CHAPTER 2

PRESENT ENVIRONMENTAL CONDITIONS OF THE STUDY AREA

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2.1 Socio-economic Conditions

(1) The study area corresponds to the so-called Mar de Dentro area and encompasses a total of 50 municipalities; 32 of these municipalities fully belong to the area, while the remaining 18 only partly make up the study area (**Fig. 2.1-1**).

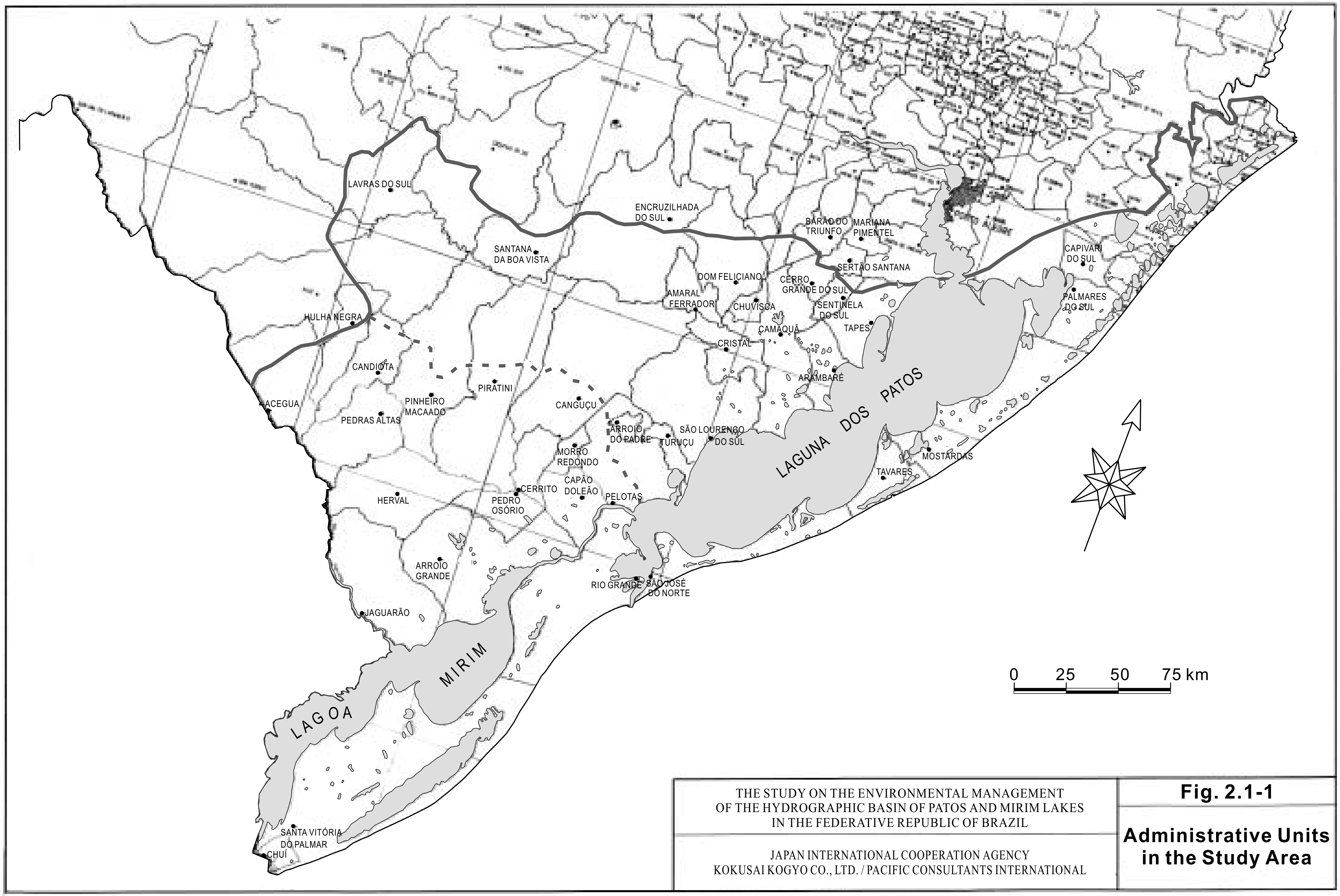
(2) The study area is populated by about 1 million inhabitants (urban population: 76%, rural population: 24%). At 18.7 persons/km^2, the average population density is considerably lower than that of the state (33 persons/km^2).

