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FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATAO REGION, STATE OF SAO PAULO

FINAL REPORT

EXECUTIVE SUMMARY

JANUARY 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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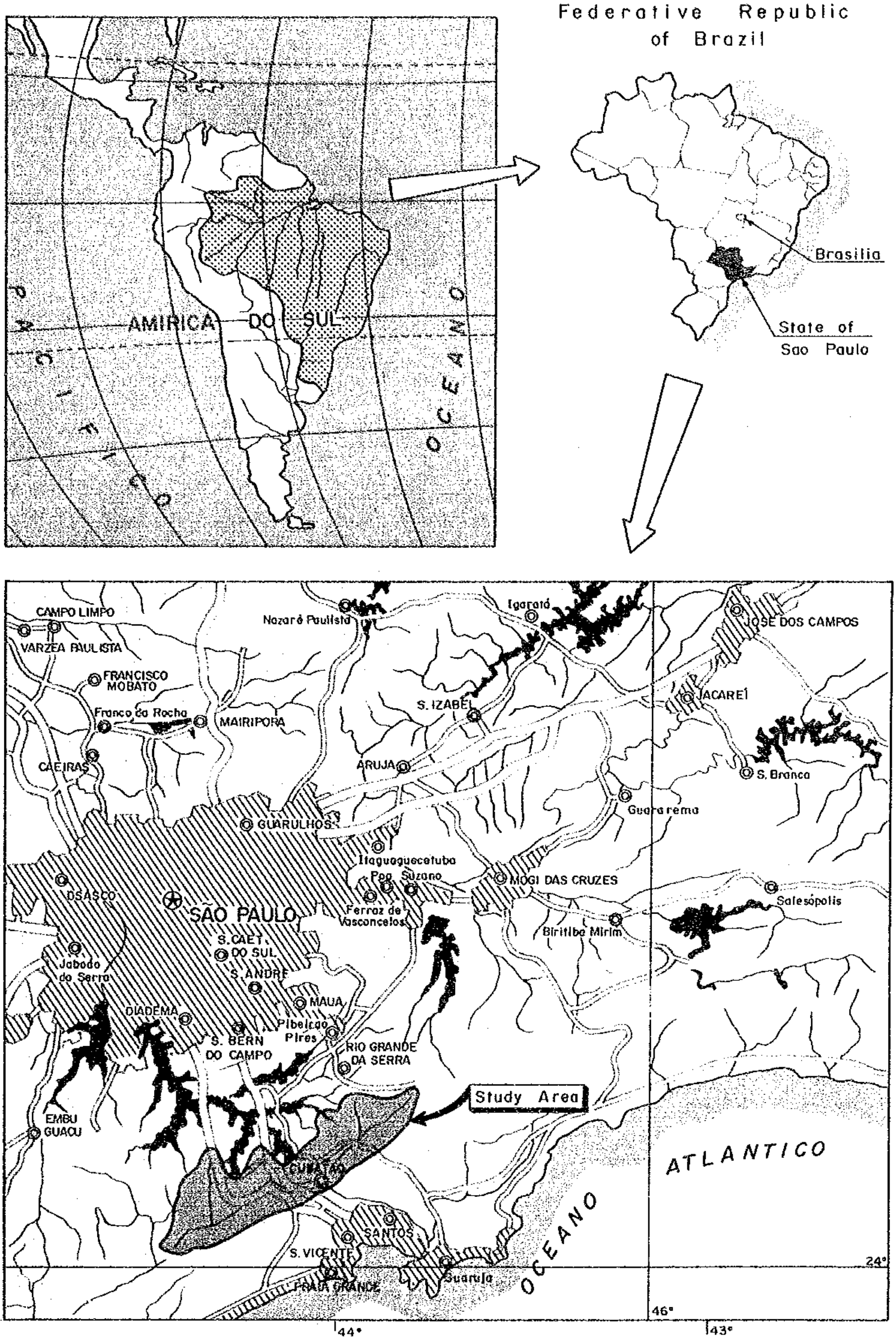

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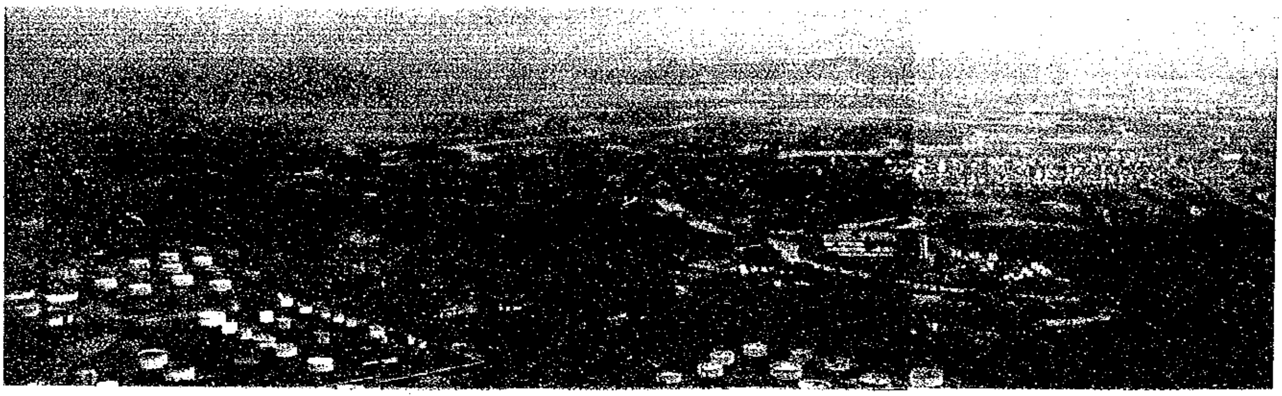
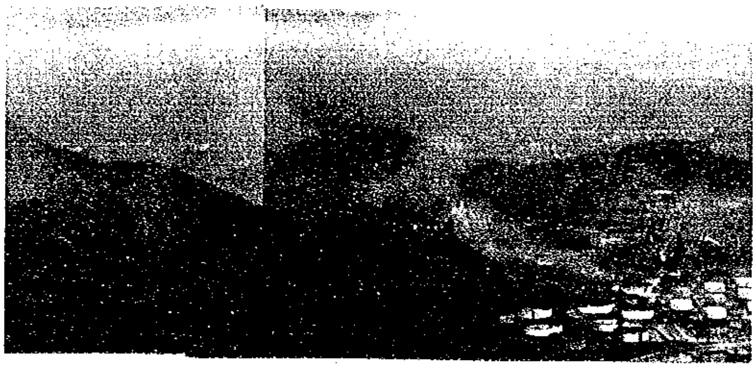
Pibeirao Pires
RIO GRANDE DA SERRA
Study Area
EMBU GUACU
CUBATAO
SANTOS
S. VICENTE
PRAIA GRANDE
Guaruja
OCEANO
ATLANTICO
24°
46°
44°
43°

GENERAL MAP



A general view of CUBATAO industrial complex and CUBATAO City.

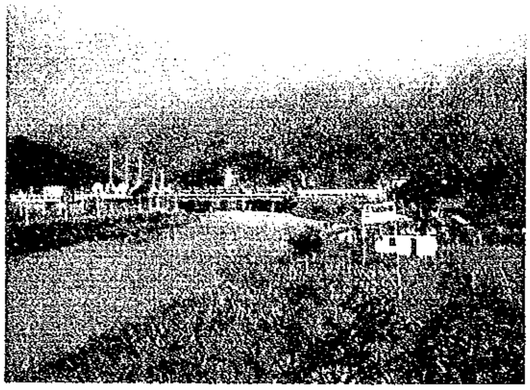


Air pollutant gases lanched from industrial establishment; Winds bring gases to the mountain side in daytime. Refinaria(left), Ultrafeltil and Copebras(right).

A large number of slope failures occured on the steep slopes upstream of the Moji River on Jan 22-25, 1985. Almost high trees standing on the slopes had already been dead by 1985's disaster(right).

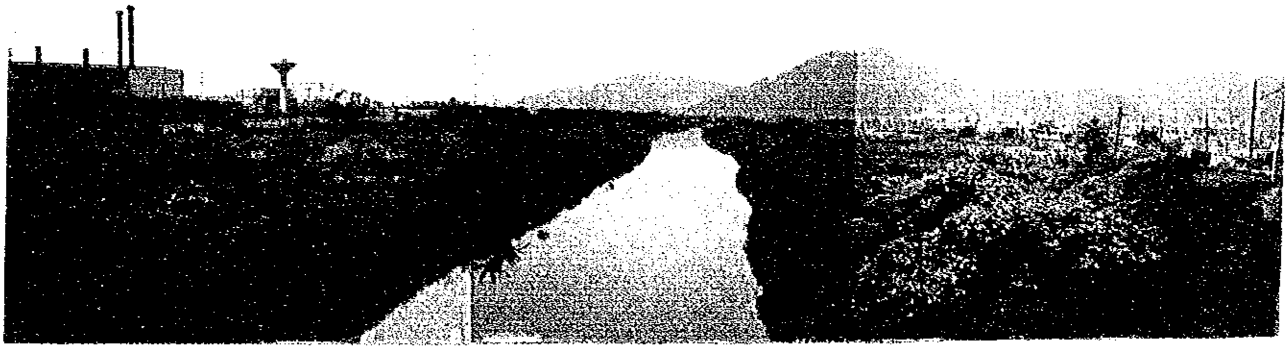
An aerial view of the riprap cross dam with sediment deposit mid-stream of the Moji River.

A series of three gabion dams constructed upstream of Ultrafertil.



Confluence of the Cubatão and the Pereque River; Flood dyke was constructed on right bank after the destructive disaster in 1971.

Lower reaches of the Cubatão River; Industrial and residential areas are developed along the both sides.



Lower reaches of the Moji River; where river channel improvement works are proposed in the priority project.

Monitoring on the control area after 3 months of seeding.

Young plant of Miconia sp, 50 cm tall, after 10 months of the aerial seeding.

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1. BACKGROUND

The study area, situated in a coastal mountain and plain area 60 km south of São Paulo, is characterized by development of heavy chemical industry and its tropical forest. However, since the mid-1970s, a number of slope failures have occurred which cause sediment run-off disasters to the industrial establishments, infrastructures and residences. These are frequently on the steep slopes of Sera do Mar, in rainy seasons, and mainly due to the degradation of vegetation by air pollution.

The lower reaches of the Moji and Cubatão rivers also suffer flood disasters, especially in the downstream reaches of the Moji river.

With the aim of restoring the damaged slopes of Serra do Mar, the Special Commission has been steadily undertaking various disaster prevention plans consisting of structural and non-structural measures, including a vegetation restoration plan, with the support of the several agencies concerned.

To cope with these disasters, the Goverment of the Federative Republic of Brazil, in October 1988, requested technical assistance in a study on sediment run-off and flood disaster prevention in this region. In response to this request, the Government of Japan(JICA) sent to Brazil a study team between November 1989 and September 1990 to conduct the study.

2. OBJECTIVES

The objectives of the study are: 1) to formulate a master plan to the year 2000 and to select a priority project, 2) to conduct a feasibility study on the priority project by the mid-1990s, and 3) technical transfer to the Brazilian counterpart personnel.

3. PRESENT CONDITIONS

3.1 Socio-Economy

(1) Population and labor force

Brazil's population in 1980 was 119.0 million with a population density of 14.0 persons/km^2. This population is expected to reach 150.4 million in 1990 with a population density of 17.6 persons/km^2. The country's labor force was estimated to have increased to 59.5 million by 1987 with an average annual growth rate of 4.68%.

The population of the State of São Paulo in 1980 was 25.0 million, which a population density of 100.9 persons/km^2. This population was estimated at 31.1 million in 1987 with a population density of 125.4 persons/km^2.

The population in Cubatão municipality in 1980 was recorded as 79,162, with a population density of 345.6 persons/km^2. This population is estimated to be 105,547 in 1990, with a population density of 713.1 person/km^2. The labor force in Cubatão was 31,576 in 1980 and is estimated to be approximately 42,100 in 1990. The detailed population growth and labor face are shown in Table 1.

(2) Economic performance

Gross Domestic Product (GDP) in 1988 was Cr$ 91,952 million (US$ 279.5 billion) at current prices. GDP at current prices has increased astronomically in the last two decades due to inflation. In real terms, however, Cr$ 12,402 million in 1980, Cr$ 13,111 million in 1985 and Cr$ 14,613 million in 1988 at 1980 constant prices, with an average annual growth of 2.07% for the period of 1980-88. Per capita GDP in 1988 was Cr$ 636.7 (US$ 1,935) at current prices. In real terms, however, it was Cr$ 0.101 at 1980 constant prices, compared with Cr$ 0.102 in 1980, indicating no real increase in per capita GDP.

Gross Regional Domestic Product (GRDP) in the State of São Paulo was Cr$ 64 thousand in 1970, Cr$ 341 thousand in 1975 and Cr$ 4,605 thousand in 1980 at current prices, respectively. Per capital GRDP in 1980 was Cr$ 0.184, which was 1.76 times larger than that of GDP. This ratio has gradually decreased from 1.96 in 1970, and 1.85 in 1975. The detailed data on GDP and GRDP are tabulated in Table 2.

The economic activities in the study area are dominated by the industrial sector, represented by the major industrial establishments in Cubatão municipality. This is one of the nation's largest industrial complexes and has been in operation since the 1950s. Its main products are petroleum, petro-chemical products, iron and steel, chemicals, and mixed fertilizers.

(3) Present land use

The total land in the study area amounting to 252 km^2 is currently used as follows: 1) 5.0 km^2 or 2.0% of the total land is built-up area, 2) 22.9 km^2 or 9.1% is industrial area, 3) 18.3 km^2 or 7.2% is grassland, and 4) 205.8 km^2 or 81.7% is forest and bush. The present land use (1990) is shown in Fig.1.

(4) Infrastructure

In the study area, there are four(4) arterial highway maintained by the state government, SP-150, Anchieta, SP-160 and Imigrantes.

All the residences in Cubatão municipality were supplied with municipal water in 1988, whereas the sewerage system covers only 1% of all the residences. Approximately 75% of the whole residences were covered by the electricity supply in 1988.

3.2 Sediment Run-off and Flood Damage

(1) Sediment run-off damage

According to records on the past disasters, a large number of small scale landslides on the steep slopes of Serra do Mar have occurred every 5 to 10 years in rainly seasons. Six(6) major sediment run-off have occurred since 1960: in 1962, 1971, 1976, 1980, 1985 and 1988 as shown in Fig.2. Of the above, sediment run-off disaster in 1985 was the largest in scale. The damage included destruction of machines, equipment and installations damage to inventory stocks, and even temporary suspension of production lines. The total direct damages and losses due to this disaster was reported to amount to approximately Cr$ 17.2 million.

(2) Flood damage

Past large scale floods occurred in 1968, Feb. 1971, Jan. 1973, Jan. 1976, Nov. 1979, Jan. 1983, Jan. 1985 and Dec. 1988. Of these, the 1971 flood was most serious.

In Feb. 1971, the urban area of Cubatão was inundated by river water which overflowed from the Cubatão and Pereque rivers as shown in Fig. 3. In addition, sea water which intruded in the low lying areas near the marsh enhanced the effect of inundation coupled with local rain water, and aggravated the flood. The flood damage was estimated to have been Cr$ 18.5 million at 1973 prices, comprising Cr$ 13.2 million in Cubatão river basin and Cr$ 5.3 million in Moji river basin, respectively.

3.3 Existing Disaster Prevention Structures

Major structures for sediment run-off control are riprap cross dams and gabion dams in the valley areas to protect specific industrial establishments. While, those for flood control are flood dikes to protect the urban area form flooding as shown in Fig.4.

3.4 Non-structural Measures

Major non-structural measures in the study area have been relocation of residents in danger areas a civil defense plan, air pollution control, experimental planting and so on. The objectives of the civil defense plan are 1) to protect residents from disasters (evacuation plan) and 2) to eliminate situations were accidents in the industrial establishments induced by disasters could cause dangerous harm to the residents (management plan).

3.5 Topography and Geology

The study area is topographically divided into three(3); a plateau area, a mountain slope area and a plain area. The study area is mainly dominated by migmatites, schists and sporadically intrusive granite of Pre-Cambrian age as illustrated in Figs.5 and 6. The migmatites including gneiss and quartzite are massive, sound and well jointed. They feature steep slopes with gradients of more than 30^{o}, continuous outcrops and large scale waterfalls. The schists are characterized by gentle slopes because of their schistosity and foliation. Generally, the rocks strike NE-SW and dip at 60-80 NW and are faulted in the same direction as the strike. From the confluence of the Cubatao and Moji rivers to the estuary, fine sand and clayey soils with organic matter of Holocene age are found at swamps in the plain area.

3.6 Present River Conditions

(1) River basins and systems

Mainstreams in the study area are the Cubatão river (A= 183 km^2) and Moji river (A= 64 km^2). Main tributaries are the Perequêand Pilões of the Cubatão river, and Piaçaguera, Indio and Onça of the Moji river. The Cubatão river with a total length of 39 km originates near the Billings reservoir on the north west plateau at an altitude of 700 m. While, the Moji river having a total length of 18 km originates on the north east mountain slope at an altitude of 800 m. The longitudinal profiles of the rivers are shown in Fig.7.

(2) Carrying capacities of channels

Carrying capacities of the existing channels were estimated by the non-uniform flow method. The average carrying capacity in the lower and middle reaches of the Cubatão is from 800 to 1000 m^3/s (w=1/5 or more) except upstream of the Anchieta bridge, which is less than 500 m^3/s. Average capacity in the Perequê is less than 200 m^3/s (w=1/2) downstream of RFFSA bridge and 500 m^3/s (w=1/25) in the upstream reaches. While, that of the Moji was estimated to be below 300 m^3/s (less than w=1/2).

