CHAPTER 1 OUTLINE OF THE STUDY

1.1 Background of the Study

The Patos and Mirim lakes in the southern region of the state of Rio Grande do Sul are suffering from water quality contamination and sedimentation due to the inflow of domestic and industrial wastewater from the basin, felling activities, and the excessive use of agro-chemicals for cultivation. The expansion of farmlands and encroaching domestic animals have also resulted in changes in vegetation and loss in bio-diversity in nearby wetlands.

The standard of living in the southern region (Mar de Dentro) of the state of Rio Grande do Sul is lower than the northern region (Guiaba River basin). The state is currently promoting the Mar de Dentro Program for the development of the southern region mainly through environmental conservation.

Given these conditions, the state of Rio Grande do Sul requested assistance from the Japanese government, through the Federal Government of Brazil, in June 1996 for the implementation of a study to formulate the master plan for the restoration and conservation of the Patos and Mirim lake environment. The scope of works (S/W) was agreed upon in July 1998.

1.2 Objectives and Contents of the Study

The objectives of the study are as shown hereunder.

(1) To formulate a water quality control plan that underscores strengthened water quality monitoring activities and wetland conservation for the Patos and Mirim lake areas.

(2) To transfer technology to the Brazilian counterparts during the study.

The studies to attain objective (1) were largely divided into three categories as shown below.

(1) Studies to understand the present deteriorating environmental conditions in lakes and wetlands.

(2) Studies to understand the pollution sources, generation load and runoff load in the basin.

(3) Studies for the formulation of countermeasures to prevent environmental deterioration in water areas and wetlands.

To attain objective (2), 2 workshops, 2 seminars, and counterpart training (2 persons) were carried out.

1.3 Study Area

Patos and Mirim lakes basin used in this report indicates that the area including the Guaiba river basin and Mar de Dentro area as shown in **Fig. 1-1**. The study covers this Patos and Mirim lakes basin which is approximately 150,000km^2. Because of the IDB financed Pro Guaiba Program in the Guiaba River basin, which is in the northern half of the Patos lake basin, only pollution load analysis based on available data was carried out therein. The study, therefore, mainly covered the Mar de Dentro area (approximately 66,000km^2), which makes up the southern half of Patos Lake basin.

1.4 Implementation of the Study

This study was jointly carried out by the JICA study team and the Brazilian counterpart agency. The JICA assigned a study team of 13 experts for the implementation of the study. The state of Rio Grande do Sul organized a counterpart agency made up of a total of 20 representatives from some sectors of the RS state government, municipality, university, and NGO, but mostly from the SCP.

1.5 Study Schedule

This study commenced in October 1998 and was completed by September 2000. The study involved 4 field surveys in Brazil and 3 periods of work in Japan.