(3) The main cities, Pelotas and Rio Grande, are located on the southern shore of Patos Lake and their combined urban population is approximately 50% of the urban population in the study area. In recent years, migration into these cities by rural residents has significantly increased, compounding both cities' problems in public sanitation and safety.

(4) There are 3,000 factories within the study area, 80% of which are concentrated in Rio Grande and Pelotas. Though 90% of those factories are small in scale with only less than 100 employees, there are large scale factories engaged in the manufacture of chemicals, fertilizers, minerals and in metallurgy in Rio Grande.

(5) Agriculture in the study area is characterized by rice cultivation. The study area contributes to 20% of the nation's rice production. Aside from rice, crops such as wheat, corn, and soybeans are also cultivated in the study area. Irrigation is mainly applied to rice cultivation; other crops depend on rainwater.

(6) Cultivated lands in the study area total 800,000ha, approximately 300,000ha of which is for rice cultivation. Areas for rice cultivation are found on: the east coast of Mirim Lake (116,000ha), west coast of Mirim Lake (60,000ha), east coast of Patos Lake (60,000ha), and west coast of Patos Lake (40,000ha). A 3 to 4 year crop rotation system is practiced, whereby lots used for paddy cultivation are either planted with crops or used for pasturage the following year. Most undulated sections are not cultivated or used for pasturage.



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. 2.1-1

Administrative Units in the Study Area

(7) Livestock farming (basically mixed livestock raising) has been a tradition in the study area, where about 6,000,000 heads of large animals are raised – this number corresponds to 6 times the study area population. Products (e.g. animal skin, meat, etc.) from livestock farming are used for food processing, tanning, shoe making, etc.

(8) In urban areas, an average of approximately 70% of the households are connected to sewage pipelines. However, only 14 municipalities (urban sections) have primary sewage treatment facilities, and only 2 have secondary sewage treatment facilities. The average water consumption in urban areas is estimated at about 130 liters/capita/day.

(9) Wastewater from households and livestock raising activities in the rural area mostly infiltrates the soil untreated. The average water consumption in rural areas is estimated at about 80 liters/capita/day.

(10) In 1999, the SCP of the State of Rio Grande do Sul publicly announced the implementation of “Programa Mar de Dentro”, a plan for the development of the study area. The plan basically aims to fully develop and utilize the characteristics and potential of the area, increase income and create jobs through environmental education and the development of ecologically oriented technologies, among others. The concrete measures to be adopted for the implementation of this program are under consideration.

(11) At present, Patos and Mirim lakes are mainly used to irrigate rice paddies. Although there are plans to use these lakes as future water supply sources of Pelotas and Rio Grande, nothing concrete has materialized.

(12) Small scale fishing is being carried out by approximately 10,000 fishermen residing in the four villages along Patos and Mirim lakes. The main fishing season is summer (from February to May) and shrimps are usually the main target. The fish catch is reportedly on the decrease.

(13) Patos Lake is used to navigate between Porto Alegre and Rio Grande. Although the nautical route measures 350km, it is very narrow and shallow in depth, compelling large ships to load and unload their freights at Rio Grande. An average of 500 ships/year pass through this lake. The nautical route between Santa Vitoria do Palmar and Pelotas, which was used until several years ago, has been abandoned since the water has become shallow by siltation.

2.2 Generation and Runoff Pollution Load

(1) Pollution sources are categorized herein as point and non-point sources. The former refers to households and industries, and the latter to pastures, forests, paddy field/pastures, uplands/pastures, wetlands, water surfaces, urban areas and beaches. The number of livestock raised in the study area is about 6 times the study area population, and most of these animals are put out to graze. Accordingly, livestock farming (large animals) is categorized under pasture in this study, and hence considered a non-point source.

(2) The generation load per unit production from domestic wastewater was assumed to contain a BOD of 45g/cap/day based on the average discharge (150ℓ/day) and water quality (300mg/ℓ) in major cities in the study area estimated by CORSAN. Using the results of the actual survey at the sewage treatment plant in Rio Grande in summer (January), the contribution of other water quality parameters to the generation load per unit production is assumed as: 117g/cap/day for COD(Cr), 11.5g/cap/day for TN and 1.89g/cap/day for TP.