3.7 Meteorology and Hydrology

(1) Climatic conditions

An average annual rainfall is around 3,400mm on the mountain slopes (EL.500m) and 2,700mm in the plan area. About 75% of the annual rainfall is concentrated in the summer. The mean temperature in Cubatão city is around 25°C in the summer and 20°C in the winter, and the mean relative humidity is around 74%. Present rainfall stations and their record availability are shown in Fig.8.

(2) Rainfall analysis

The average monthly rainfall fluctuates from 400 to 460 mm on the mountain slopes and from 320 to 340 mm on the plan area. Rainfall is mostly concentrated at night. The average duration of rainfall is around 50 hours ranging from 34 to 63 hours and about 90% of the total rainfall depth has been concentrated in 2 days in the eight(8) main floods of recent times.

The probable basin mean rainfall and point rainfall were estimated by the Gumbel method as follows:

Basin Mean Rainfall and Point Rainfall

(Unit: mm)

Return Period (yr)	Basin Mean Rainfall (2-day)		Point Rainfall (2-day)	
	Cubatão Basin	Moji Basin	E3-153R (Cubatão)	E3-038R (Moji)
2	205.7	182.3	233.1	191.5
5	281.2	249.9	311.4	262.7
10	331.2	294.6	363.3	309.9
25	394.2	351.1	428.9	369.4
50	441.3	393.0	477.5	413.6
100	487.8	434.7	525.7	457.5

(3) Run-off and discharge analysis

Probable flood run-off was estimated by using the storage function method and design hyetographs of the Feb. 1971 type in the Cubatão river basin and the Feb. 1985 type in the Moji river basin. The basin was divided into subbasins as shown in Fig.9 and estimated peak discharges at main points are presented in Table 3.

(4) Flooding analysis

Flooding analysis was conducted by constructing a simple hydraulic model in order to estimate inundation depths in the land areas. According to this analysis, it is observed that the inundation occurs with a five (5) year return period or more in the Cubatão river and a flood which possibly occurs every year in the Moji river.

3.8 Sedimentation

Channel sediment transport capacities were estimated for the Cubatão, Perequê and Moji rivers by three(3) kinds of sediment formulae. Of these formulae, the estimated capacities by Brown formula is most applicable to this study. It can be seen that there is wide variety in sediment capacity and therefore some reaches are relatively subject to sudden removal of accumulated sediment.

3.9 Sediment Run-off

Sediment run-off is the combined effect of slope failure and discharge of unstable torrent bed deposit. Slope failures in this study are small scale landslides on the steep mountain slopes. Distribution maps of total slope failures and individual past major failures are illustrated in Fig.10 and 11,and are summarized in Table 4.

The average area, depth to slip surface and volume of typical slope failures are considered to be 2,420 m^2, 0.7 m and 1,700 m^3, respectively.

Slope gradient, slope configuration and vegetation conditions can be identified as the main cause, and intensive rainfall as the trigger of slope failures. It is found that the slopes with gradients of less than 20^o are free from slope failures, but those of greater than or equal to 30^o are susceptible to the slope failures.

Vegetation degradation by air pollution has been recognized as one of the main causes of slope failures since the mid-1970s. In particular the vegetation of around 80 percent of the area had been degraded by pollution by 1977 and more than 95 percent by 1985.

With regard to the trigger of slope failures, the Special Commission has clarified the relationship between slope failures and rainfall such as rainfall intensity and accumulated rainfall. As a result of the analysis, 6-hour rainfall was considered to be the best index to estimate total area of slope failures.

Relationship between Slope Failures and Rainfall

Group	Equation	Correlation Coefficient
A	Y = 0.46(X-63.3)	0.940
B	Y = 0.30(X-80.6)	0.944
C	Y = 0.21(X-80.3)	0.971
D	-	-
E	-	-

Note: Y means total area (10^3 m^2) of slope failures per km^2

X means 6-hour rainfall (mm)

From the viewpoint of the soil mechanism, the reduction of apparent cohesion at the slip surface by the vertical infiltration and the saturated zone enlargement with time are considered to be main cause of the slope failures.

3.10 Vegetation and Soil

The forest, consisting of three(3) strata: upper, middle and lower, is widely covered with coppices (capoeira) including some subhigh trees of Tibouchina SP.

Soil types in the study area are Red Yellow Latosol, Red Yellow Podzolic Soil, Cambisol and Red Yellow Latosol Intergrade Red Yellow Podzolic Soil.

According to the vegetation maps prepared by CETESB shown in Fig.12, it can be seen that vegetation conditions have been remarkably degraded since the last half of the 1970s mainly due to air pollution.

CETESB and IBt have been conducting the forest restoration activities according to the basic plan as shown in Fig.13.

3.11 Environment

(1) Air quality conditions

The study area has a remarkable agglomeration of air pollution sources emitted from the industrial complex in Cubatão. Facing serious pollution over the entire Cubatão municipality in early 1980's, air pollution control over the main pollution sources has been enforced since 1984 and has attained remarkable results.

The initial emission load of 557 tons per day in 1984 was reduced by 66% to around 187 tons per day in 1989. Annual change of industry products and SO_2/SO_3 concentration is illustrated in Fig.14.

(2) Gases hazardous to vegetation

Among the various kinds of hazardous gases observed in the study area, such gases as Sulfurous oxides (SOx), Fluoride (HF), Ozone, Ammonia and Nitrogen Oxides (NOx) are considered to be the main pollutants causing vegetation degradation. Air pollution intensity area is shown in Fig.15.

4. MASTER PLAN

The outline of the master plan formulated is shown in Fig.16 and its components are as follows:

4.1 Sediment Run-off Disaster Prevention Plan

(1) Basic considerations

The master plan for the sediment run-off disaster prevention was formulated on the assumption that the present vegetation conditions will not be improved in near future because of the difficulty in restoring completely degraded forest to original conditions by the year 2000. Accordingly,

- a protection area having 12 Sabo subbasins was chosen on grounds of probable slope failure, past major sediment run-off records and the properties at risk to be protected as shown in Fig.17.

- a design scale of 100 years was adopted for the following reasons; the importance of the area to be protected, the uncertainty of natural disaster phenomena and Japanese standards.

(2) Disaster prevention plan

Thirty-two(32) Sabo dams and eleven (11) channel improvement works with a total length of 5,740 m were proposed for the master plan as shown in Table 5 and Fig.18. The main dimensions of the proposed structures are shown below.

Main Dimensions of Structures

Sabo Subbasin No.	Structural Measures		
	Sabo Dams No.	Sabo Dams Effective Height	Channel Works (m)
1	1	10 m	860
2	3	7 m,10 m,10 m	560
3	2	10 m each	530
4	2	8 m,10 m	600
5	2	10 m, 5 m	450
6	3	10 m each	700
7	6	10 m each	350
8	2	7 m,10 m	420
9	3	10 m each	150
10	2	8 m,10 m	-
11	3	10 m each	560
12	3	9 m,10 m,10 m	560
Total	32		5,740

4.2 Flood Disaster Prevention Plan

(1) Basic considerations

The master plan for flood disaster prevention was formulated on the basis of the following basic considerations.

- the urban area and industrial establishments in the fluvial plain shown in Fig.19 were determined to be the protected areas as follows:

  Cubatão river (RFFSA bridge - Sabesp weir)

  Perequê river (Road bridge at river mouth - Ultrafèrtil weir)

  Piaçaguera river (Confluence with the Moji river - spillway of Copebras estate)

  Indio river (Confluence with the Moji river - RFFSA bridge)

- the design scale of a 50-year return period was adopted for the mainstreams of the Cubatão and Moji rivers, and a 25-year return period for their tributaries by the reason of importance of protected area and the criteria applied in the State of São Paulo.

(2) Disaster prevention plan

Of the conceivable alternative schemes shown in Fig.20, schemes of C-2(2) in the Cubatão river basin and M-2 in the Moji river basin were selected as the optimum plan on the basis of least cost as shown in Fig.21.

Scheme C-2(2) consists of 2 tunnels of 600 m each and river channel improvement of 6.7 km, and scheme M-2 consists of 9.5 km of river channel improvement.

Work items	Quantities
<u>Cubatão River System</u>	
Construction of diversion tunnel	600 m
Channel improvement	6.7 km
<u>Moji River System</u>	
Channel improvement	
Moji	4.5 km
Piaçaguera	3.7 km
Indio	1.3 km

4.3 Forest Restoration Plan

(1) Basic considerations

The present forest restoration plan of the State of São Paulo includes two stages, namely first stage; planting and aeroseeding or pioneer species, and second stage; replantation of the climax species in Capoeira area.

According to the monitoring survey conducted by CETESB on February 1990, first stage's works is judged to have finished with success results satisfactorily. Therefore, the second stage of the present forest restoration plan can be adopted as the master plan project with a target year of 2000.

Twenty(20) areas shown in Fig.22 were selected as the strategic replantation areas with a catchment area of 0.4 ha, respectively.

(2) Forest restoration plan

Replantation of one thousand trees in each wood area was proposed for the master plan. The work items and quantities are as shown next.

Item	Quantities
Selection of climax species	-
Seedling production	24,000 units
Service roads restoration	35 km
Topographic works	80,000 m^2
Planting works	20,000 units
Maintenance works	20,000 units
Support works	-

4.4 Non-structural Measures

Non-structural measures, in combination with structural measures, are effective and of vital importance in minimizing damage from natural disasters. From experiences Japan, the following points can be suggested.

- Preparation and publication
- Simplification of existing judgment and information transmitting systems
- Prompt and accurate management of existing observation stations

4.5 Implementation Program

(1) Implementation schedule

The implementation schedule of the master plan was prepared by taking into account the construction sequence and conditions. The total project period was assumed to be 10 years, in which the project period was divided into two(2) stages: the first five(5) years (1991-1995) and the second five(5) years (1996-2000). Implementation schedules for sediment run-off and flood disaster prevention works, and forest restoration plan are shown in Fig.23 and 24.

(2) Construction cost

The construction cost of the master plan on a financial basis was estimated for the sediment run-off and flood disaster prevention works as given below. The price level was set at the end of June 1990 and official exchange rates were fixed as US$1.00 = Cr$60. The detailed financial cost is tabulated in Table 6.

(Unit: US$ million)

Item		Financial	Direct	Indirect
Sediment Run-off Prevention Plan		75.0	45.9	29.1
Flood Prevention Plan	- Cubatão	43.2	25.5	17.7
	- Moji	22.7	13.9	8.8
Forest Restoration Plan		2.0	1.7	0.3
Total		142.9	87.0	55.9

4.6 Project Justification

(1) Economic cost

The economic cost was estimated as follows:

(Unit: US$ million)

Item	Sediment Run-off Prevention	Flood Disaster Prevention	
		Cubatão	Moji
Direct Construction Cost	41.1	23.3	12.7
Compensation Cost	0.06	0.06	0.08
Administration Cost	2.1	1.2	0.6
Engineering Services	4.1	2.3	1.3
Physical Contingency	7.1	4.0	2.2
Total	54.4	30.9	16.9

(2) Economic benefit

The economic benefits were estimated as the reduction in damages or losses to damageable properties, which will be brought about by implementation of the designed disaster prevention works. Probable damages and annual damages were estiamted as follows:

Probable Sediment Run-off Damage and Annual Damage

(Unit: US$ million)

Sabo Subbasin	Return Period				Annual Damage
	5	25	50	100	
1	-	-	-	-	-
2	0.4	6.0	7.0	7.7	0.8
3	0.3	4.6	8.1	8.1	0.6
4	0.3	0.5	0.6	0.7	0.2
5	0.1	0.1	0.1	0.2	0.1
6	0.2	0.3	0.3	0.8	0.1
7	1.9	3.6	4.6	6.3	0.8
8	0.5	0.6	0.6	0.6	0.1
9	0.1	0.6	0.8	1.3	0.1
10	0.1	0.6	1.4	1.9	0.1
11	1.4	2.2	2.7	3.1	0.5
12	0.9	2.4	9.5	12.7	0.6

Note: 1 US$ = 60 Cr$

Probable Flood Damage and Annual Damage

(Unit: US$ million)

Basin	Return Period						Annual Damage
	2	5	10	25	50	100	
Cubatão	1.1	1.8	2.5	4.3	6.6	7.8	1.2
Moji	0.9	1.4	2.1	2.4	2.8	3.1	0.9

Note: 1 US$ = 60 Cr$

(3) Economic evaluation

Economic evaluation was carried out to assess economic viability by comparing economic costs and benefits. The Economic Internal Rate of Return (EIRR) was used as the criterion as shown in the following table.

Item	Sediment Run-off Prevention Plan	Flood Prevention Plan	
		Cubatão	Moji
EIRR (%)	11.2	5.4	8.3

(4) Project justification

The master plan for the sediment run-off prevention works could be justified solely by EIRR of 11.2% quoted above. When the unmeasurable social impacts and intangible damages which would be induced from sediment run-off disasters are taken into account, this master plan was judged to be highly viable for implementation.

When regard to the master plan for the flood protection works, major industrial establishments are at high risk of recurrent inundation from the Moji river and its tributaries. In considering the future land use plan envisaged for the Moji river basin, the probable flood damages in future is likely to increase significantly as compared the present projection. If this is combined and with the economic evaluation the flood protection works for the Moji river basin is also highly viable.

The master plan for the forest restoration would be justified from effective erosion control aiming at preventing sediment run-off and flood disaster in the middle and long term.

5. SELECTION OF PRIORITY PROJECT

The priority project targeted on the mid-1990s was selected from the master plan as follows. The outline of the priority project is shown in Fig.25.

5.1 Sediment Run-off Disaster Prevention

Priority project was determined as shown below in accordance with the two selection priorities; the probability of serious disaster and EIRR. As a result, nine(9) Sabo dams, and six(6) channel works in seven(7) subbasins were selected as shown below. These structural measures were designed for the probable sediment run-off discharge of about a 25-year return period.

	Subbasin											
Item	1	2	3	4	5	6	7	8	9	10	11	12
1st criteria		+	+				+	+				
2nd criteria EIRR (%)	(-)	12.7	14.7	2.4	1.8	2.1	17.0	9.1	3.9	11.8	11.9	12.9
Priority Project		*	*				*	*		*	*	*

Note: + means first priority subbasins having possibility of flowing out toxic gases and liquid in sediment run-off disaster
* means selected priority project

5.2 Flood Disaster Prevention

About 4.5 km of channel improvement and flood dike construction on the Moji river, including the lower reaches of some tributaries were selected for the priority project because of their higher economic viability and the circumstances of recurrent inundation. These structural measures will be designed for a 10-year return period.

5.3 Forest Restoration Plan

Forest restoration works to be done by 1995 were selected as the priority project in accordance with the implementation program of the master plan.

The quantities of the forest restoration works in the priority project is summarized below:

Item	Quantities
Selection of climax species	-
Seedling production	24,000 units
Service roads restoration	35 km
Topographic works	80,000 m^2
Planting works	20,000 units
Maintenance works	20,000 units
Support works	-

The project cost for the priority project was estimated on the basis of the restoration plan in the master plan as shown below:

(Unit : US$ 1,000)

Item	Project Cost
(1) Direct Cost	
. Service road	175
. Topographic works	70
. Seeding production	96
. Planting works	80
. Maintenance works	20
. Management works	600
. Monitoring by aerophotos	60
Sub-total	1,101
(2) Contingency (20%)	224
Total	1,325

6. FEASIBILITY STUDY ON PRIORITY PROJECT

6.1 Preliminary Design and Work Quantities

(1) Sediment run-off disaster prevention works

The preliminary design for the sediment run-off disaster prevention works was carried out based on the design criteria in Japan as shown in Fig.26 and 27. The work quantities of the sabo dams, channel works and groundsills are shown in Table 7 and they are summarized below.

Dam No.	Dam		Channel Works	Groundsill	
	H (m)	V (m^3)	L (m)	Nos	V (m^3)
2-1	13	22,000	530	4	1,200
3-1	14	9,800	490	1	200
7-1	12	3,600	250	5	1,000
7-3	14	3,800	-	-	-
7-4	12	2,000	-	-	-
8-1	11	3,700	440	4	400
10-1	9	1,100	-	-	-
11-1	14	7,300	410	11	1,100
12-1	13	4,900	750	9	900
Total		58,200	2,870	34	4,800

Note: H; Dam height V; Volume of structure L; Total length

(2) Flood disaster prevention works

The preliminary design for the flood disaster prevention works was conducted in accordance with the criteria in Japan as shown in Fig.28 and 29. The work quantities of the river improvement works are as shown in Table 8 and they are summarized below.

Component	Type of Structure	Quantity
Dike		265,000 m^3
Excavation		334,000 m^3
Dredging		141,000 m^3
Revetment	Wet masonry	9,800 m^2
Culvert		1.5m x 1.5m (6 sites)
		2.0m x 2.5m (1 site)
Intake Weir	Concrete	
Parapet Wall	Concrete	
Road Bridge		40.8 m
Railway Bridge		130.5 m

6.2 Construction Plan

The contract system considering the participation of foreign contractors associated with Brazilian contractors are proposed to execute the project works.

The projects will be proposed to be executed with four (4) packages taking into account the project scale, amount of construction costs and secure implementation.

6.3 Cost Estimate

The construction cost for the priority project was estimated based on the preliminary design and construction plan. The basic assumptions and conditions adopted for the cost estimate are basically the same as that of master plan stage. The detailed financial cost is tabulated in Table 9.