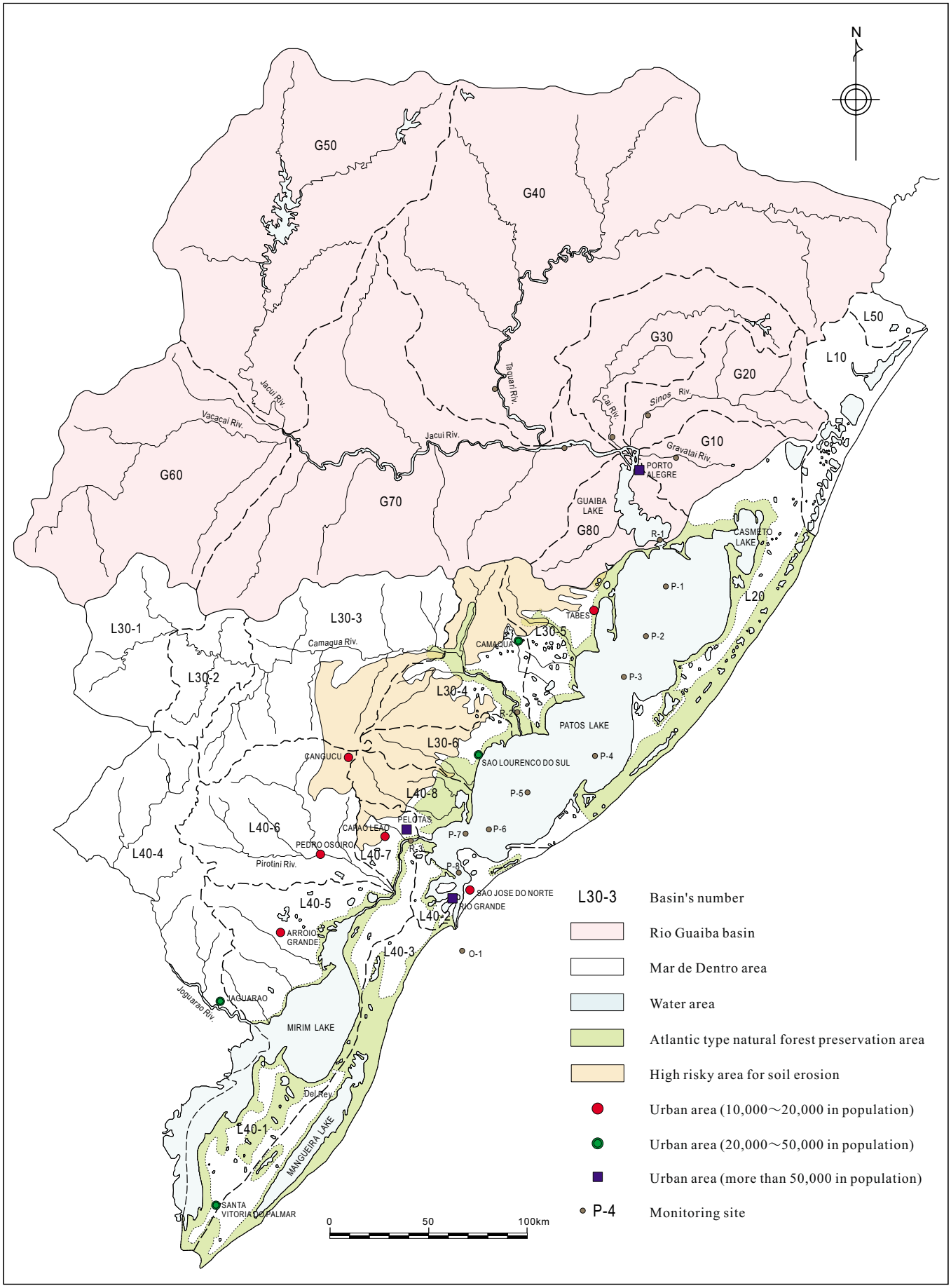


Fig.1-1 Hydrographic Basin of Patos and Mirim Lakes

CHAPTER 2 PRESENT ENVIRONMENTAL CONDITIONS IN THE STUDY AREA

2.1 Population and Industry in the Mar de Dentro Area

(1) The Mar de Dentro area has a population of approximately 1 million people and a population density of 18.7p/km^2. Pelotas and Rio Grande are the main cities and are located on the southern part on the ridge of Patos Lake. Combined, these two cities make up approximately 50% of the total population in the Mar de Dentro area.

(2) There are about 3,000 factories in the Mar de Dentro area and 90% are small in scale with less than 100 employees. Large scale factories manufacturing chemical products, fertilizers and minerals, as well as metallurgical products are located in Rio Grande.

(3) Agriculture and livestock raising are the main industries in the Mar de Dentro area. The cultivated area totals 800,000ha and is planted with rice, wheat, corn, beans and tobacco. Rice paddies total 300,000ha and are distributed around the Patos and Mirim lakes. 35 to 40% of the study area is used for the pasturage of about 6 million domestic animals—6 times the study area human population.

2.2 Present Utilization of Patos and Mirim Lakes and Water Resources

(1) The Patos and Mirim lakes are largely used to irrigate surrounding rice paddies. Rio Grande exploits Mirim Lake for water supply. The Sao Goncalo canal located at the downstream section of the lake is targeted for future development as a water supply source for Pelotas.

(2) Tapes, Arambare, San Lourenco do Sul, and Laranjal are on the west coast of Patos Lake and are designated as swimming areas. These areas are hardly in use in recent years, however, due to urban wastewater contamination.

(3) The southern water section of Patos Lake is brackish and therefore rich in marine fish and shellfish, e.g. shrimps. About 10,000 of the residents of the 4 villages along the lake's ridge are engaged in small scale artisan type fishery. Due to

deterioration in water quality, however, the catch has declined to 1/5 in the past 20 years.