(3) The FEPAM/GTZ (1997) report on factories in the RS State contain information on industrial generation load per unit production. The total annual generation load from industrial wastewater in the entire Patos Lake basin was estimated to contain 90,000tons in BOD and 234,000tons in COD(Cr). Since there are no data on TN and TP values, the generation load per unit production data of Japanese livestock processing industries were referred to, to estimate the contribution of these parameters. The results show that TN and TP respectively contribute 1/10 and 1/100 of the COD(Cr) load to the generation load per unit production.

(4) Using the methods mentioned in (2) and (3), the BOD, COD (Cr), TN and TP in the annual generation load from the point sources in the Patos Lake basin were calculated as 232,086 tons, 653,578 tons, 45,849 tons and 6,864 tons, respectively. The ratio between domestic and industrial generation load is about 6:4.

(5) Since Brazil has no data on non-point source generation load, the unit values established in the USA, where land-use conditions are similar to Brazil, were multiplied by the area of land-use interpreted on the satellite images. The results led to the estimation that the non-point source annual generation load contains: 173,322 tons in BOD, 856,933 tons in COD (Cr), 77,699 tons in TN and 20,494 tons in TP.

(6) The total generation load from point sources and non-point sources in the entire Patos Lake basin was estimated to contain 405,408 tons in BOD, 1,510,511 tons in COD (Cr), 123,548 tons in TN and 27,357 tons in TP. The ratio between point source and non-point source generation load is 57:43 for BOD, 43:57 for COD (Cr), 37:63 for TN and 25:75 for TP.

(7) The method to estimate the annual runoff load from a basin was developed using available flow and water quality data on the major tributaries of Guaiba River, and with given precipitation and evaporation values. The calculation process is as shown below (see **Fig. 2.2-1)**.

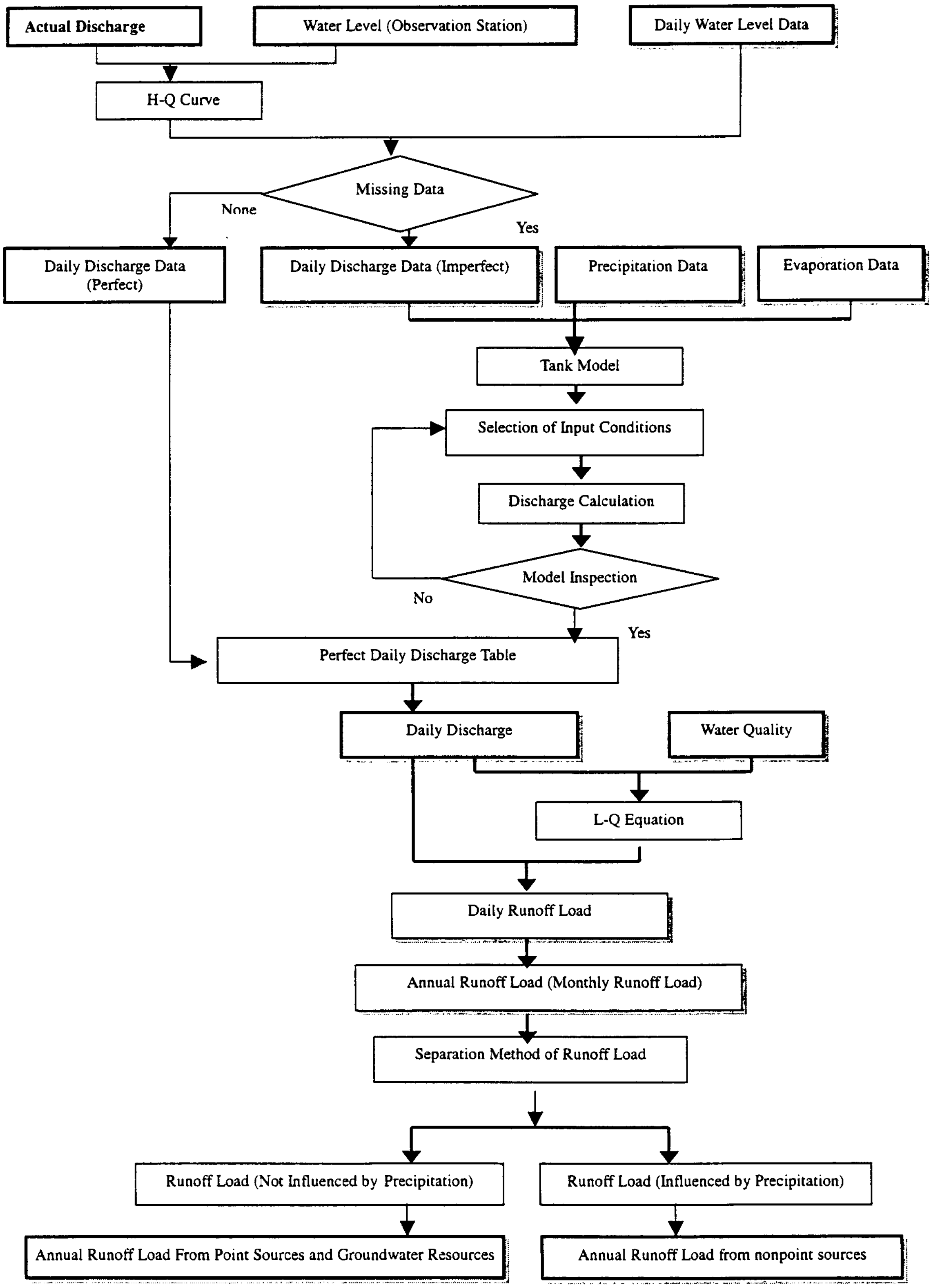
① A tank model was used for rivers more or less complete with past data on hydrology and water quality to calculate daily runoff amount (including missing daily data) for a period of 1 year, using past data on precipitation and evaporation as given values.