The construction costs for the priority projects in the financial basis were estimated as follows:

(Unit: US$ million)

Item	Sediment Run-off Prevention Works			Flood Disaster Prevention Works Moji River		
	F/C	L/C	TOTAL	F/C	L/C	TOTAL
I Preparatory Work (5-15% of II)	1.0	1.2	2.2	0.2	0.1	0.3
II Construction Cost	7.0	7.8	14.8	4.0	3.1	7.1
III Compensation Cost		0.1	0.1		0.2	0.2
IV Administration Cost (5% of I + II)		0.9	0.9		0.4	0.4
V Engineering Service (10% of I + II)	1.4	0.3	1.7	0.6	0.1	0.7
VI Physical Contingency (15% of I+II+III+IV+V)	1.4	1.5	2.9	0.7	0.6	1.3
VII Price Contingency (F/C 3%, L/C 3%)	1.5	1.6	3.1	0.8	0.6	1.4
Total	12.3	13.4	25.7	6.3	5.1	11.4

(Unit : million US$)

Works	Construction Cost		
	Direct	Indirect	Total
(1) Sediment run-off disaster prevention works	17.0	8.7	25.7
Basin 2	6.0	3.0	9.0
Basin 3	2.7	1.3	4.0
Basin 7	2.7	1.4	4.1
Basin 8	1.1	0.8	1.9
Basin 10	0.3	0.1	0.4
Basin 11	2.2	1.1	3.3
Basin 12	2.0	1.0	3.0
(2) Flood disaster prevention works	7.4	4.0	11.4
(3) Forest restoration works	1.1	0.2	1.3
Total	25.5	12.9	38.4

6.4 Project Economic Evaluation

(1) Economic cost

The constitution and concept of the economic cost for the priority project was assumed to be the same as applied in the master plan. The economic cost for the priority project was estimated as follows:

(Unit : million US$)

Works	Economic Cost		
	Direct	Indirect	Total
(1) Sediment run-off disaster prevention works	15.1	4.9	20.0
Basin 2	5.4	1.7	7.1
Basin 3	2.3	0.8	3.1
Basin 7	2.4	0.8	3.2
Basin 8	1.1	0.3	1.4
Basin 10	0.2	0.1	0.3
Basin 11	1.9	0.6	2.5
Basin 12	1.8	0.6	2.4
(2) Flood disaster prevention works	6.8	2.2	9.0
Total	21.9	7.1	29.0

(2) Economic benefit

The economic benefits were estimated as the reduction in damages or losses to damageable properties, which will be brought about by implementation of the designed disaster prevention works. Probable damages and annual damages were estiamted as follows:

Probable Sediment Run-off Damage and Annual Damage

(Unit: US$ million)

Sabo Subbasin	Return Period				Annual Damage
	5	25	50	100	
2	1.2	6.0	7.0	7.7	0.7
3	0.3	4.6	6.2	8.1	0.4
7	1.9	3.6	4.6	6.3	0.6
8	0.7	0.8	1.1	1.4	0.2
10	0.1	0.6	1.4	1.9	0.1
11	1.4	2.2	2.7	3.1	0.4
12	1.0	3.0	8.6	11.4	0.4

Note: Annual damage with the design scale of approximately 25-year return period
1 US$ = 60 Cr$

Probable Flood Damage and Annual Damage

(Unit: US$ million)

Basin	Return Period						Annual Damage
	2	5	10	25	50	100	
Moji	0.9	1.5	2.0	2.1	2.4	2.5	1.0

Note: 1 US$ = 60 Cr$

(3) Economic evaluation

An economic evaluation was carried out to ascertain the economic viability of the proposed projects by comparing the economic costs and benefits. The Economic Internal Rate of Return (EIRR) was applied as a criterion for economic evaluation.

Works/Sabo Sub-basin	EIRR (%)
Sabo Works	
2	13.3
3	17.8
7	23.5
8	16.8
10	30.1
11	21.2
12	22.3
Total	18.2
River Improvement Works	11.1

6.5 Environmental Impact Assessment

As a result of environmental impact assessment based on the guide-line of the State of São Paulo, the environmental effects of the priority projects will be generally limited to the construction stage. However, the magnitude are expected to be small, because the impacts are tentative and effective countermeasures will be taken during construction of the projects.

6.6 Project Justification

Overall economic evaluation of the Sabo works, consisting of 7 Sabo sub-basins, shown an EIRR of 18.2%. Of the above, sub-basin No.7, 10, 11 and 12 were analyzed to exhibit quite high economic return of more than 20%. On the other hand, the Moji river improvement works shown an EIRR of 11.1%.

For the above-mentioned reasons, both the sediment run-off and the flood prevention works could be justified. Moreover, taking into account unmeasurable social impacts and intangible damage, these projects were judged to be highly viable for implementation.

7. RECOMMENDATION

1. The proposed priority project for the sediment run-off and flood disaster prevention works is strongly recommended to be implemented at the earliest possible time because of eminent social request from high potential of disaster, as shown that the project is technically feasible and economically viable with high economic return.

2. It is well known that the forest restoration plan is very important to protect industrial establishments and inhabitants from sediment run-off and flood disasters. Therefore, basic study on the relationship between vegetation changes and air pollution, and monitoring on the aeroplantation should be carried out in continuous and effective methods as applied presently.

In considering uncertainty and difficulty in predicting accurate time and location of occurrence for the sediment run-off disasters, the present civil defense plan and forest restoration program are also strongly requested to be continued as effective countermeasures which are complementary to the proposed priority project in order to restore forest in Serra do Mar.

3. Prior to the detailed design and during the construction, it is also recommended that geotechnical investigations for bearing capacity of foundation, cutting slope stability and bank materials should be carried

out because of complex geological conditions in the project area of the priority project.

4. Other projects in the Master plan especially diversion tunnel works including open channel through the marsh area, which were not selected as the priority project, could seem to cause relatively serious impact on mangrove and its neighboring environment. From the above, detailed environmental impact assessment should be undertaken before the project is implemented.

TABLES

TABLE 1 POPULATION GROWTH AND LABOR FORCE

Item	Population				Average Annual Growth Rate (%)		
	1960	1970	1980	1990(87)	'60-'70	'70-'80	'80-90(87)
(1) BRAZIL							
1. Population	70,070,457	93,139,037	119,002,706	150,367,841	2.89	2.48	2.37
2. Male	35,055,457	46,331,343	59,123,361	74,992,111	2.83	2.47	2.41
3. Female	35,015,000	46,807,694	59,879,345	75,375,730	2.95	2.49	2.33
4. Urban	31,303,034	52,084,984	80,436,409	112,743,732	5.22	4.44	3.43
5. Rural	38,767,423	41,054,053	38,566,297	37,624,109	0.57	-0.63	-0.25
6. Economically Active	48,740,564	65,683,745	87,677,224	(104,311,844)	3.03	2.93	2.51
7. Labor Force	22,750,100	29,557,224	43,235,712	(59,542,958)	2.65	3.88	4.68
8. Labor Force Participation(%)	46.7	45.0	49.3	57.1	-0.37	0.92	2.12
(2) Sao Paulo							
1. Population	12,809,231	17,771,948	25,040,772	(31,124,350)	3.33	3.49	3.16
2. Male	6,480,421	8,931,360	12,519,890	(15,416,521)	3.26	3.49	3.02
3. Female	6,328,810	8,840,588	12,520,882	(15,707,829)	3.40	3.54	3.29
4. Urban	8,019,743	14,276,239	22,196,378	(28,202,067)	5.94	4.51	3.48
5. Rural	4,789,488	3,495,709	2,844,334	(2,922,283)	-3.20	-2.08	0.27
6. Economically Active	9,308,538	13,334,701	19,327,707	(24,231,757)	3.66	3.78	3.28
7. Labor Force	4,517,600	6,372,842	10,411,726	(14,249,629)	3.50	5.03	4.58
8. Labor Force Participation(%)	48.5	47.8	53.9	58.8	-0.15	1.21	1.25
(3) Cubatao							
1. Population	25,166	51,009	79,162	105,547	7.32	4.49	2.92
2. Male	-	27,342	43,208	58,950	-	4.68	3.16
3. Female	-	23,667	35,954	46,597	-	4.27	2.63
4. Urban	-	37,255	78,569	105,547	-	7.75	3.00
5. Rural	-	13,754	593	0	-	-36.94	-
6. Economically Active	-	35,598	59,177	(76,571)	-	5.21	3.75
7. Labor Force	-	15,822	31,576	-	-	7.15	-
8. Labor Force Participation(%)	-	44.5	53.4	-	-	1.86	-

Source : Anuario Estatistico do Brasil 1989: IBGE
Estatisticas Historicas do Brasil 1988: IBGE
Anuario Estatistico do Estado de Sao Paulo 1988: IBGE
Boletim Informativo de Cubatao: P.M.C
Secretaria de Ciencia, Tecnologia e Desenvolvimento Economico

Remark : *1 Quated in 1990 are projected population.
*2 Figures in parentheses are projected data in 1987.
*3 Economically active population is defined as persons aged 10 years and over.
*4 (7)/(6)

TABLE 2 GROSS DOMESTIC PRODUCT

Year	Gross domestic Product				Gross Domestic Product per Capita			
	Current Price (Cr$ 1,000)	Constant Price at 1980(Cr$1,000)	Annual Growth Rate (%)	Current Prie (US$ million)	Current Price (Cr$)	Constant Price at 1980(Cr$)	Annual Growth Rate (%)	Current Price (US$)
1970	194	5,419	-	34,034	0.002	0.057	-	355.18
1971	258	6,037	11.3	39,529	0.003	0.061	8.7	402.43
1972	347	6,754	11.9	45,704	0.003	0.067	9.3	454.21
1973	512	7,698	14.0	55,329	0.005	0.074	11.3	536.91
1974	745	8,326	8.2	66,403	0.007	0.079	5.7	629.32
1975	1,050	8,756	5.2	76,219	0.01	0.081	2.7	705.52
1976	1,634	9,654	10.3	88,896	0.01	0.087	7.6	803.78
1977	2,493	10,130	4.9	99,342	0.02	0.089	2.5	877.53
1978	3,617	10,634	5.0	112,205	0.03	0.092	2.5	968.46
1979	5,961	11,352	6.8	133,338	0.05	0.096	4.3	1,124.71
1980	12,402	12,402	9.2	165,264	0.10	0.102	6.8	1,362.60
1981	24,654	11,859	-4.4	174,334	0.20	0.096	-6.6	1,405.15
1982	51,025	11,939	0.7	186,311	0.40	0.094	-1.6	1,468.35
1983	118,927	11,531	-3.4	185,737	0,92	0.089	-5.6	1,431.32
1984	393,647	12,111	5.0	203,505	2.97	0.091	2.8	1,534.05
1985	1,413,312	13,111	8.3	228,137	10.43	0.097	6.0	1,682.87
1986	3,708,949	14,099	7.5	250,123	26.78	0.102	5.3	1,806.03
1987	11,899,911	14,611	3.6	268,663	84.13	0.103	1.5	1,899.32
1988	91,952,490	14,613	0.0	279,492	636.67	0.101	-2.0	1,935.16
1989*	1,366,421,000	15,139	3.6	303,452	9,270.00	0.103	1.5	2,058.64

Source: Anuario Estatistico do Brazil, 1989 : IBGE
Relatorio, 1989: Banco Central do Brasil
Remarhs: * Provisional estimate by IBGE

TABLE 3 ESTIMATED PROBABLE DISCHARGES

PRESENT CHANNEL CONDITION

Return Period (Year)		2	5	10	25	50	100
CUBATAO RIVER SYSTEM (Feb.24.1971 Flood Type, 2DAY-Rainfall=301.8mm)							
Probable Rainfall (mm)		206	282	331	394	441	488
Scale factor of total rainfall		0.683	0.934	1.100	1.309	1.465	1.617
Probable Discharges at Major Points (m3/s)							
-River Mouth	(29)	916	1301	1555	1876	2121	2366
-After Pereque	(28)	915	1302	1552	1877	2128	2376
-Pereque River	(27)	212	321	382	460	519	581
-Before Pereque	(20)	724	1033	1231	1489	1690	1890
- "	(19)	748	1056	1258	1530	1743	1956
-Anchieta Bridge	(17)	586	878	1070	1330	1534	1739
-Imigrantes Brg.	(14)	537	828	1022	1289	1498	1708
-After Piloes	(10)	570	868	1062	1320	1521	1725
-Piloes River	(9)	173	282	356	455	532	609
-Before Piroes	(4)	397	586	706	865	1018	1172
MOJI RIVER (Jan.22.1985 Flood Type, 2DAY-Rainfall=286.5mm)							
Probable Rainfall (mm)		182	250	295	351	393	435
Scale factor of total Rainfall		0.639	0.873	1.030	1.229	1.375	1.568
Probable Discharges at Major Points (m3/s)							
-River Mouth	(49)	243	367	453	566	652	714
-After Piacag.	(48)	278	429	536	683	806	866
-Piacaguera R.	(44)	79	128	168	227	274	292
-Before Piacag.	(41)	234	365	461	585	675	737
-After Indio R.	(38)	240	376	489	644	762	819
-Indio River	(34)	28	44	58	79	95	101
-Before Indio	(33)	220	346	451	595	706	759
-Intake Weir	(30)	240	421	570	788	965	1040

IMPROVED CONDITION OF EXISTING CHANNEL

Return Period (Year)		2	5	10	25	50	100
CUBATAO RIVER SYSTEM (Feb.24.1971 Flood Type, 2DAY-Rainfall=301.8mm)							
Probable Rainfall (mm)		206	282	331	394	441	488
Scale factor of total rainfall		0.683	0.934	1.100	1.309	1.465	1.617
Probable Discharges at Major Points (m3/s)							
-River Mouth	(29)	920	1346	1617	1970	2242	2515
-After Pereque	(28)	915	1326	1589	1933	2199	2467
-Pereque River	(27)	209	324	395	488	558	627
-Before Pereque	(20)	724	1058	1270	1549	1767	1988
- "	(19)	751	1069	1278	1556	1774	1993
-Anchieta Bridge	(17)	589	891	1090	1356	1565	1776
-Imigrantes Brg.	(14)	537	827	1022	1279	1482	1687
-After Piloes	(10)	570	868	1062	1320	1521	1725
-Piloes River	(9)	173	282	356	455	532	609
-Before Piroes	(4)	397	586	706	865	1018	1172
MOJI RIVER (Jan.22.1985 Flood Type, 2DAY-Rainfall=286.5mm)							
Probable Rainfall (mm)		182	250	295	351	393	435
Scale factor of total Rainfall		0.639	0.873	1.030	1.229	1.375	1.568
Probable Discharges at Major Points (m3/s)							
-River Mouth	(49)	213	345	438	551	658	706
-After Piacag.	(48)	273	443	578	759	897	949
-Piacaguera R.	(44)	79	128	168	227	274	292
-Before Piacag.	(41)	228	378	503	676	810	864
-After Indio R.	(38)	231	377	487	632	740	778
-Indio River	(34)	28	44	58	79	95	101
-Before Indio	(33)	218	359	466	609	716	755
-Intake Weir	(30	240	421	570	788	965	1040

TABLE 4 PAST MAJOR SLOPE FAILURES

Area: Unit (10E-2 Km2)

Division	1962		1971		1976		1980		1985		1988		1962-1989	
Name	Nos.	Area	Nos.	Area	Nos.	Area	Nos.	Area	Nos.	Area	Nos.	Area	Nos.	Area
MOJI RIVER BASIN														
MR-1	3	0.98	100 (1)	34.07	77 (6)	21.25	45 (9)	12.21	302 (29)	61.05	26 (2)	5.13	664	161.7
MR-2	7	1.1	7 (1)	3.79	43 (3)	12.82	16 (4)	3.42	57 (9)	12.45	10 (2)	1.75	155	39.34
MR-3	2	0.49	13 (0)	2.67	88 (1)	19.9	31 (7)	10.5	136 (10)	27.23	40 (10)	5.86	342	73.06
MR-4	0	0	0	0	2 (0)	0.73	0	0	0	0	0	0	2	0.73
MR-5	0	0	0	0	0	0	0	0	8 (0)	1.22	0	0	18	1.22
ML-1	9	2.56	38 (0)	16.85	7 (1)	18.8	10 (8)	8.42	118 (16)	35.29	12 (8)	2.56	252	109.74
Sub-Total	21	5.13	158 (2)	57.38	217 (11)	73.5	102 (28)	34.55	621 (64)	137.24	88 (22)	15.30	1433	385.79
CUBATAO RIVER BASIN														
CR-1	4	0.2	20 (0)	3.33	16 (3)	2.92	0	0	1 (0)	0.73	0	0	43	5.86
CR-2	0	0	12 (0)	1.88	10 (0)	1.88	2 (0)	1.56	1 (0)	0.73	2 (0)	1.59	26	3.79
CR-3	0	0	0	0	0	0	0	0	4 (0)	2.13	0	0	4	2.56
CL-1	1	0.1	4 (0)	0.38	0	0	8 (0)	1.46	3 (0)	0.79	2 (0)	1.59	21	2.81
CL-2	3	0.2	1 (0)	0.1	1 (0)	0.16	5 (0)	1.04	6 (0)	2.13	11 (1)	3.79	32	8.18
CL-3	5	0.33	3 (0)	0.31	2 (0)	0.16	4 (0)	3.25	16 (1)	3.05	21 (1)	4.5	64	8.01
CL-4	0	0	0	0	0	0	0	0	3 (0)	1.59	24 (0)	3.3	45	8.15
CL-5	0	0	0	0	0	0	2 (0)	1.71	26 (0)	3.42	14 (1)	1.71	68	11.63
CL-6	0	0	4 (0)	1.47	1 (0)	0.73	1 (0)	1.22	44 (1)	7.2	14 (1)	2.32	114	23.05
CL-7	6	1.59	16 (0)	5.74	56 (1)	15.26	63 (10)	13.8	172 (15)	34.19	39 (4)	5.37	446	96.23
CL-8	0	0	0	0	0	0	0	0	6 (0)	1.10	0	0	8	1.47
Sub-Total	19	2.42	60 (0)	13.21	86 (4)	21.11	85 (10)	24.04	282 (17)	55.96	127 (8)	24.17	871	171.74
Total	40	7.55	218 (2)	70.59	303 (15)	94.61	187 (38)	58.59	903 (81)	193.2	215 (30)	39.47	2304	557.53

Note: ( ) Shows number of slope failures that occured again at the same places compared with previous aerial photographs interpretation results.