(4) Patos Lake is used to navigate between Porto Alegre and Rio Grande. Although the nautical route measures 350km, it is narrow and shallow, compelling large ships to load and unload their freights at Rio Grande. For maintenance purposes, dredging is carried out every year. There also used to be a nautical route in Mirim Lake that linked Santa Vitoria do Palmar and Pelotas. The route was closed, however, because the water depth decreased.

2.3 Environmental Deterioration in the Patos and Mirim Lakes

The deteriorating environmental conditions in the Patos and Mirim lake areas are summarized in **Table 2-1**, based on the results of the water quality and hydrological monitoring activities in Patos Lake and available data.

(1) The level of coliform, an indicator of contamination by human excreta (bacteria), in Patos Lake was observed at 10 to 1,000MPN/100ml offshore, even more than 10km from the lake coast. The survey conducted by FEPAM in December 1999 and January 2000 detected the highest fecal coliform level (13,000MPN/100ml) in Laranjal. Incidentally, the safety standard set by CONAMA No. 20 for fecal coliform levels in swimming areas is less than 250MPN/100ml (excellent), less than 500MPN/100ml (good) and less than 1,000MPN/100ml (satisfactory) respectively.

(2) TP, an indicator of eutrophication, was observed in summer at 0.1 to 0.15mg/l at the northern section of Patos Lake and 0.05 to 0.1mg/l at the southern section. On the other hand, values all year-round at the central section was less than 0.05mg/ℓ. According to Vollenweider (1984), over 0.035mg/l of TP and over 8μg/l of Chl-a (both mean annual values) indicate high probability of water bloom generation, a condition that hampers the use of the water area. Based on this observation, it is presumed that the degree of eutrophication in Patos Lake is extremely high.

(3) Although available data show that the thickness of sediments in Patos lake and the date of C^{14} indicate a mean sedimentation rate of 5mm/year from 8,000 years ago to 100 years ago, quantitative data relevant to the present inflow and sedimentation velocity do not exist. However, there is no doubt that a considerable

Table2-1 Deterioration in the Water Quality and Wetland Ecosystem in the Mar de Dentro Area

Deterioration Level / Problems	Contamination Level in the Central Water Area of Patos Lake			Water Areas With Significant Pollutant Inflow & Sedimentation	Required Countermeasures
	Northern Area (P-1, P-2, P-3)	Central Area (P-4, P-5)	Southern Area (P-6, P-7, P-8)		
Contamination by Human Excreta (Contamination by Bacteria)	Coliform: log1~3MPN/100ml	Coliform: <log 1 MPN/100ml	Coliform: log 1~3 MPN/100ml	East Coast of Guaiba Lake Beaches of Laranjal, Tapes, and Sao Lourenco do Sul	Treatment of domestic wastewater in municipalities near the lake shore (construction of sewage treatment plant)
Eutrophication	Eutrophic	Mesotrophic	Mesotrophic	Guaiba Lake Northern Area of Patos Lake Southern Area of Patos Lake	Countermeasures for non-point sources (entire Patos Lake Basin including Guaiba river basin) Treatment of domestic wastewater
Soil Runoff/Sedimentation	Clay silt ~ silt Distribute widely	Sand ~ clay (northern half area) Sand ~ clay silt (southern half area)	Sand distributes except in the ship route.	Guaiba Lake Lower Reaches of Rio Camaqua Mirim Lake	Countermeasures for non-point sources (entire Patos Lake Basin including Guaiba river basin)
Contamination by Organic Substances BOD COD (Mn)	Low 0.4 ~ 1.9mg/l 2.0 ~ 7.3mg/l	Low 0.5 ~ 1.4mg/l 2.2 ~ 10.4mg/l	Low 0.5 ~ 1.6mg/l 3.1 ~ 5.6mg/l	Guaiba Lake Saco deTapes Saco da Mangueira/RG Harbor	Improvement of water circulation Dredging of sludge
Contamination by Agricultural Chemicals	Levels of agricultural chemicals and their by-products in any water area are below the detectable limit. Organic chloride levels extracted from living organisms sampled from the 5 stations at the west coast of Patos Lake were lower than the detectable limit in almost all samples.			Unconfirmed	Unconfirmed
Contamination by Heavy Metals	Heavy metal concentration in any of the water areas is lower than the WHO standard. In sludge, however, Ni, Cu and Hg concentrations exceed environmental standard in the northern area.			Guaiba Lake Rio Camaqua Saco da Mangueira/RG Harbor	Unconfirmed
Contamination by Harmful Substances (CN, As, etc.)	CN levels in any of the water areas and the sludge were lower than the detectable limit. A small amount of As was detected in sludge extracted from the central area.			Unconfirmed	Unconfirmed
Saltwater Intrusion	None	Slight increase	Often	Southern area of Patos Lake	Changes in the form/structure of Rio Grande Channel
Wetland Ecosystem	Decrease in biodiversity	Decrease in biodiversity Decrease in wetland forest	Decrease in biodiversity Decrease in wetland forest		Removal of factors that cause deterioration (e.g. illegal drains) in areas adjacent to wetlands