② Based on available flux and water quality data, the relational expression ($L=aQ^b$) for flux (Q) and runoff load (L) was determined to formulate the L-Q equation for every river and water quality parameter.

③ This formula (L-Q) was used to calculate daily runoff (including missing daily data) for a period of 1 year, using the calculated daily runoff amount above mentioned.

④ The monthly mean runoff load was calculated based on the daily runoff load, and load from point and non-point sources was distinguished by allocating the lowest value as the monthly runoff load from point sources.

(8) The average annual precipitation in Camaqua River basin in the past 20 years was calculated at 1,430mm based on available data. The average of the precipitation of 1996 and 1997 (1,410mm) is close to the above mentioned annual precipitation. Data on the water quality of major rivers, which are necessary for runoff load calculation, were also found to be comparatively abundant in these two years. Accordingly the runoff discharge of main rivers was calculated using a tank model that adopts the 1996 and 1997 precipitation values, and the results were compared with actual values. The comparison showed a sufficiently high consistency in the



THE STUDY ON THE ENVIRONMENTAL MANAGEMENT OF THE HYDROGRAPHIC BASIN OF PATOS AND MIRIM LAKES IN THE FEDERATIVE REPUBLIC OF BRAZIL	**Fig. 2.2-1**
JAPAN INTERNATIONAL COOPERATION AGENCY KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL	**Detailed Procedure Flow of Runoff Load Calculation**

order of the mean, maximum and minimum runoff discharge values at a certain period, as well as in the fluctuation curve pattern. The calculation of the average of the actual runoff discharge in 1996 and 1997 indicates that 65% of the runoff discharge from the Patos Lake basin originate from the Guaiba Lake basin (G10～80); the remaining 35% is from other basins.

(9) The runoff load simulation model was referred to in the calculation of the runoff load from the sub-basins of Patos Lake in 1996 and 1997. The calculation confirmed that the following averages originated from non-point sources: 80% for BOD, 86% for TN and 83% for TP. As for TP, 38% of the load flowing into G80 (the basin also covers Porto Alegre) originated from point sources; urbanization in this basin is progressive. In contrast, 84% of the TP load in the L30 basin (Camaqua River), which is predominantly made up of farming villages, originate from non-point sources (**Fig. 2.2-2**).

(10) The runoff ratios calculated from the generation load estimated in (6) and the above mentioned runoff load are 41% for BOD, 81% for TN and 77% for TP. These runoff ratios are appropriate in comparison with the values obtained in Japan.

2.3 River and Basin Conditions

(1) The study area consists of extensive low-lying flatlands around Patos and Mirim lakes and the 4 hills (Serra) in the west. The hills have gentle undulations, comparatively flat peaks, and are around 300 to 600m in elevation.