TABLE 5 DIMENSION OF STRUCTURAL MEASURES

(Unit:m3)

Sub-basin No.	Sediment Run-off Discharge	Existence Structural Measures				Design Sediment Run-off Discharge	Proposed Structural Measures (Sabo-dam)						
		1st	2nd	3rd	Total		1st	2nd	3rd	4th	5th	6th	Total
1	155,500	(H=8) 24,800	(H=10) 138,200	(H=10) 44,200	207,200	0	(H-10)* 7,400						7,400
2	159,400	(H=4) 70,000				159,400	(H-7) 124,800	(H=10)* 16,200	(H=10)* 19,300				160,300
3	109,400	(H=4) 82,000				109,400	(H=10) 85,800	(H=10)* 28,500					114,300
4	158,700					158,700	(H=8) 120,000	(H=10)* 45,000					165,000
5	38,700					38,700	(H=10) 38,100	(H=5)* 2,300					40,400
6	80,100					80,100	(H=10) 36,700	(H=10) 41,600	(H=10)* 2,400				80,700
7	166,600					166,600	(H=10) 44,600	(H=10) 20,300	(H=10) 35,700	(H=10) 49,500	(H=10)* 8,500	(H=10)* 8,600	167,200
8	15,200					15,200	(H=7) 12,000	(H=10)* 3,600					15,600
9	27,700					27,700	(H=10) 21,800	(H=10)* 3,600	(H=10)* 3,300				28,700
10	37,700					37,700	(H=8) 34,000	(H=10)* 4,000					38,000
11	26,100					26,100	(H=10) 20,000	(H=10) 6,000	(H=10)* 2,000				28,000
12	46,800					46,800	(H=9) 37,800	(H=10) 5,500	(H=10)* 4,500				47,800

Note ; * : means control amount

TABLE 6 FINANCIAL COST FOR MASTER PLAN

Unit : 1,000 US$

Item	Sediment Disaster Prevention Works			Flood Disaster Prevention Works									(Sediment+Flood) Disaster Prevention Works		
				Cubatao			Koji			(Cubatao + Koji)					
	F/C	L/C	TOTAL	F/C	L/C	TOTAL	F/C	L/C	TOTAL	F/C	L/C	TOTAL	F/C	L/C	TOTAL
I Preparatory Work (5-15% of II)	2,879	3,102	5,980	695	520	1,215	378	283	661	1,073	803	1,876	3,952	3,904	7,856
II Construction Cost	19,191	20,678	39,869	13,899	10,394	24,293	7,563	5,658	13,221	21,462	16,052	37,514	40,653	36,730	77,383
III Compensation Cost		188	188		180	180		248	248		428	428		616	616
IV Administration Cost (5% of I + II)		2,292	2,292		1,275	1,275		694	694		1,969	1,969		4,262	4,262
V Engineering Service (10% of I + II)	3,668	917	4,585	2,041	510	2,551	1,111	278	1,388	3,151	788	3,939	6,819	1,705	8,524
VI Physical Contingency (15% of I+II+III+IV+V)	3,861	4,077	7,937	2,495	1,932	4,427	1,358	1,074	2,432	3,853	3,006	6,859	7,714	7,083	14,796
VII Price Contigentcy (F/C 3%, L/C 3%)	6,901	7,289	14,190	5,242	4,058	9,300	2,299	1,801	4,100	7,541	5,859	13,400	14,442	13,148	27,590
Total	36,499	38,543	75,042	24,372	18,869	43,241	12,708	10,036	22,744	37,080	28,905	65,985	73,579	67,448	141,027

TABLE 7 WORK QUANTITIES FOR SEDIMENT RUN-OFF DISASTER PREVENTION WORKS

Unit : m3

Dam No.	Item	Dam	Channel	Groundsill	Total
2-1	V	22,000	(530 m)	1,200	23,200
	Ve	35,200	70,800	15,700	121,700
3-1	V	9,800	(490 m)	200	10,200
	Ve	8,500	31,200	100	39,800
7-1	V	3,600	(250 m)	1,000	4,600
	Ve	10,300	39,400	10,500	60,200
7-3	V	3,800	(0 m)	-	3,800
	Ve	2,400	-	-	2,400
7-4	V	2,000	(0 m)	-	2,000
	Ve	1,200	-	-	1,200
Sub-total	V	9,400	(250 m)	1,000	10,400
	Ve	13,900	39,400	10,500	63,800
8-1	V	3,700	(440 m)	400	4,100
	Ve	6,400	23,200	4,000	33,600
10-1	V	1,100	(0 m)	-	1,100
	Ve	600	-	-	600
11-1	V	7,300	(410 m)	1,100	8,400
	Ve	4,400	12,300	15,700	32,400
12-1	V	4,900	(750 m)	900	5,800
	Ve	3,900	64,000	19,000	86,900
Total	V	58,200	(2,870 m)	4,800	63,000
	Ve	72,900	240,900	65,000	378,800

Note : V ; volume of structure
Ve ; excavation volume

TABLE 8 WORK QUANTITIES FOR FLOOD DISASTER PREVENTION WORKS

Item		Unit	Quantity
(1)	Dike (L=9.3km)		
	1) Gravel metalling	m3	6,600
	2) Excavation	m3	329,000
	3) Dredging	m3	141,000
	4) Embankment	m3	255,000
	5) Sod Facing	m2	111,600
(2)	Revetment (L=1.45km)		
	1) Wet stone masonry	m2	9,800
	2) Concrete block	m3	170
	3) Berm concrete	m3	120
	4) Gabion	m3	2,900
(3)	Culvert (6 Sites)		
	1) Excavation	m3	2,300
	2) Concrete	m3	550
	3) Reinforcement bar	ton	30
	4) Form	m2	960
	5) RC pile	m	136
	6) Gate	ton	8
(4)	Intake Weir (1 Site)		
	1) Excavation	m3	2,000
	2) Concrete	m3	270
	3) Wet stone masonry	m2	460
	4) Concrete block	m3	840
(5)	Parapet wall (1 Site)		
	1) Excavation	m3	680
	2) Concrete	m3	310
	3) Reinforcement bar	ton	25
	4) Form	m2	870
(6)	Road Bridge (1 Site)		
	1) Embankment	m3	5,100
	2) Super structure (Steel)	ton	74
	3) Sub structure (Concrete)	m3	350
	4) Steel pile	m	450
(7)	Railway Bridge (1 Site)		
	1) Embankment	m3	5,240
	2) Ballast	m3	550
	3) Super structure (Steel)	ton	270
	4) Sub structure (Concrete)	m3	440
	5) Steel pile	m	620

TABLE 9 FINANCIAL COST FOR PRIORITY PROJECT

Unit : 1,000 US$

Item	Sediment Disaster Prevention Works			Flood Disaster Prevention Works Moji River			(Sediment+Flood) Disaster Prevention Works		
	F/C	L/C	TOTAL	F/C	L/C	TOTAL	F/C	L/C	TOTAL
I Preparatory Work (5-15% of II)	1,039	1,177	2,216	198	156	354	1,237	1,333	2,570
II Construction Cost	6,926	7,846	14,772	3,959	3,125	7,084	10,885	10,971	21,856
III Compensation Cost		62	62		180	180		242	242
IV Administration Cost (5% of I + II)		849	849		372	372		1,221	1,221
V Engineering Service (10% of I + II)	1,359	340	1,699	595	149	744	1,954	489	2,443
VI Physical Contingency (15% of I+II+III+IV+V)	1,399	1,541	2,940	713	597	1,310	2,111	2,138	4,250
VII Price Contigentcy (F/C 3%, L/C 3%)	1,490	1,642	3,133	760	637	1,396	2,250	2,279	4,529
Total	12,213	13,457	25,670	6,224	5,216	11,440	18,437	18,673	37,111

