion of tourism development; and integration of Niteroi with adjacent Municipalities, especially in the solution of common problems.

Land use is to be governed by environmental macro-zoning into (1) urban zone: appropriate for urbanization, effectively occupied or destined for urban expansion, and (2) zone for restricted use: unsuitable for urban use due to physical-geological characteristics, or preservation area for fauna, flora or scenery. A more detailed land use is to be defined by Areas of Special Interest comprising Social Interest, Environmental Interest, Economic Interest and Urban Interest.

The Areas of Special Social Interest comprise (1) public or private land occupied by favelas or low-income housing, (2) irregular land parceling, and (3) unutilized or underutilized land where low-income housing development can take place.

The Areas of Special Environmental Interest are municipal units for environmental preservation, or areas for permanent preservation. Also included are Risk Areas: threat to life or economic damages, and Areas for Scenery Preservation.

The Areas of Special Economic Interest comprise Area of Special Touristic Interest, Area of Special Agricultural Interest, Area of Special Fishery Interest and Area of Special Economic Interest.

The Areas of Special Urban Interest include Area of Special Urbanistic Interest and Area of Urban Preservation.

Economic development is to be compatible with environmental protection. Labor intensive activities are to be encouraged, and legalization of the informal sector is to be promoted through simplified legalization or regularization procedures. Economic activities are to be decentralized by permitting coexistence of small scale commerce and manufacturing plants in residential areas.

Tourism is to be promoted by improving tourism infrastructure, especially along the sea shore which is to become the area for tourism, recreation and sports. Municipal units for environmental preservation are to be established to promote ecologic tourism. Construction of accomodation facilities is to be promoted by granting tax exempt status for five years to hotels in Areas of Special Touristic Interst.

Agriculture is to be promoted by concession of idle municipal land for food production, creation of direct marketing channels from producers to consumers, restriction of land parceling in Areas of Special Agricultural Interest, promotion of organic farming, and incentives for small-scale farming in harmony with the environment. Also, small-scale fishery is to be supported with the provision of necessary infrastructure, and promoting fishery methods which can be balanced with environmental preservation.

Access to housing is to be improved by revising legislation on urbanization and buildings, by including favelas as subjects of urban planning, by establishing Programs for Low Income Population Settlements and Programs for Land Ownership Regularization.

Environmental protection and satisfactory quality of life for the people are to be pursued through conservation of vegetation cover, control of polluting activities, rational use of natural resources, preservation and recuperation of essential ecosystems, and protection of water resources. The municipal units for environmental conservation are the following.

Ecologic Reserve: public or private, for protection of water resources, the Atlantic forest and other natural vegetation for permanent preservation, where no environment-modifying activity is permitted.

Area for Environmental Protection - APA: public or private, for protection of natural systems through land-use zoning to improve simultaneously the ecology and the living conditions of the population.

Municipal Park: public, for protection of nature, but public visit is permitted for recreation, education and scientific uses according to a management plan and zoning.

Biologic Reserve: public, for preservation of natural ecosystems and rare or endangered species, where no environment-modifying activity is permitted, except scientific activities duly authorized by the Municipality.

Ecologic Station: public, for protection of representative regional or local ecosystems, where basic and applied research can be conducted, especially for environmental education.

In addition, the Governor of Rio de Janeiro can establish as Areas of Permanent Preservation those areas which, although not classified as municipal conservation units, show special characteristics of slope, altitude or vegetation cover which make them unsuitable for human occupation or environment-modifying activities.

For protection of human health, of water bodies and beaches, sewer systems should include at least secondary treatments. Similarly, collection and final disposal of solid wastes should follow environmental criteria, on the basis of garbage classification for recyling purposes.

(3) São Goncalo

The Development Master Plan formulated in 1991 seeks improvements in income, transportation, health care, education, housing and environmental preservation through a balanced land use. For this purpose, land use types are classified into three groups.

1) Consolidated urban area: residential use
2) Coastal peripheral area: preservation of mangrove forests, recreation along beaches, and farming.
   Residential use is to be restricted to clearly defined and demarcated areas, avoiding dispersion

3) Inland peripheral area: agriculture and preservation of mountain ranges. Residential use is to be restricted to clearly defined and demarcated areas, avoiding dispersion

Housing development is to be discouraged in areas where provision of water supply, sewer and drainage services are difficult. A fishery harbor is to be built at Porto Velho as a way to promote fishery development. Agriculture is to be promoted by providing assistance for production and marketing. Micro and small busi-