(2) The hills are mainly made up of granite of the Precambrian period. Sedimentary rocks (sediments in the Palana River basin) from the Palaeozoic to the Mesozoic period overlie the granite in the west and north. On one hand, unconsolidated sediments of the Quaternary period are distributed in the low-lying zone.

(3) According to Köppen’s climatic classification, the study area is in a subtropical zone (Cf). In the low-lying coastal area, the average temperature in summer (January to March) is 21℃ to 23℃. In the hilly area, summer is comparatively cool, while winter (July to September) is slightly cold and chilly. There are 4 seasons in a year. Rain is abundant in winter than in summer and the annual rainfall

amount ranges from 1,200mm (coastal area) to 1,500mm (inland).

(4) Camaqua River is the longest river within the study area, with a length of 430km and a basin area of 16,843km^2. Sao Goncalo canal measures 76km and connects Patos Lake to Mirim Lake. This manmade canal has an average depth of 5.0m. To prevent the backwash of saltwater into the canal downstream section, a weir with 18 gates (12m wide, 3.2m high) was constructed. Although a number of irrigation facilities, e.g. dam, weir, pumping area, etc., are constructed in the study area, there are no river structures for flood and erosion control.

(5) The soil in the study area mainly consists of Planosol, Podzol, and Lithosol, the latter being erosive, infertile, and, therefore, not suitable for crop cultivation. Almost 20% of the study area is covered of the latter soil type.

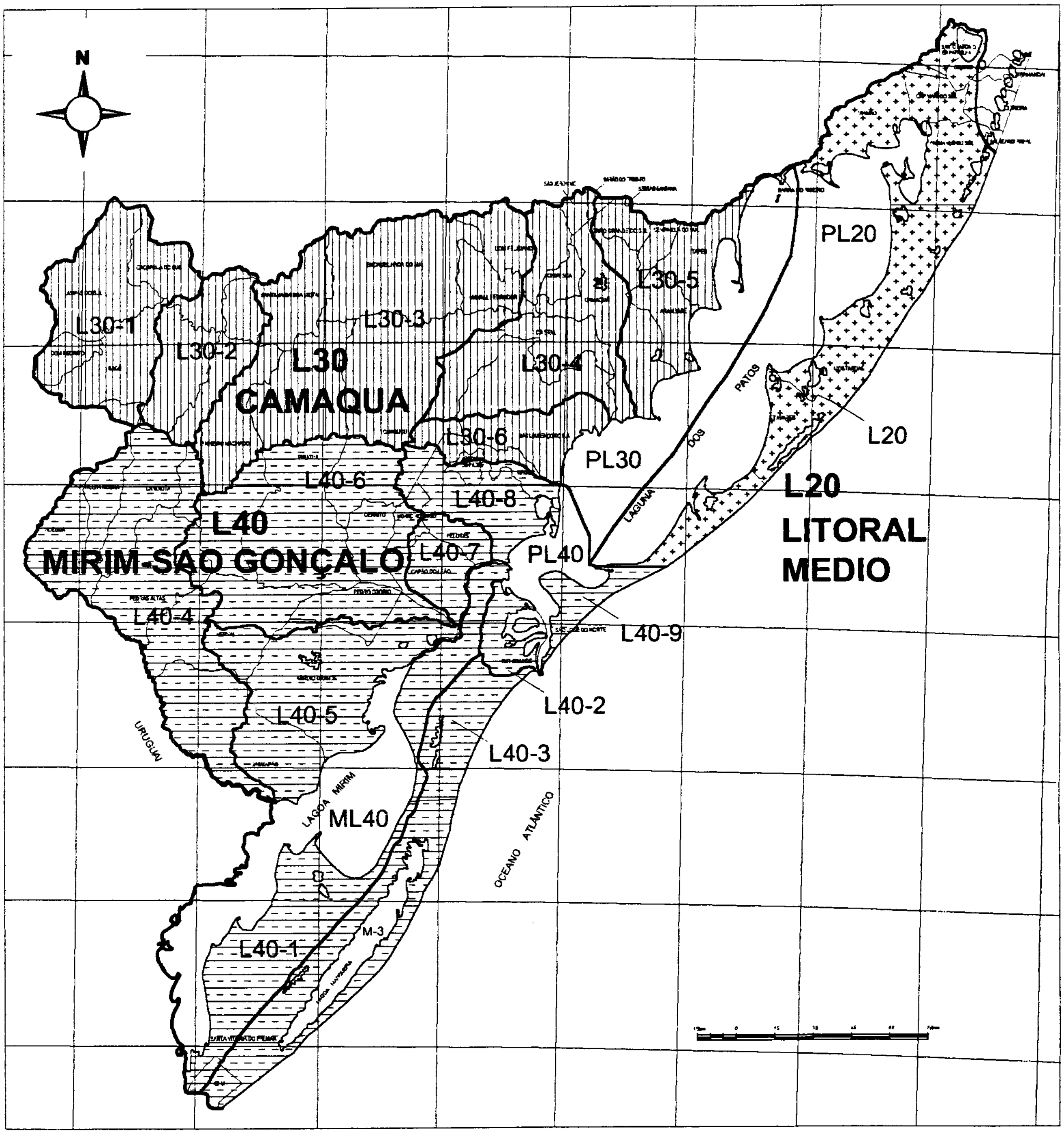
(6) The state of Rio Grande do Sul divided the Patos and Mirim lake basins into a total of 12 sub-basins (**Fig. 2.3-1**). Of these sub-basins, the study area encompasses Litoral Medio (L20), Camaqua (L30), and Mirim-Sao Goncalo (L40) and measures 53,560km^2 exclusive of the lake water area. For convenience, this area was divided into 16 sub-basins; each sub-basin is given a name and measured using satellite images. The natural conditions in each sub-basin were also determined.