FIGURES

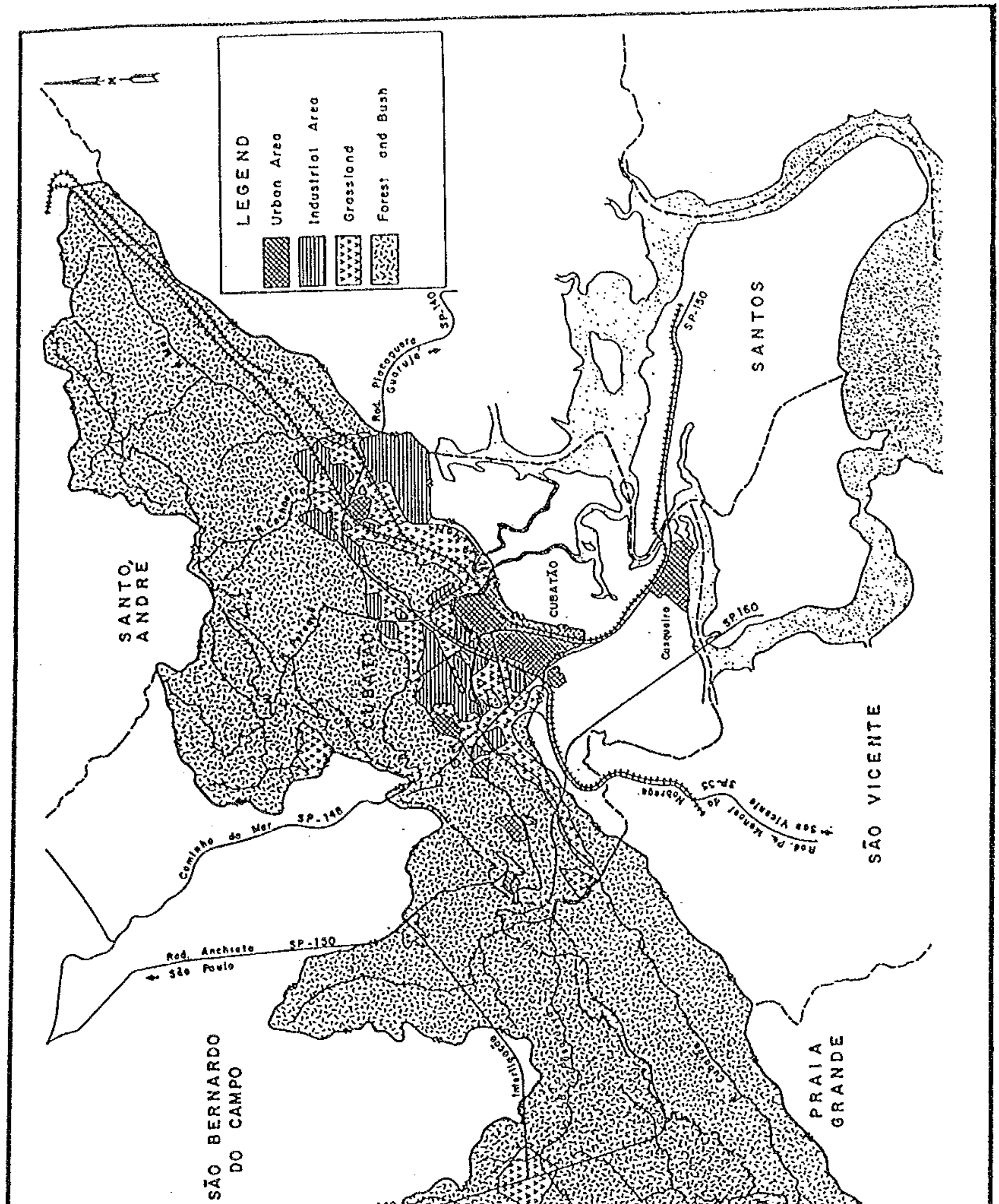


FIG. 1

PRESENT LAND USE MAP IN STUDY AREA : 1990

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

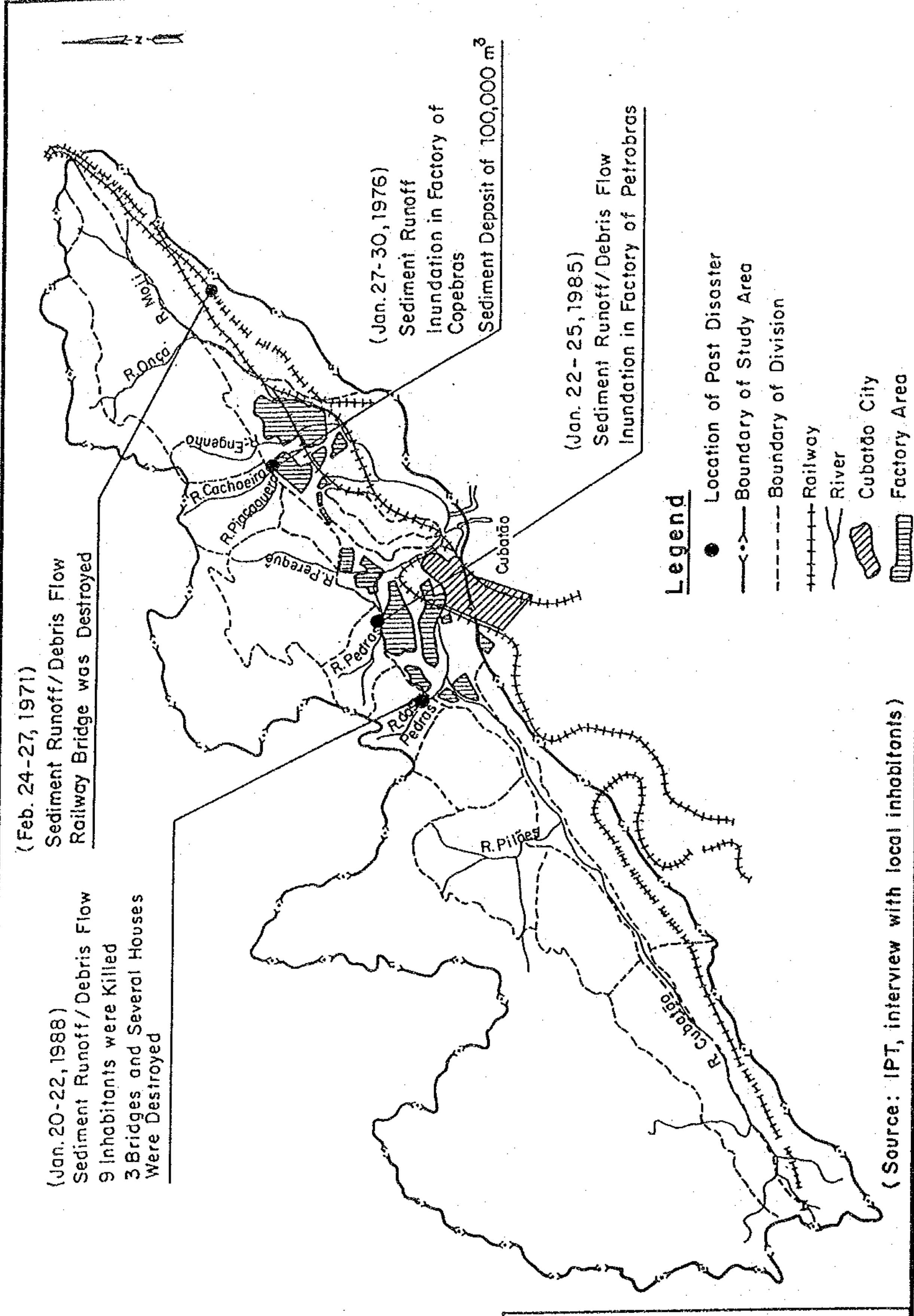


FIG. 2

LOCATION MAP OF PAST MAJOR DISASTERS

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

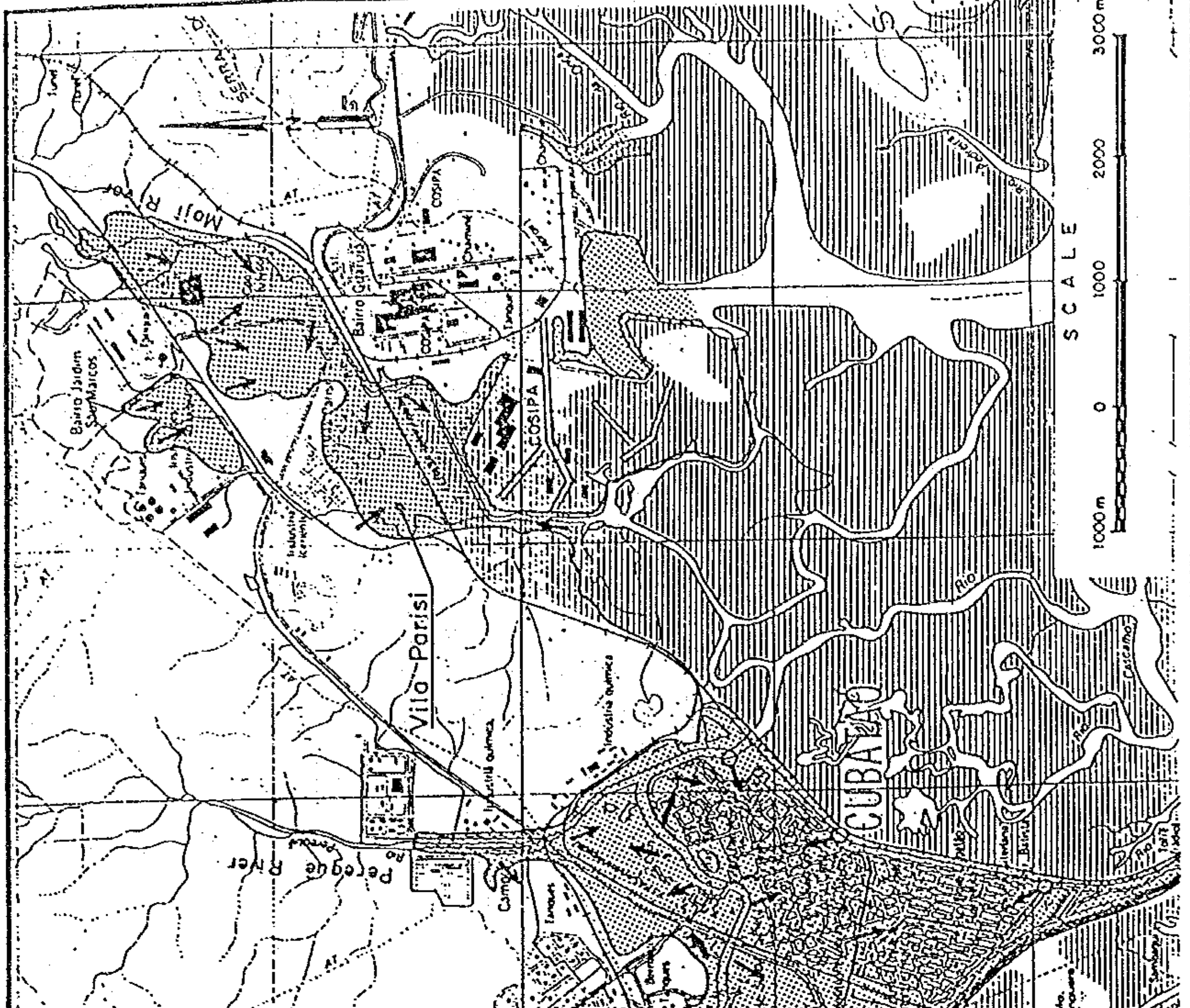


FIG. 3

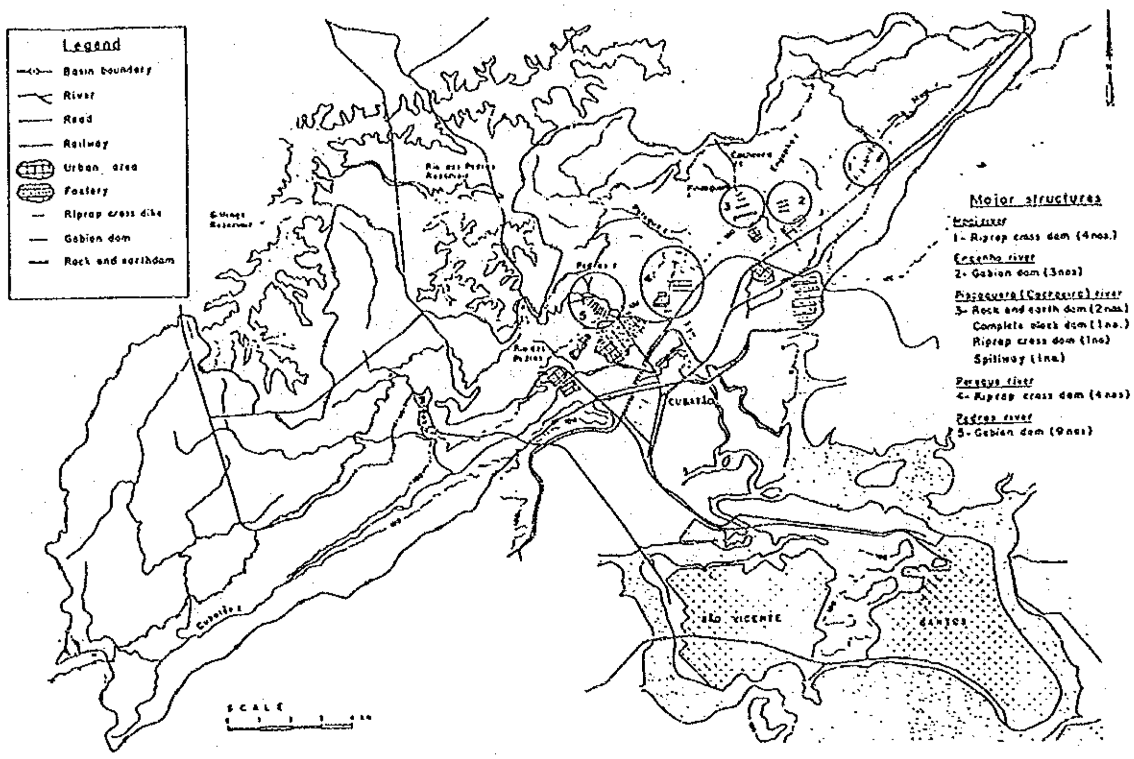
LOCATION MAP OF FLOOD PRONE AREA

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

Sediment Runoff Control



Flood Control

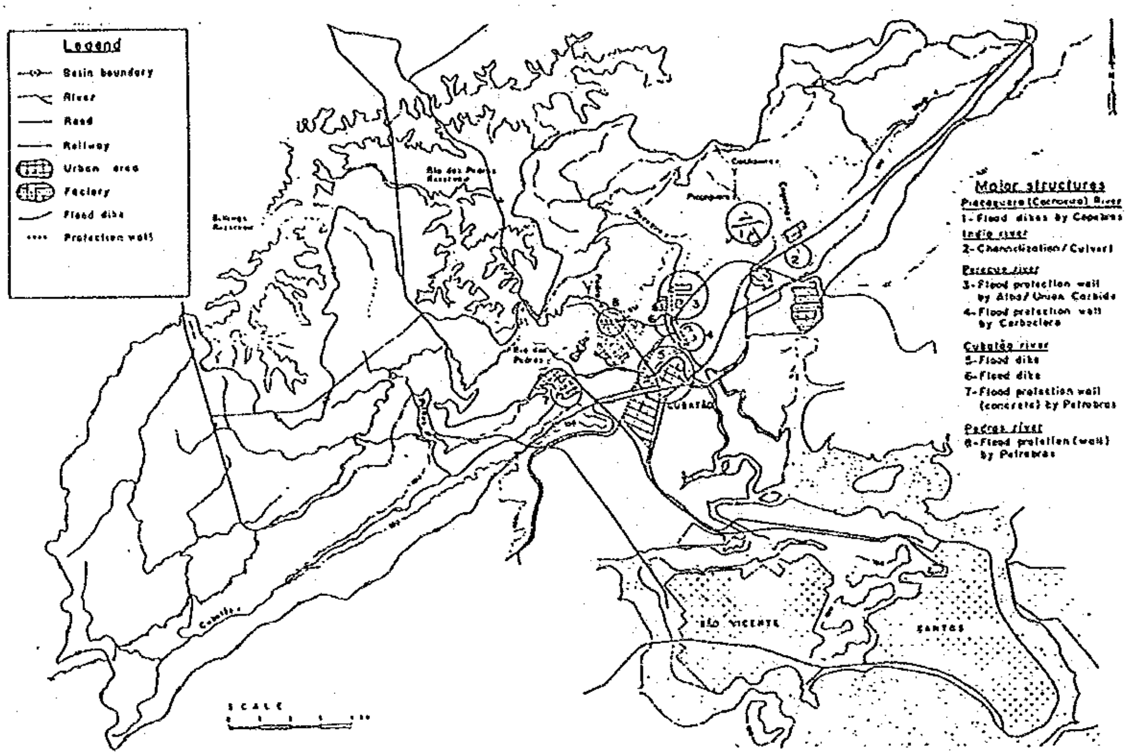


FIG. 4

LOCATIONS OF EXISTING DISASTER PREVENTION WORKS FOR SEDIMENT RUN-OFF AND FLOOD CONTROL

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

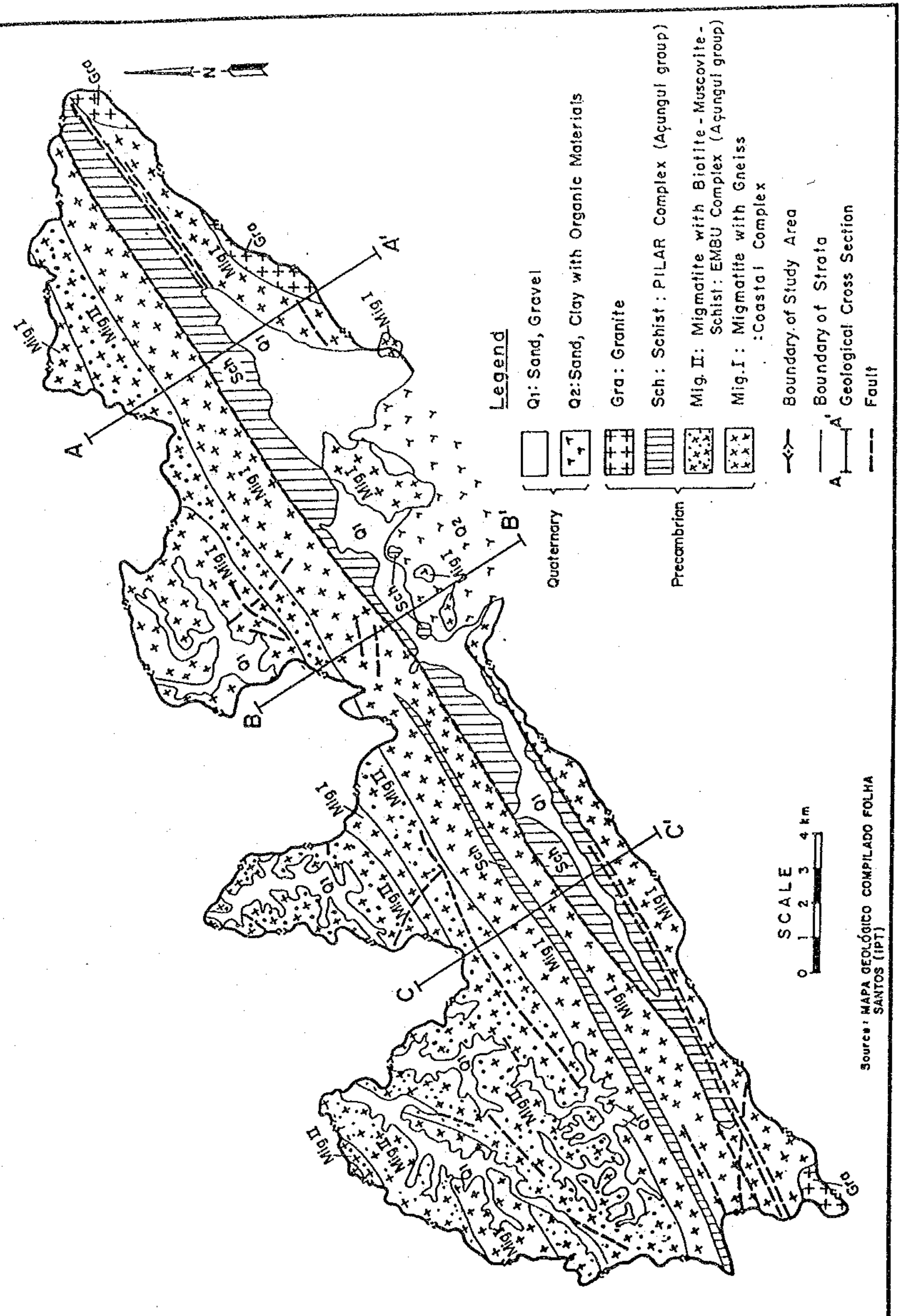


FIG. 5

GEOLOGICAL MAP OF THE STUDY AREA

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

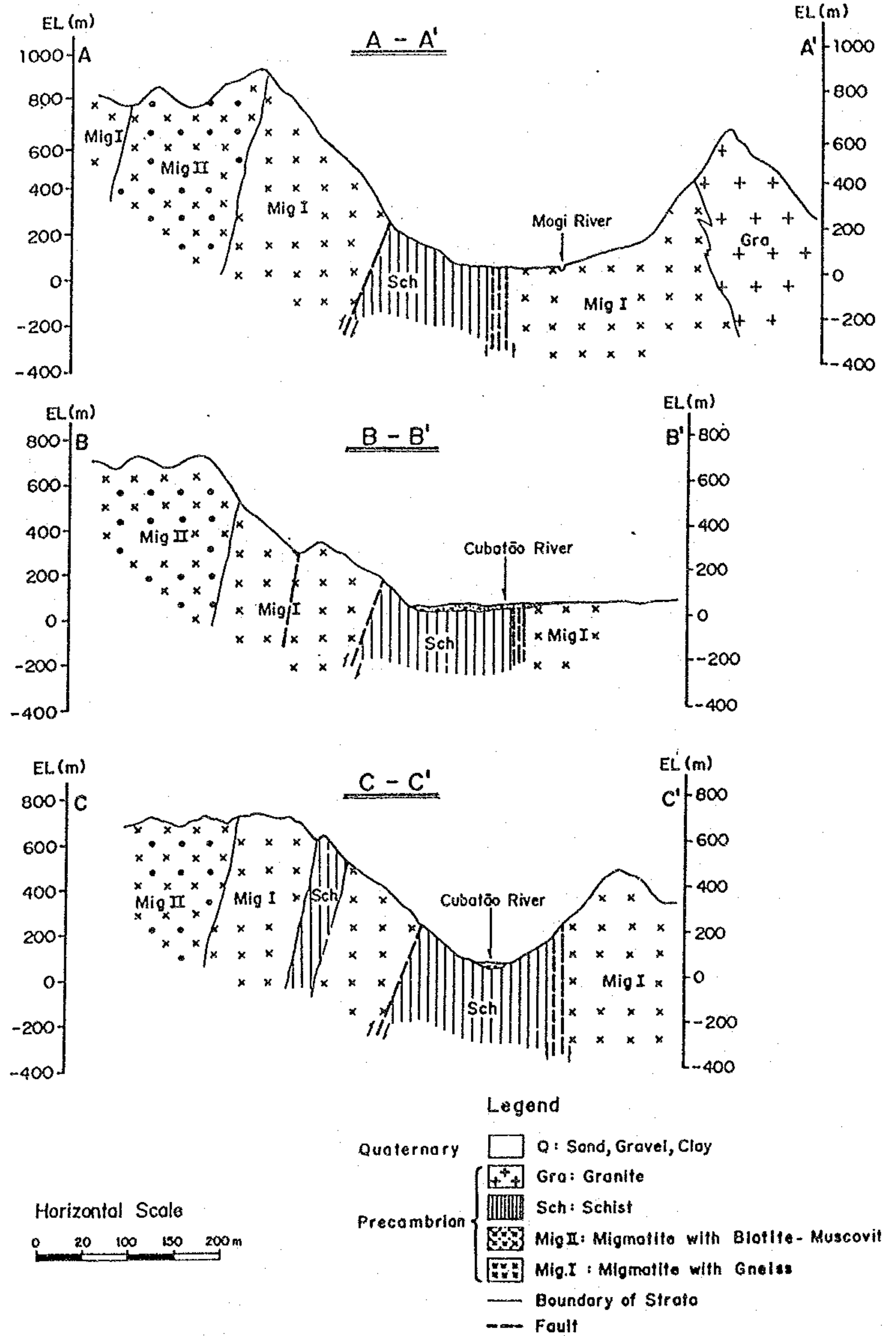


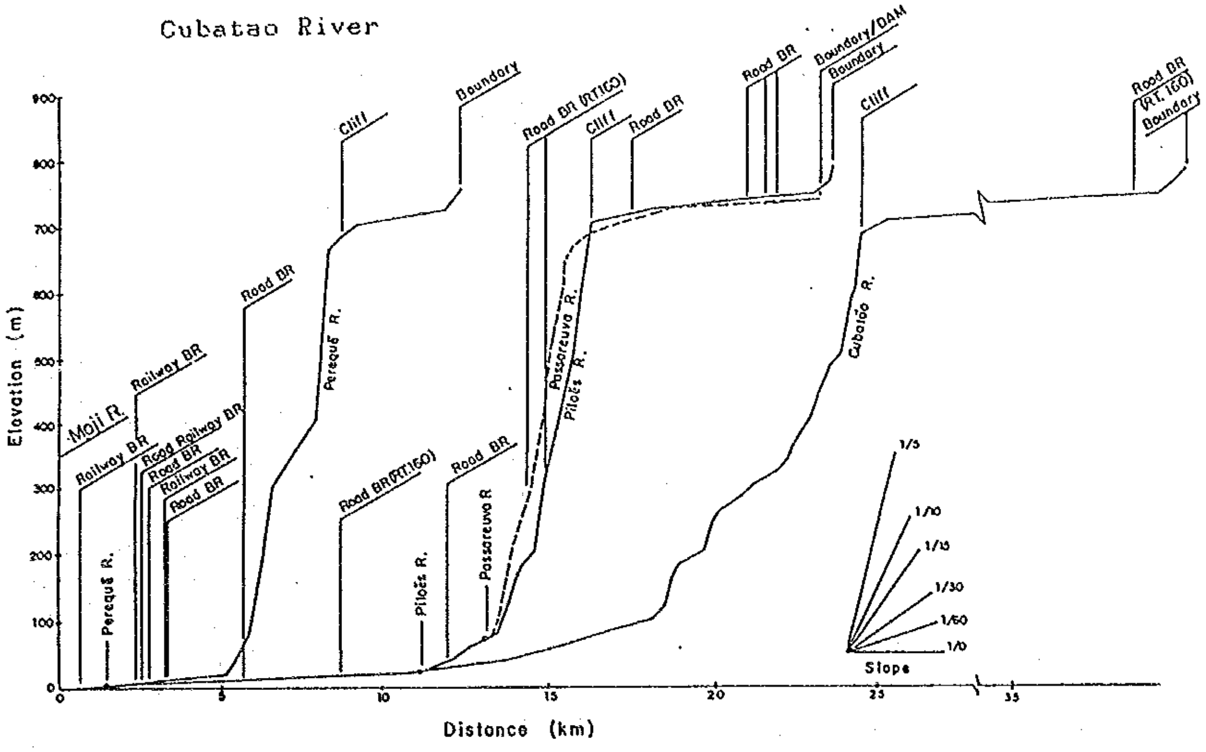
FIG. 6

GEOLOGICAL PROFILES OF THE STUDY AREA

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY



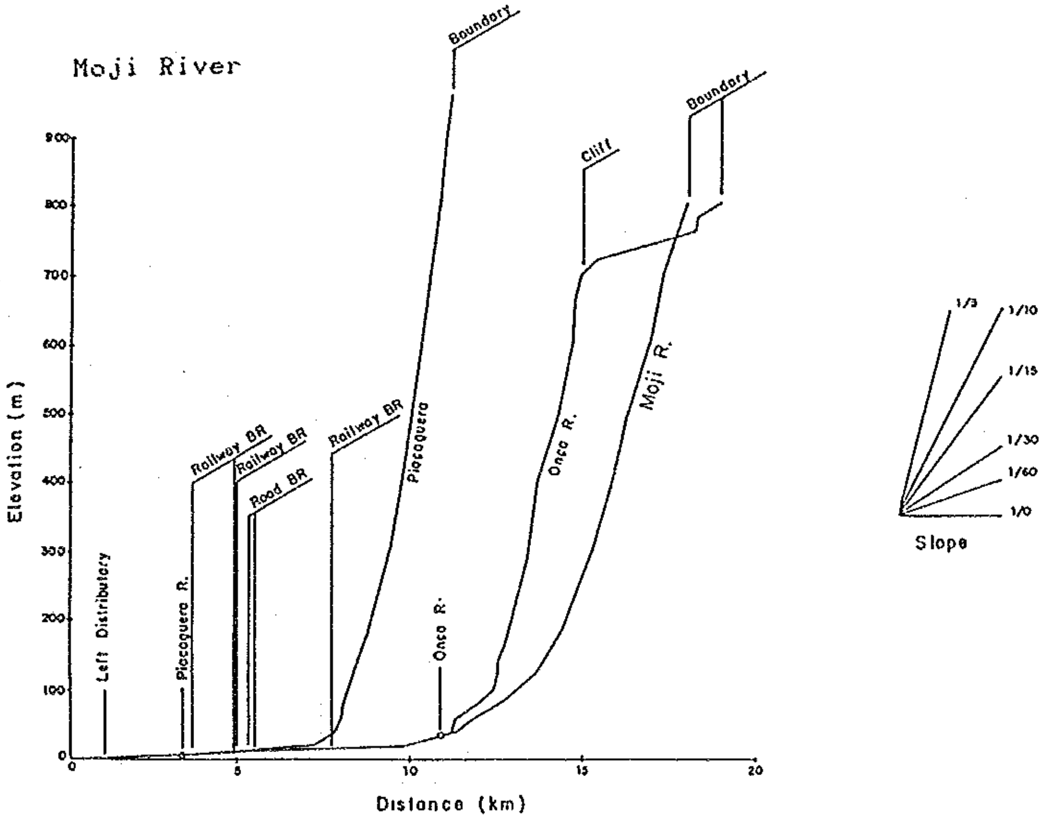
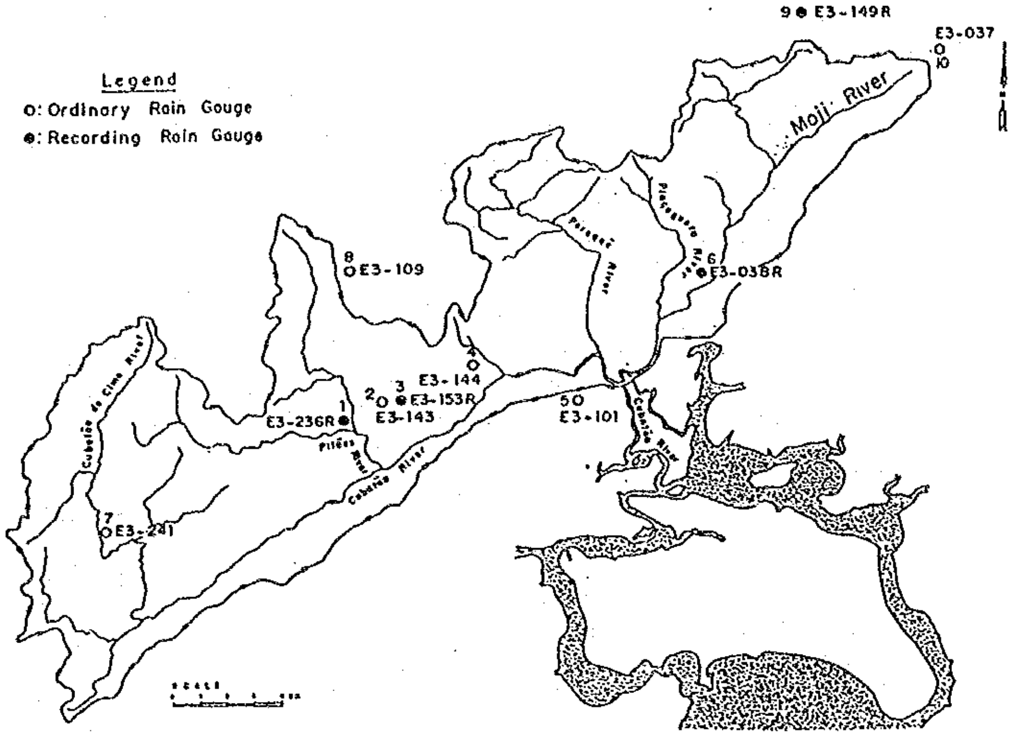


FIG. 7