amount of sand and soil continues to flow in and gets deposited in the area since a capital-intensive dredging work is carried out every year to maintain the nautical route between Porto Alegre and Rio Grande.

(4) BOD and COD (Cr), indicators of organic pollutants, were low in the entire Patos Lake. Available data and interpretation of satellite images, however, show that contamination by organic pollutants is progressing in some areas (Tapes Bay, Mangueira Bay) where the water does not circulate well enough.

(5) From the results of the monitoring activities, the level of agro-chemicals, heavy metals and other harmful substances was not significant enough to be a cause any worries. However, since the samples were very limited, a detailed survey that would also cover the generation source should be carried out in the near future.

(6) Sea water enters Patos Lake, and vice versa, through the Rio Grande channel. Depending on river discharge and wind conditions, saltwater backflows all the way to the central lake section. Although a detriment to the use of the lake water for paddy irrigation, saltwater backflow is a plus to fisheries as it brings in fish from the ocean and helps improve the lake's water quality. It also significantly affects wetland vegetation, fish ecosystem as well as the birds that inhabit the area.

(7) There used to be a lot of wetlands around Patos and Mirim lakes. But as these areas are being developed for farming and pasturage, and because of the illegal drainage, the number of wetlands and their coverage continue to decrease. In addition, the local ecosystem, mainly wetland ecosystem, is also significantly affected by the changes in vegetation, which results in loss in bio-diversity. Even with legislation enacted for their protection, the following are fast becoming extinct in the study area: 11 types of mammals, 6 types of birds, 6 types of reptiles, 20 fauna.

2.4 Generation and Runoff of Pollutants in the Patos Lake Basin

The Patos and Mirim Lakes basin defined in **1.3** is divided into 13 sub-basins by the RS state. Nine of the sub-basins (G10-G90) are situated within the Guaiba River basin, while the remaining 3, L20 (Litoral Medio), L30 (Camaqua), and L40 (Mirim-Sao Goncalo) are situated within the Mar de Dentro area. In this study, the Mar de Dentro area was further subdivided into a total of 16 sub-basins to facilitate survey activities

(see **Fig. 2-1**).

(1) Based on available data, the generation load in the entire Patos Lake area (excluding the section that falls in the Uruguay territory) is estimated at: 405,408 t/y for BOD, 1,510,511 t/y for COD (Cr), 122,989 t/y for TN, and 27,357 t/y for TP. The ratio between generation load from point sources and non-point sources is: 57:43 for BOD, 43:57 for COD (Cr), 37:63 for TN, and 25:75 for TP.

(2) The ratio between generation load from domestic and agricultural point sources is about 6:4.

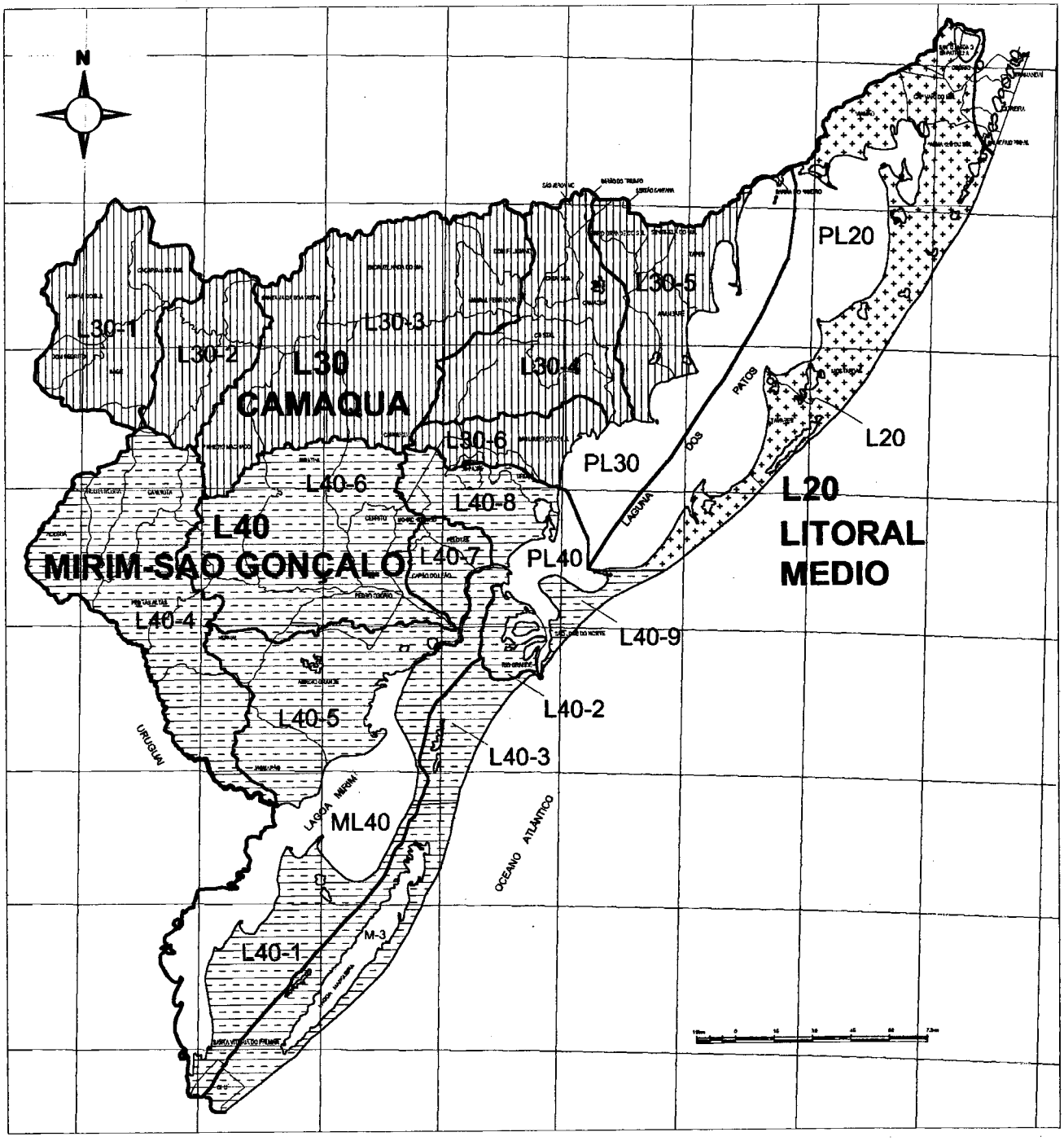
(3) Using the runoff load simulation model developed for this study, the runoff load in the entire Patos Lake (average of 1996 and 1997 values) was calculated as: 167,310 t/y for BOD, 1,493,506 t/y for COD (Cr), 106,988 t/y for TN, and 21,171 t/y for TP. The calculation estimates that 80% of the BOD, 82% of the COD (Cr), 83% of the TN, and 86% of the TP originate from non-point sources (see **Fig. 2-2**).

(4) The TP runoff load ratio by basin was calculated as: 55.5% from Guaiba River basin (G10 to G190), 14.5% from Camaqua River basin (L30-1 to L-30-4), 13.2% from the San Goncalo canal and Mirim Lake basin (L40-4 to L40-6), and 17.0% from other basins.

(5) The sub-basins within the Mar de Dentro area were categorized into slopes and plains, and the annual volume of soil erosion in these sections was calculated using the USLE method. In the slopes, soil erosion was estimated at an annual average of 22.8t/ha overall.

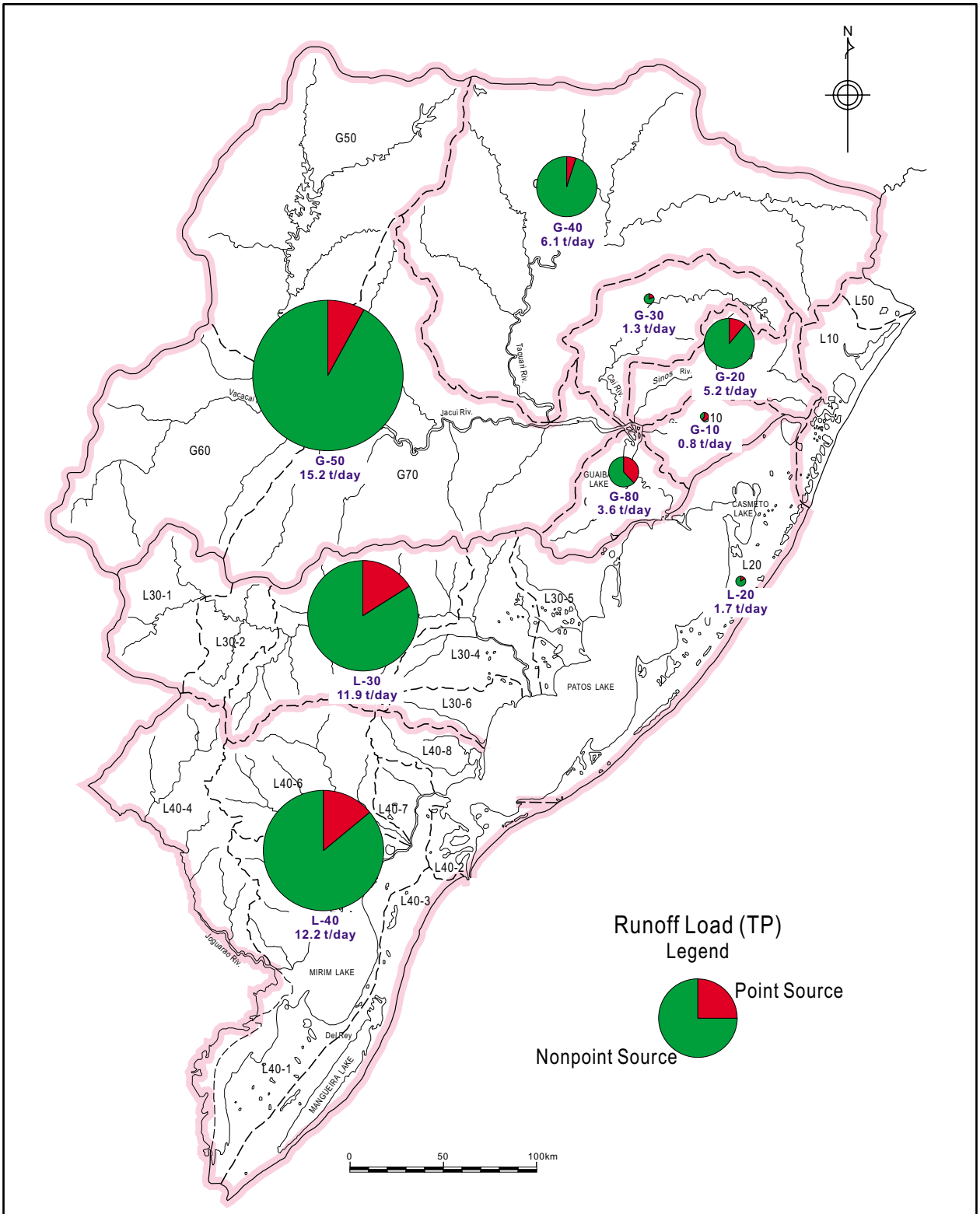
(6) The areas considered to be highly prone to soil erosion are the slopes of Sutil & Dulo river basins and the Cangucu area. Agricultural activities thrive in these areas where even forests are being cultivated (see **Fig. 2-3**). Combined, both areas make up 22% of the Mar de Dentro area (excluding the water area).

(7) Agro-chemicals are abundantly used in the study area for the cultivation of rice, soybeans, potatoes, onions, tobacco, peach, etc. The amount of agro-chemicals utilized (the total for pesticides, herbicides, germicides) was estimated at 1.28kg/ha (1990).



Source: JICA Study Team

THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES IN THE FEDERATIVE REPUBLIC OF BRAZIL	Fig. 2-1
JAPAN INTERNATIONAL COOPERATION AGENCY KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL	Hydrographic Sub-basins in the Study Area



THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES IN THE FEDERATIVE REPUBLIC OF BRAZIL

JAPAN INTERNATIONAL COOPERATION AGENCY
KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL

Fig. 2-2

Runoff Load from the Sub-basins