(7) A study was carried out to determine the natural conditions in every sub-basin to gather data on soil erosion and the factors that are seriously related to this phenomenon. The annual soil erosion amount in the slopes and plains of each sub-basin was calculated using the USLE method. The results of the calculation indicated maximum values, near 40 tons/ha/year, in L30-6, and an annual average of 22.8 tons/ha in the entire slope area.

(8) Soil erosion hazard was arranged into 4 categories. With due consideration of farming conditions, the slopes of L30-4, L30-5, L30-6, L40-5, L40-6, L40-7, and L40-8 are areas (20% of the entire study area) designated as highly prone to soil erosion hazards (refer to **Fig.8.2-1**).

(9) Using the Murano Formula, the amount of earth and sand produced in designated sections of several rivers in the study area was calculated. The results show an annual production of 100 to 300 tons/km^2; none of the rivers were particularly observed to produce large amounts.

(10) Available data show rice, corn, soybeans, wheat, and tobacco as the main crops cultivated in the study area. Agricultural chemicals are used for rice, soybeans, potatoes, onions, tobacco, and peach trees. The annual amount of agricultural chemicals (insecticides, herbicides, disinfectants) used is 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. 2.3-1
JAPAN INTERNATIONAL COOPERATION AGENCY KOKUSAI KOGYO CO., LTD. / PACIFIC CONSULTANTS INTERNATIONAL	Hydrological Sub-basin in the Study Area

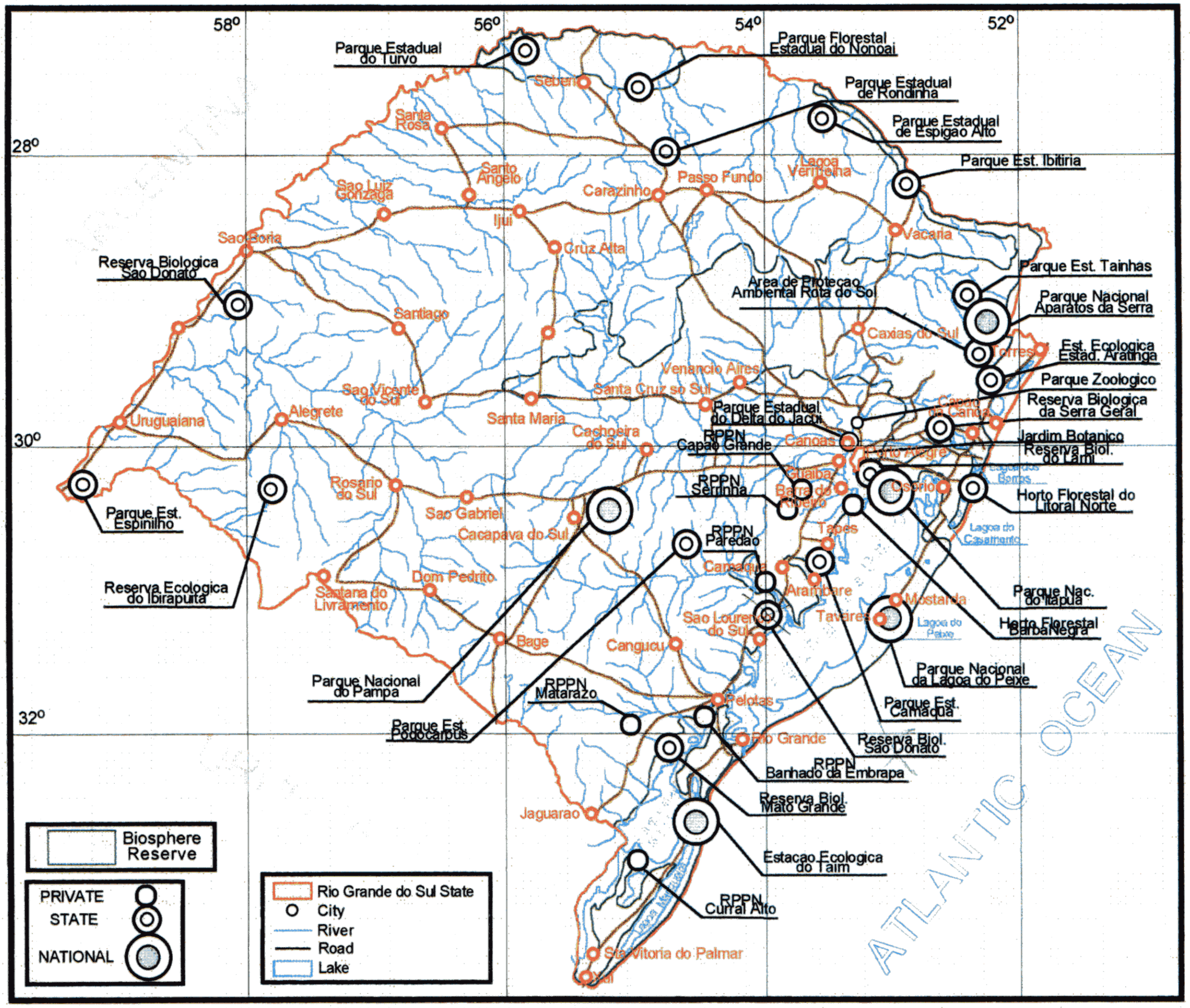
2.4 Ecosystem

(1) The Study Area can be divided into 3 zones in terms of ecosystem: Littoral, Southwest Mountains and Campanha. The Littoral zone varies from 10 to 100km in width and faces the Atlantic Ocean. It constitutes dunes, lakes and wetlands around Patos/Mirim lakes. Vegetation in the coastal area is low, and shrubs and forests predominate toward the inland. Land use in this zone had been significantly modified due to pasturage, expansion of paddy fields, drainage, deforestation and plantation. The only areas yet untouched by human activities are parts of the sand dunes.

(2) The Ecosystem study was mainly done in the Littoral zone. The Littoral zone almost covers the Mata Atlântica Biosphere Reserve that UNESCO established in 1993, and its risk potential and critical level have already been studied. This biosphere reserve includes 3 federal, 9 state and 5 private conservation areas (**Fig. 2.4-1**).

(3) A great number of studies related to the ecosystem have been carried out in the study area, but since the majority focused on particular regions and species, the general characteristics of the ecosystem have not been uniformly understood. The preliminary list of fauna/flora in the lowland area includes 57 mammals, 318 birds, 161 fishes, 29 reptiles, 6 amphibians, 261 insects, 30 mollusks, 31 crustaceans, 41 planktons, 94 alga and 586 plants (numbers are tentative). On the other hand, the number of fauna/flora protected by law or threatened of extinction is 11 for mammals, 6 for birds, 6 for reptiles and 20 for plants.

(4) The agricultural chemicals utilized in the cultivation of rice, potatoes, wheat, tobacco, etc. are absorbed by animals in large quantities. To analyze toxicity levels due to the consumption of these crops, shrimps, fish and mollusks were collected in 5 points (Tapes, Arambaré, Camaquã, São Lourenço do Sul and Laranjal) and organo-chlorine compounds in the viscera of these aquatic species were analyzed. The compounds fell below the detectable limit in mollusks and shrimps, but small amounts were detected in some fish (*Pimeladus maculatos*).



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