LONGITUDINAL PROFILES OF CUBATÃO AND MOJI RIVERS

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO
JAPAN INTERNATIONAL COOPERATION AGENCY



AVAILABILITY OF RAINFALL RECORDS

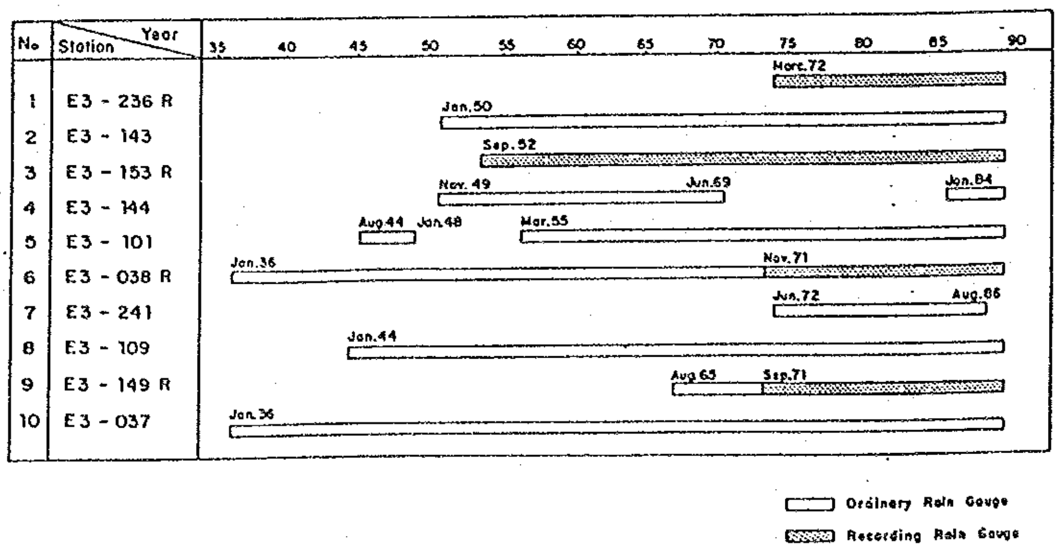


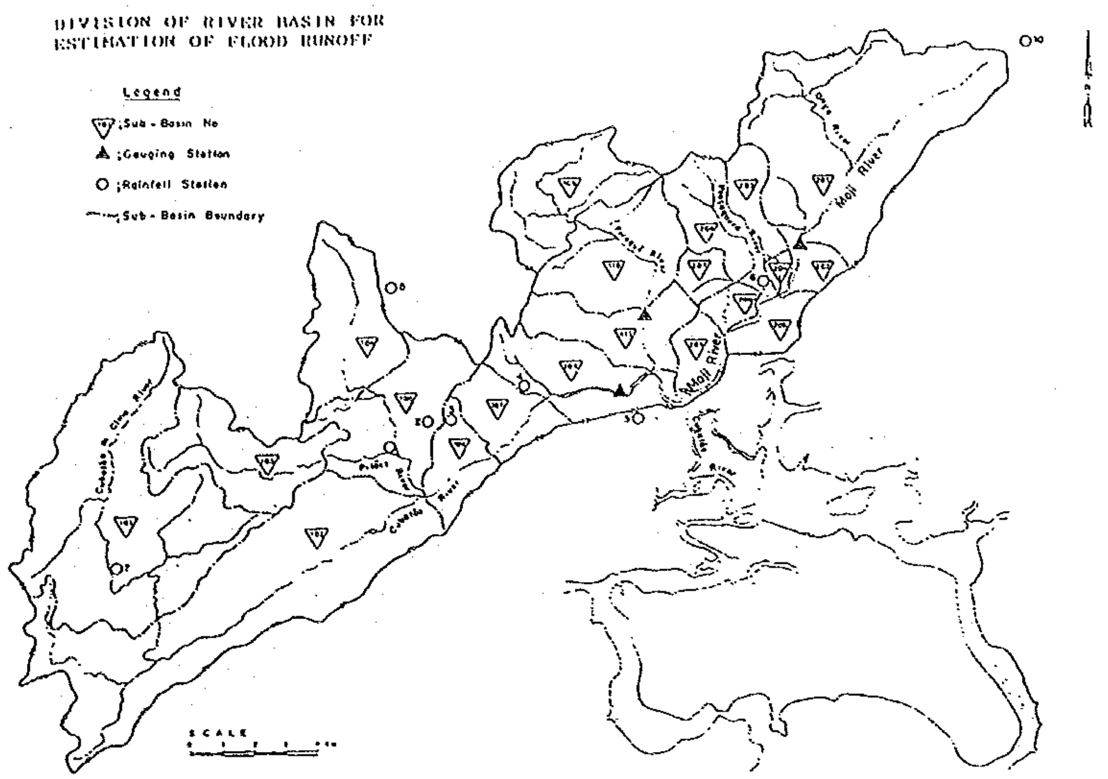
FIG. 8

LOCATION MAP OF RAINFALL STATIONS AND THEIR RECORD AVAILABILITY

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY



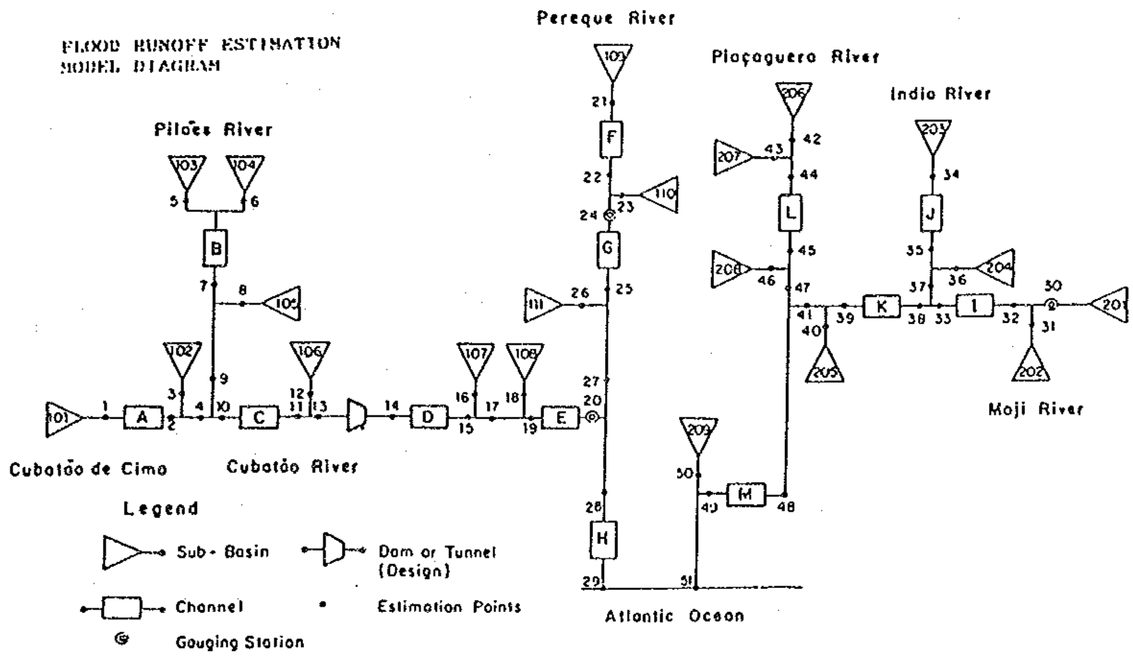


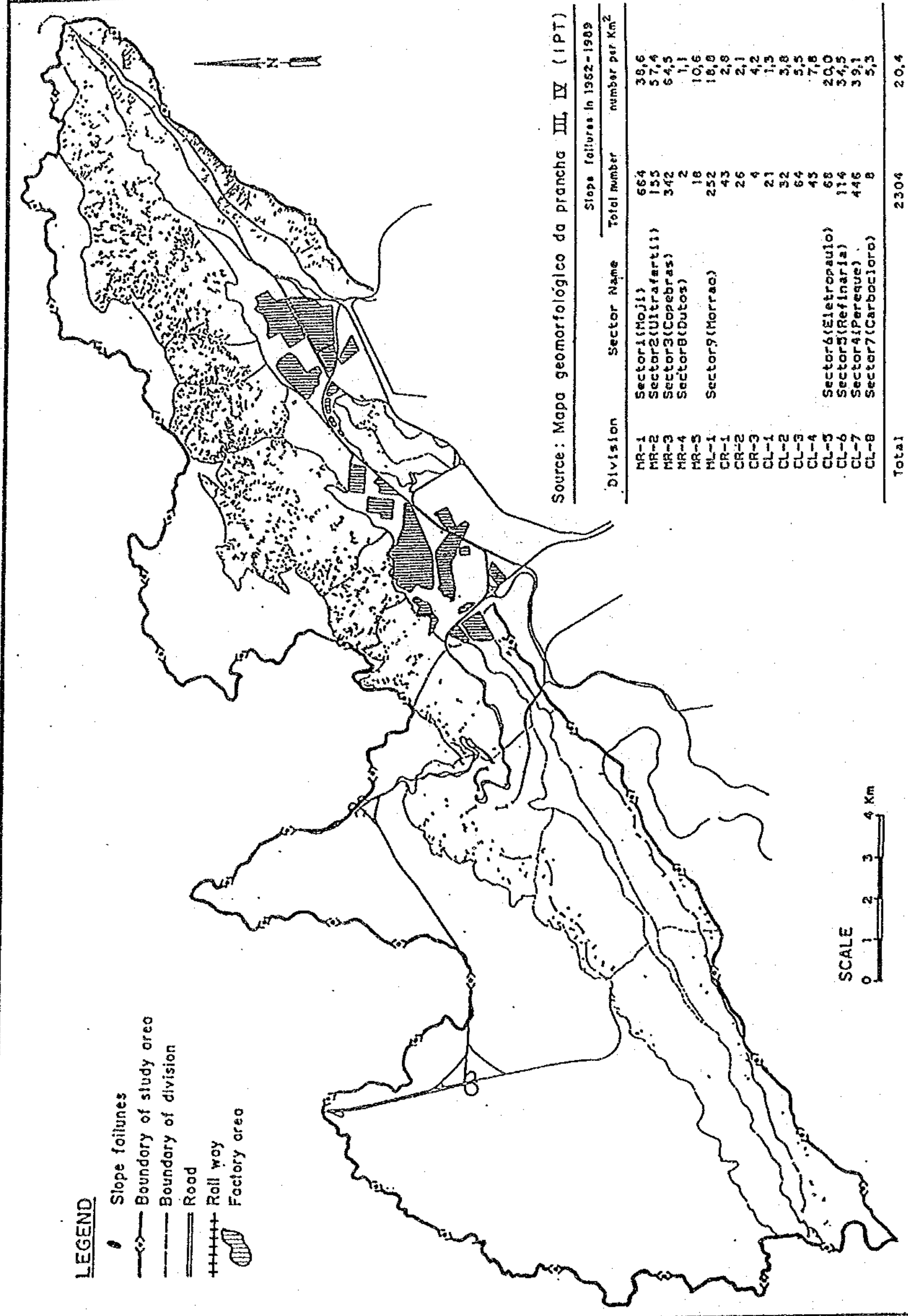
FIG. 9

DIVISION OF RIVER BASIN FOR ESTIMATION OF FLOOD RUN-OFF

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY



Source: Mapa geomorfológico da prancha III, IV (IPT)

Division	Sector Name	Slope failures in 1962-1989 Total number	number per Km^2
MR-1	Sector1(Moji)	664	38,6
MR-2	Sector2(Ultrafertil)	155	57,4
MR-3	Sector3(Copebras)	342	64,5
MR-4	Sector8(Dutos)	2	1,1
MR-5		18	10,6
ML-1	Sector9(Morrao)	252	18,0
CR-1		43	2,8
CR-2		26	2,1
CR-3		4	4,2
CL-1		21	1,3
CL-2		32	3,8
CL-3		64	5,5
CL-4		45	7,8
CL-5	Sector6(Eletropaulo)	68	20,0
CL-6	Sector5(Refinaria)	114	34,5
CL-7	Sector4(Pereque)	446	39,1
CL-8	Sector7(Carbocloro)	8	5,3
Total		2304	20,4

FIG.10

DISTRIBUTION MAP OF TOTAL SLOPE FAILURES OF 1962-1989

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

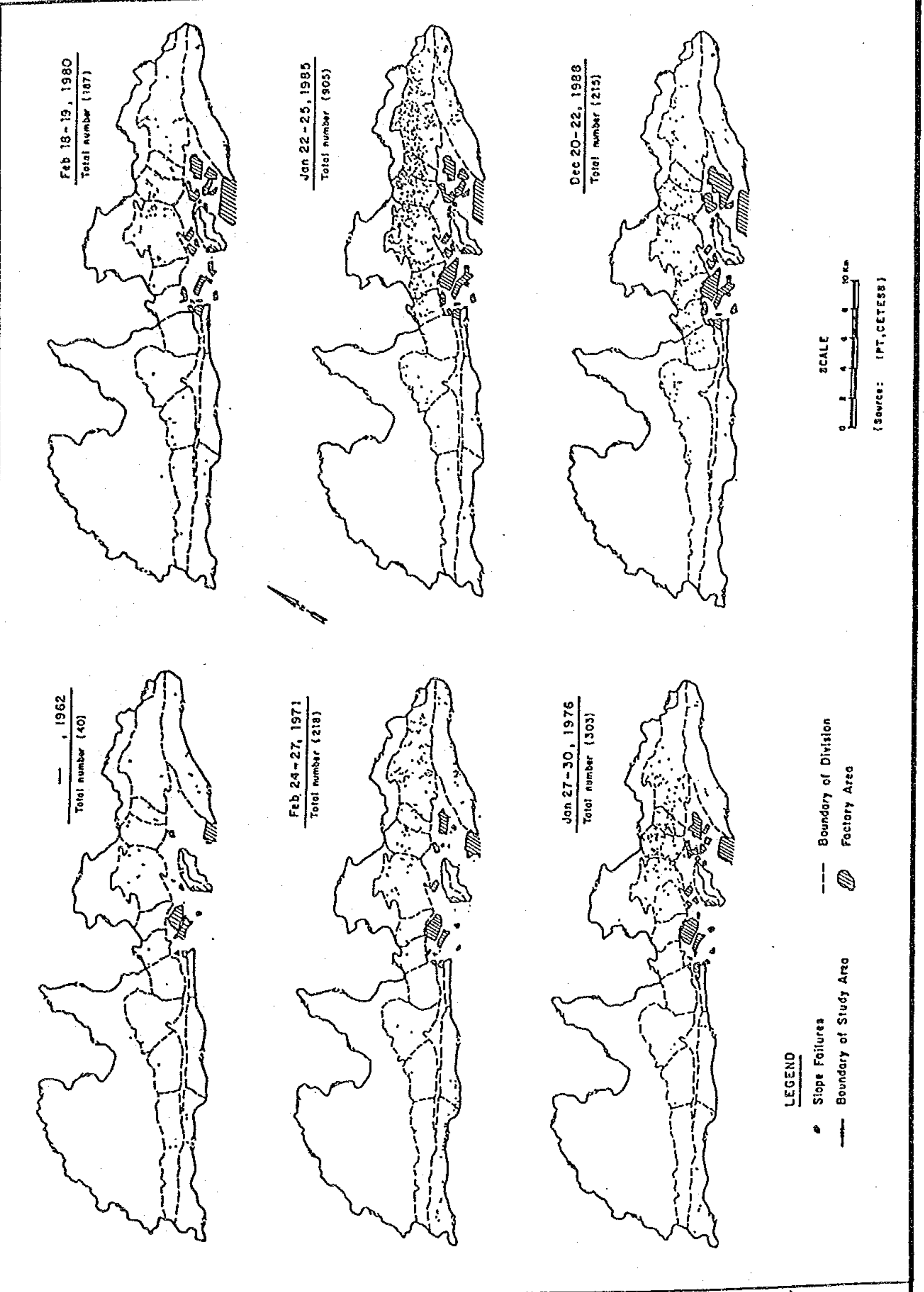


FIG.11

DISTRIBUTION MAP OF INDIVIDUAL PAST MAJOR SLOPE FAILURES

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

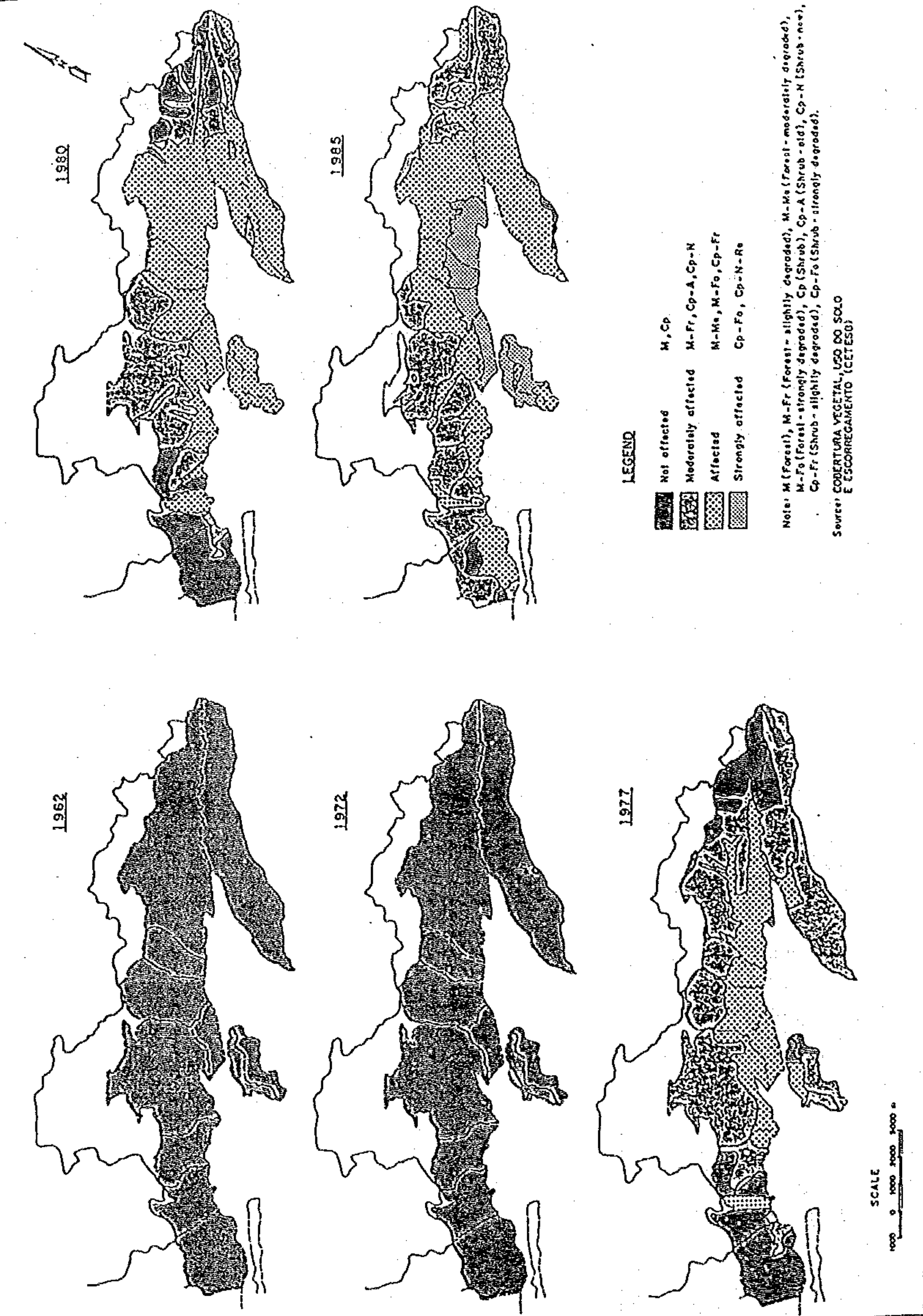


FIG.12

MAP OF VEGETATION CHANGE BY AIR POLLUTION IN 1962-1985

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

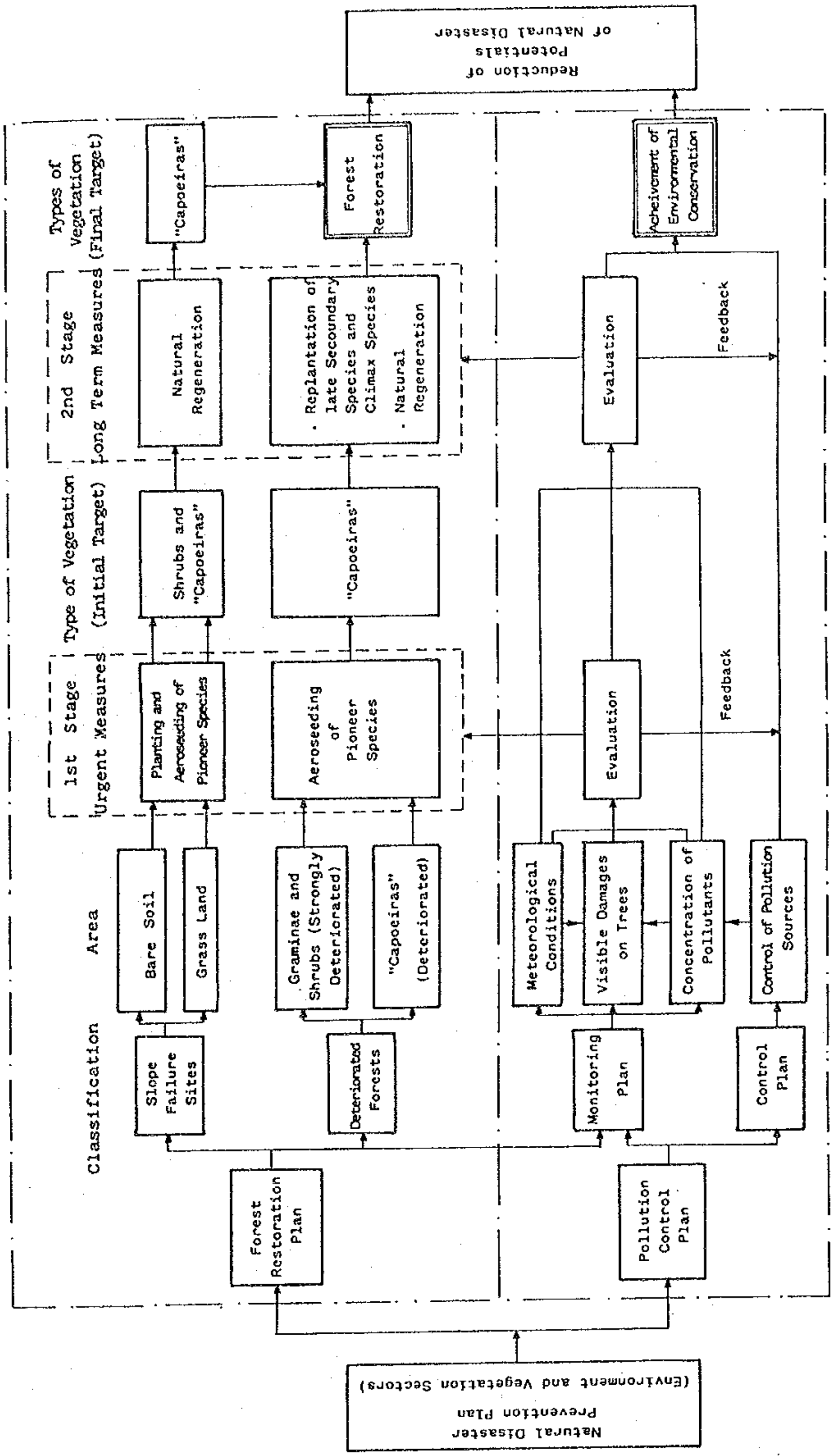


FIG.13

THE OUTLINE OF FOREST RESTORATION PLAN FOR CUBATÃO REGION

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

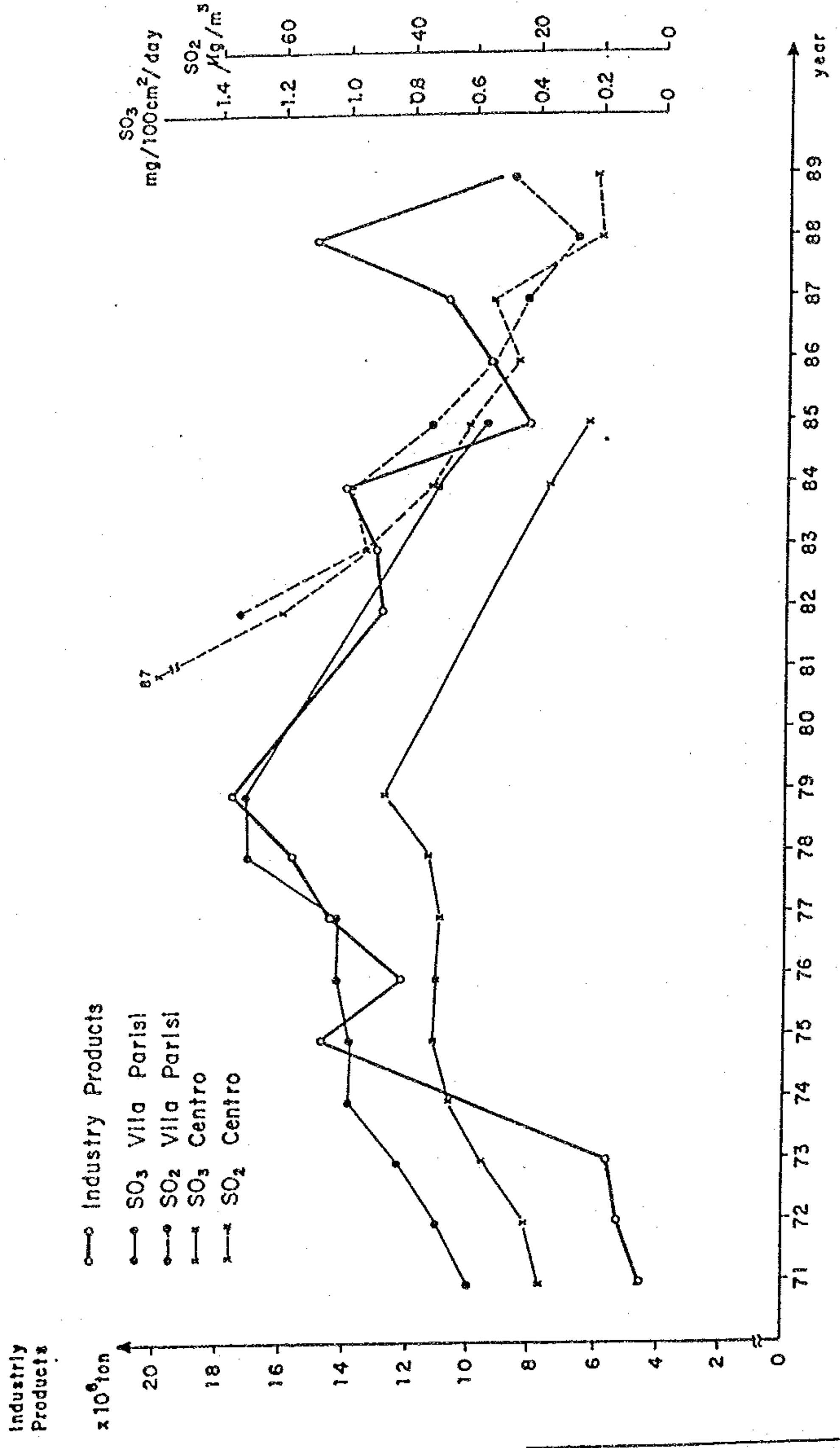


FIG.14

ANNUAL CHANGE OF INDUSTRY PRODUCTS AND SO_2/SO_3 CONCENTRATION

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

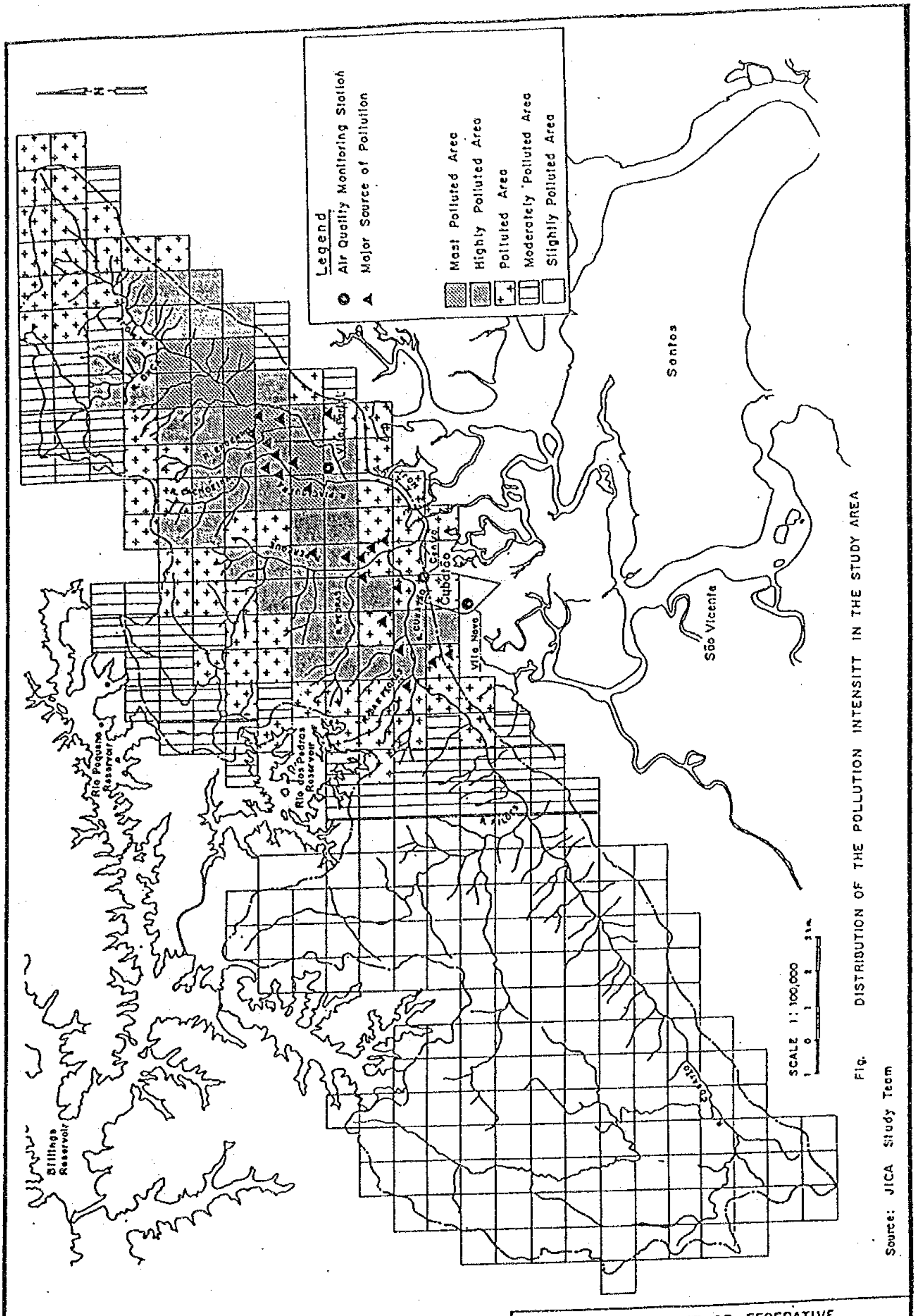


FIG.15

DISTRIBUTION OF AIR POLLUTION INTENSITY AREA

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

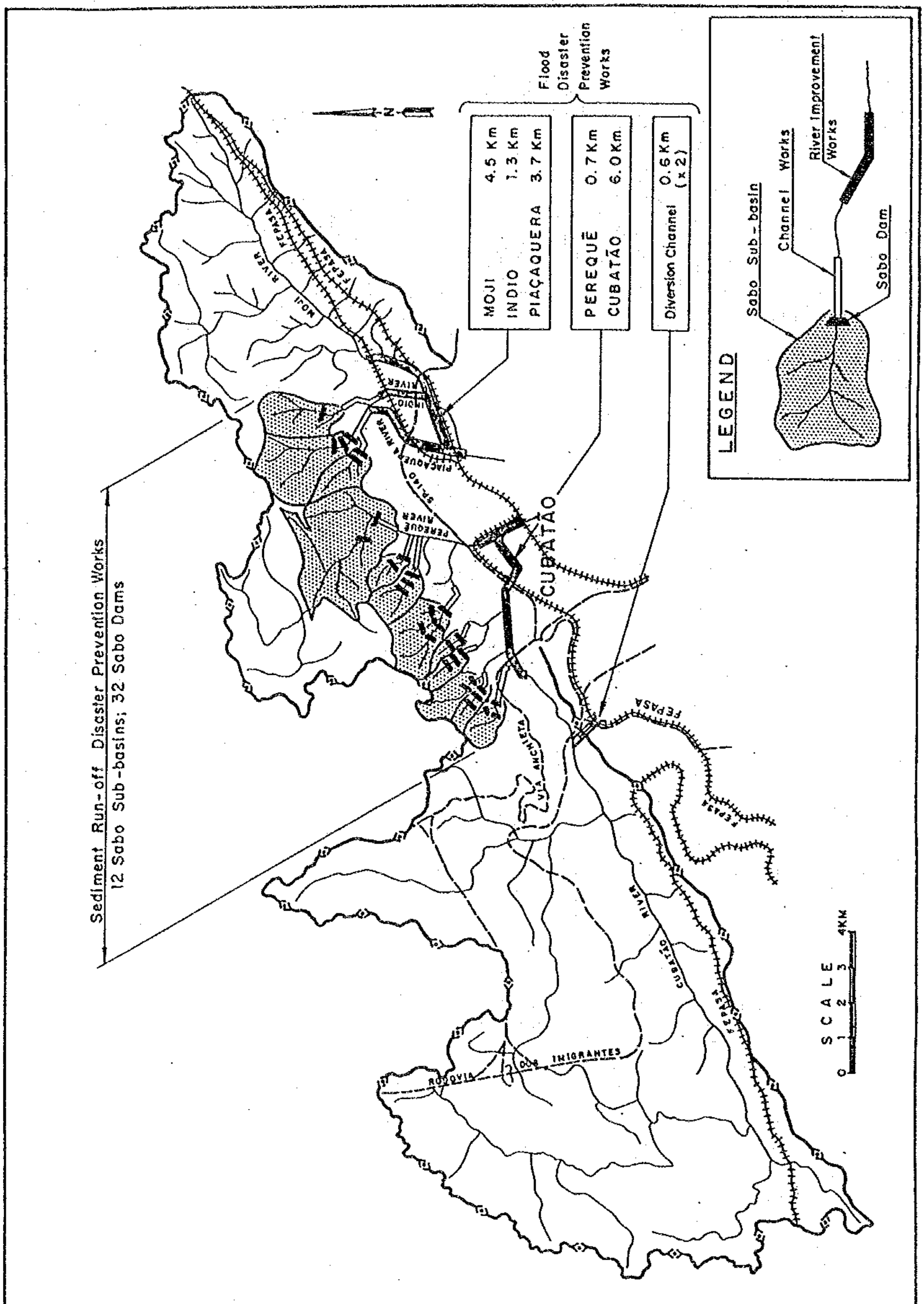


FIG.16

OUTLINE OF THE MASTER PLAN

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

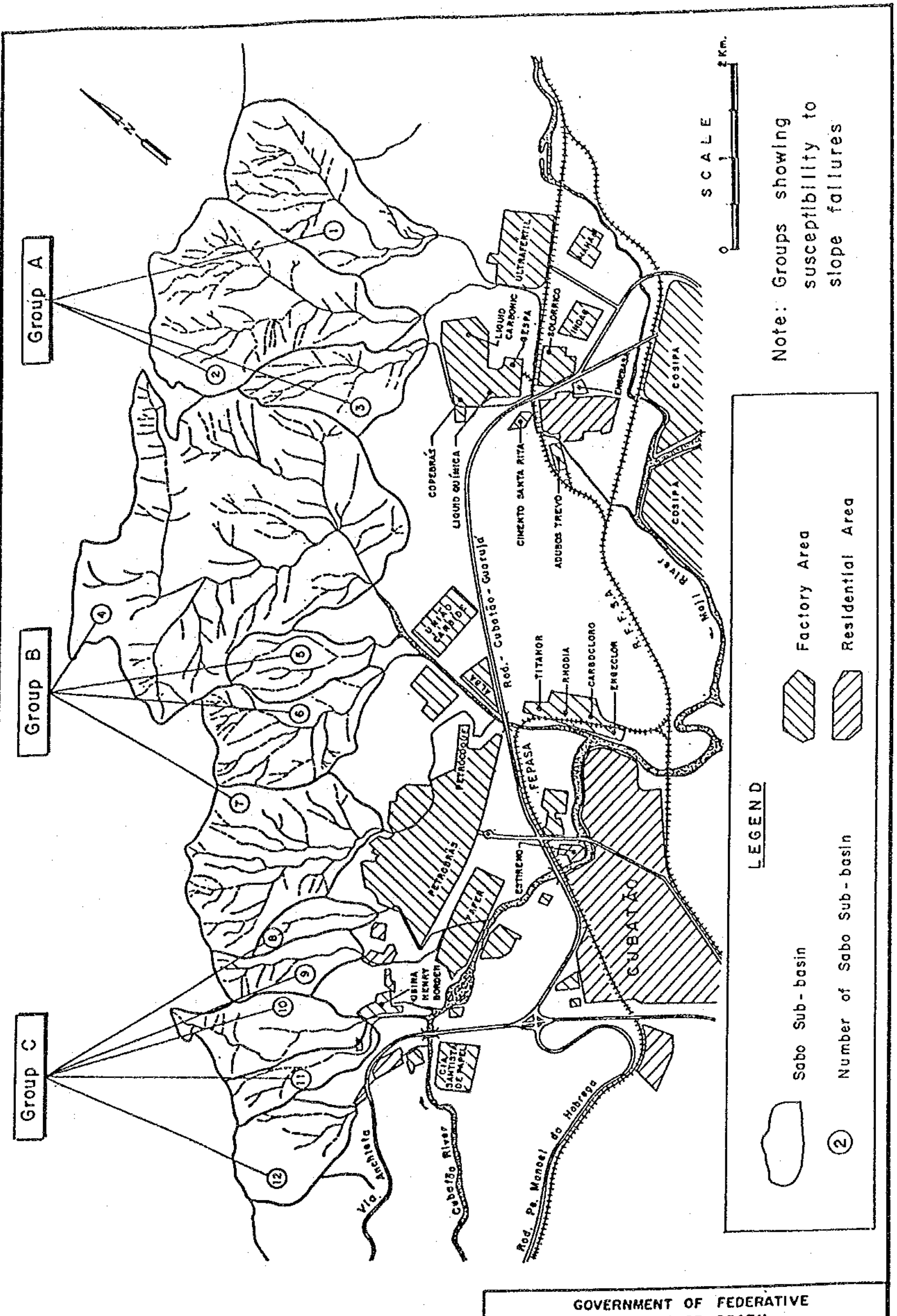


FIG.17

LOCATION MAP OF SABO SUB-BASINS OF PROTECTION AREA

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

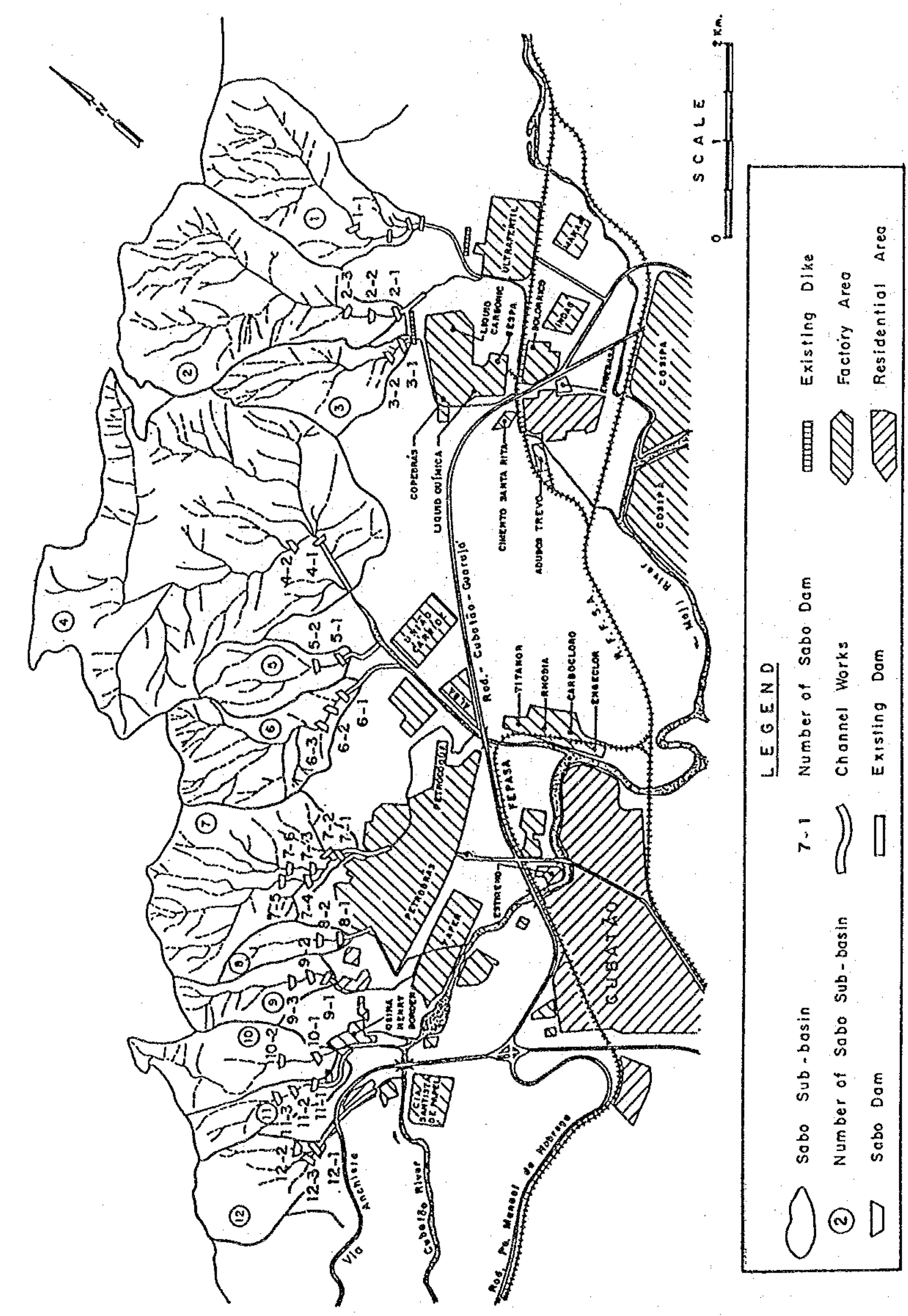


FIG.18

STRUCTURAL LAYOUT OF SEDIMENT RUN-OFF PREVENTION PLAN IN MASTER PLAN

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

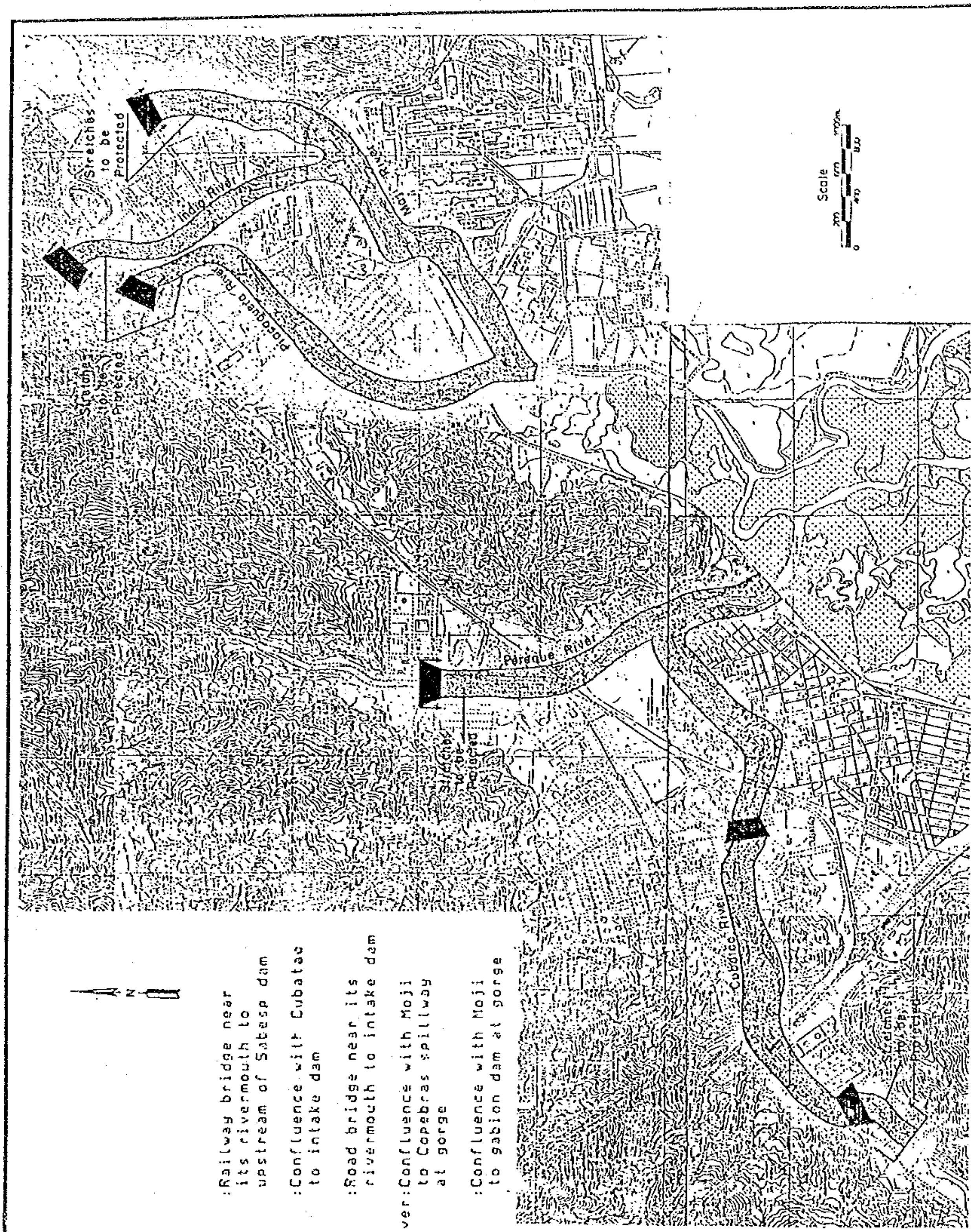


FIG.19

STRETCHES TO BE PROTECTED BY FLOOD CONTROL IN THE MASTER PLAN

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY