JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

STATE SECRETARIAT OF PLANNING AND GENERAL COORDINATION,
PARANÁ STATE, THE FEDERATIVE REPUBLIC OF BRAZIL

THE MASTER PLAN STUDY ON THE UTILIZATION OF WATER RESOURCES IN PARANÁ STATE IN THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT

MAIN REPORT III

MASTER PLAN FOR TIBAGI RIVER BASIN

December, 1995

Yachiyo Engineering Co., Ltd.
Tokyo, Japan

and

Nippon Koei Co., Ltd.
Tokyo, Japan

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Cost Estimate is Based
on The Price Level of August, 1994,
According to The Following Exchange Rate.

US$ 1.00 = ¥ 98.87
(as of August, 1994)

PREFACE

In response to a request from the Government of the Federative Republic of Brazil, the Government of Japan decided to conduct a study on the Master Plan for the Utilization of Water Resources in Paraná State and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Brazil a study team headed by Mr. Yoshio Nakagawa, Yachiyo Engineering Co., Ltd., and composed of staff members of Yachiyo Engineering Co., Ltd. and Nippon Koei Co., Ltd. (5 times between March 1994 and October 1995).

The team held discussions with the officials concerned of the Government of Brazil, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Federative Republic of Brazil for their close cooperation extended to the team.

December, 1995

Kimio Fujita
President
Japan International Cooperation Agency

December, 1995

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Mr. Fujita,

We are pleased to submit to you the Master Plan report on the Utilization of Water Resources in Paraná State in the Federative Republic of Brazil. This report presents a strategy over the state on water environment, which includes not only comprehensive surface and underground resources development for various types of water use but also environmental facets of water, such as flood, quality of river water, soil erosion, eco-system, forest, etc., as well as a Master Plan for improvement of water environment in selected two pilot river basins.

In the Master Plan for the pilot river basins, projects and recommendations are embodied towards the year of 2015 for sectors of water supply, hydro-electric generation, flood control, water quality control and sewerage development, soil erosion control, eco-system conservation, forest preservation, water environment management, and institutional improvement. Urgent implementation of studies to follow this Master Plan Study is also proposed in the report.

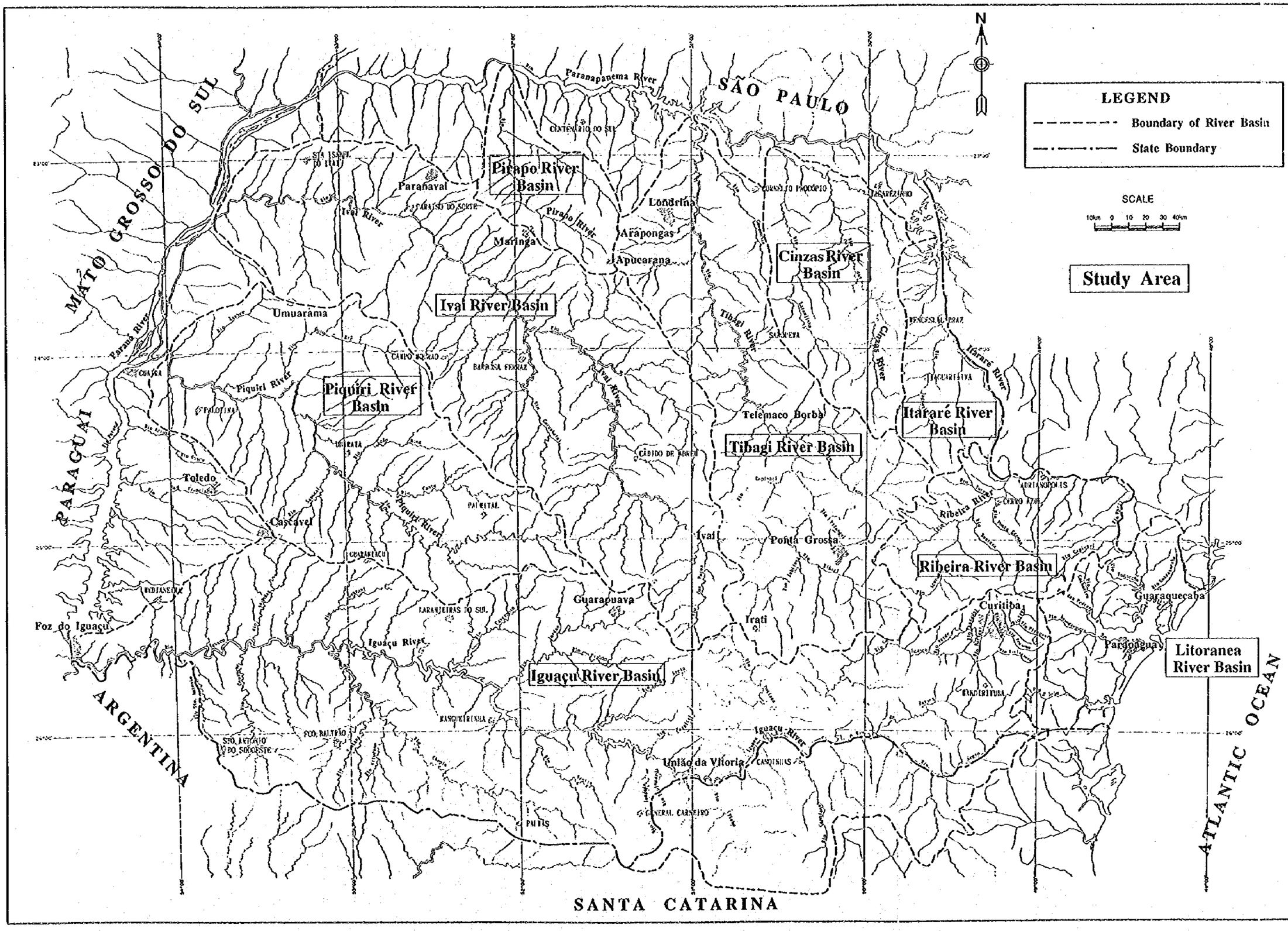
It would be a great honor for us that the result of the study would contribute to socio-economic development of Paraná State and to closer friendship between Japan and the Federative Republic of Brazil.

We wish to take this opportunity to express our sincerest gratitude to your Agency, the Ministry of Foreign Affairs, the Ministry of Construction, the Hokkaido Development Agency, the Embassy of Japan in Brazil and the General Consulate of Japan at Curitiba. We also wish to express our deepest gratitude to the State Secretariat of Planning and General Coordination and other authorities concerned of Paraná State as well as those of the Federative Republic of Brazil for close cooperation and assistance extended to us.

Very truly yours,

Y. Nakagawa

Yoshio Nakagawa
Team Leader
The Master Plan Study on
the Utilization of Water Resources in
Paraná State in the Federative Republic of Brazil


N
LEGEND
Boundary of River Basin
State Boundary
SCALE
10km 0 10 20 30 40km
Study Area
MATO GROSSO DO SUL
SÃO PAULO
PARAGUAI
ARGENTINA
SANTA CATARINA
ATLANTIC OCEAN
Paranapanema River
Pirapo River Basin
Ivai River Basin
Piquiri River Basin
Cinzas River Basin
Tibagi River Basin
Itararé River Basin
Ribeira River Basin
Iguaçu River Basin
Litoranea River Basin
Paranavaí
Londrina
Maringá
Arapongas
Apucarana
Umuarama
Toledo
Cascavel
Foz do Iguaçu
Telemaco Borba
Ponta Grossa
Guarapuava
Curitiba
Guaraqueçaba
União da Vitoria
Paranaguá
Ivai River
Piquiri River
Iguaçu River
Tibagi River
Ribeira River

COMPOSITION OF FINAL REPORT

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THE MASTER PLAN STUDY ON
THE UTILIZATION OF WATER RESOURCES IN PARANA STATE
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MAIN REPORT III

MASTER PLAN FOR TIBAGI RIVER BASIN

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List of Abbreviation

CEPA	:	State Commission for Agricultural Planning *Comissão Estadual de Planejamento Agrícola*
COMEC	:	Coordination of the Metropolitan Area of Curitiba *Coordenação da Região Metropolitana de Curitiba*
CONAMA	:	National Council of Environment *Conselho Nacional do Meio Ambiente*
COPATI	:	Inter Municipal Concessionaire for the Environmental Protection of the Tibagi River Basin *Consórcio Intermunicipal para a Proteção Ambiental de Bacia do Rio Tibagi*
COPEL	:	Energy Company of the State of Paraná *Companhia Pananaense de Energia*
CORPRERI	:	Permanent Regional Commission Against Floods in the Iguaçu River *Comissão Regional Permanente Contra as Cheias do Rio Iguaçu*
DAGRI	:	Agricultural Operation Department *Departamento Operacional da Agricultura*
DEPEC	:	Livestock Department *Departamento de Pecuária*
DERAL	:	Economy Department *Departamento de Economia*
DNAEE	:	National Department of Water and Electric Energy *Departamento Nacional de Águas e Energia Elétrica*
ELETROBRAS	:	Brazilian Central Electric Joint-stock Company *Centrais Elétricas Brasileiras S.A.*
ELETROSUL	:	Electric Center of the South *Centrais Elétricas do Sul do Brasil S.A.*
EMATER	:	Paraná State Technical Assistance and Rural Extension Company *Empresa Paranaense de Assistência Técnica e Extensão Rural*
EMBRAPA	:	Brazilian Agriculture and Livestock Research Company *Empresa Brasileira de Pesquisa Agropecuária*

FAMEPAR	:	Institute for Municipal Assistance of Paraná State *Instituto de Assistência aos Municípios do Estado do Paraná*
FAO	:	Food and Agriculture Organization *Fundo das Nações Unidas para Alimentação e Agricultura*
IAP	:	Environmental Institute of Paraná *Instituto Ambiental do Paraná*
IAPAR	:	Agricultural Research Institute of Paraná *Instituto Agronômico do Paraná*
IBAMA	:	Brazilian Institute of Environment and Renewable Natural Resources *Instituto Brasileiro do Meio Ambiente e de Recursos Naturais Renováveis*
IBDF	:	Brazilian Forest Development Institute (current IBAMA) *Instituto Brasileiro de Desenvolvimento Florestal*
IBGE	:	Brazilian Institute of Geography and Statistic *Instituto Brasileiro de Geografia e Estatística*
IPARDES	:	Economic and Social Development Institute of the State of Paraná *Instituto Paranaense de Desenvolvimento Econômico Social*
JICA	:	Japan International Cooperation Agency *Agência de Cooperação Internacional do Japão*
MERCOSUL	:	South Common Market in Brazil, Argentina, Uruguay and Paraguay *Merca do Cone Sul*
MINEROPAR	:	Paraná State Mineral Company *Minerais do Paraná S/A*
PROSAM	:	Environmental Sanitation Program for Curitiba Metropolitan Region *Programa de Saneamento de Região Metropolitan de Curitiba*
SANEPAR	:	Sanitation Company of the State of Paraná *Companhia de Saneamento do Paraná*
SEAB	:	State Secretariat of Agriculture and Supply *Secretaria de Estado da Agricultura e do Abastecimento*
SEDU	:	State Secretariat of Urban Development *Secretaria de Estado do Desenvolvimento Urbano*

SEFA	:	State Secretariat for Treasury Secretaria de Estado da Fazenda
SEID	:	State Secretariat for Industry, Commerce and Economic Development *Secretaria de Estado da Indústria, Comércio e do Desenvolvimento Econômico*
SEMA	:	State Secretariat of Environment *Secretaria de Estado do Meio Ambiente*
SEPL	:	State Secretariat of Planning and General Coordination *Secretaria de Estado do Planejamento e Coordenação Geral*
SETR	:	State Secretariat of Transport *Secretaria de Estado dos Transportes*
SIMEPAR	:	Meteorological System of Paraná *Sistema Meteorológico do Paraná*
SETI	:	State Secretariat of Science, Technology and Higher Education *Secretaria de Estado da Ciência, Technologia e Ensino Superior*
SUCEAM	:	Superintendency of Erosion Control and Environmental Sanitation *Superintendência do Controle de Erosão e Saneamento Ambiental*
SUREHMA	:	Superintendency of Water Resources and Environment *Superintendência dos Recursos Hidricos e Méio Ambriente*
UEL	:	State University of Londrina *Universidade Estadual de Londrina*
UNDP	:	United Nation Development Program *Programa das Nações Unidas para o Desenvolvimento*

CHAPTER 1 INTRODUCTION

1.1 Background of Study

The state of Paraná is located in the south of Brazil and has an area of approximately 200 thousand km^2, equivalent to 87% of Japan's main island, Honshu, and a population of about 8.5 million inhabitants. Regarding economy, north and north-eastern Brazil are not well developed, while about 80% of the economy, including the agricultural and industrial sectors, is concentrated in eastern and southern Brazil. The state of Paraná is one of the wealthiest states in Brazil together with Rio De Janeiro and Sao Paulo.

Agriculture was the main sector in the state of Paraná; however, agro-industry, chemical industry, paper industry etc. have been expanding around urban areas in line with the industrialization policy of the state government. This expansion of industry has promoted a concentration of population around large cities, such as Curitiba, Londrina, Maringa, Cascavel and Ponta Grossa causing shortages of domestic and industrial water. In addition, water pollution due to sewage and waste water from factories has become an important issue and the turbidity of river water has been increased by soil erosion on the large plateau.

The topography of Paraná is mainly plateau and most cities and agricultural lands are located on the plateau. Since the major rivers flow in valleys eroding the plateau, it is popular to utilize the smaller tributary rivers which flow on the plateau, or groundwater, for city and agriculture use. As a result, it has tended to be difficult to distribute enough water to each sector, despite the fact that rainfall is quite plentiful.

To account for the situation described above, the state of Paraná urgently needs to formulate a Master Plan for the utilization of water resources with a target year of 2015, including countermeasures for environmental issues such as water pollution, soil erosion, flood mitigation, etc.

With this situations as a background, the Government of the Federative Republic of Brazil requested technical cooperation related to the Master Plan Study on the Utilization of Water Resources in Paraná State (hereinafter referred to as the "Study") from the Government of Japan in August, 1993. The importance of the Study had been realized through the environmental Joint-Programming (JP) carried out as a part of JP between the two governments to find and establish a project which is necessary and worthwhile. In compliance with the request, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched a Preparatory Study Team headed by Mr. Koichi UZUKA in October, 1993, and the Scope of Work and Minutes of Meeting were agreed among the Governor of Paraná state, Secretary of State Secretariat of Urban Development (SEDU), Executive Director of Brazilian Cooperation Agency, Secretary of State Secretariat of Planning and General Coordination (SEPL), Secretary of State Secretariat of Environment (SEMA) and the leader of the Preparatory Study Team. With these agreements, a study team headed by Mr. Yoshio NAKAGAWA (Study Team) commenced the Study at the middle of March 1994.

1.2 Implementation of the Study

The objectives of the Study are as follows:

1) To formulate a Master Plan for the utilization of water resources, which contributes to urban, industrial, agricultural, hydropower development and environment conservation, in Paraná state aiming at the target year of 2015.

2) To promote technology transfer to the Brazilian counterparts during the Study.

The area covered by the Study is the whole of the state of Paraná as shown in Figure at frontispiece and consists of 11 main river basins.

The Study was divided into three phases as follows:

Phases I: To determine the methodology to formulate a Master Plan considering not only utilization of water resources but also environmental conservation in river basins, such as flood control, water quality improvement, ecosystem preservation, soil erosion control, etc.

Phase II: Based on the above mentioned methodology, to formulate the Strategy regarding utilization of water resources and environmental conservation in river basins in Paraná state and select pilot river basin(s) for the Master Plan considering importance and urgency of water utilization and environmental issues.

Phase III: To formulate the Master Plan for the selected pilot river basin(s).

After Phase II, two pilot basins, Iguaçu river basin and Tibagi river basin, were selected for the Master Plan Study in Phase III.

This report, Main Report III, deals with the Master Plan Study for the Tibagi river basin.

CHAPTER 2 SUMMARY OF MATER PLAN

The summary of the Master Plan for the Tibagi river basin is as shown in Table-2.1.

Table-2.1 (1) Summary of Master Plan for Tibagi River Basin

Contents of Master Plan	Development Water (m³/day)	Development Method	Cost 10⁶ US$	Implementation Schedule: Present - 2000	2001 - 2005	2006 - 2010	2011 - 2015
1.Water Supply			160.80				
(1) Domestic and Industrial Water			159.80				
Area of Project							
1) Large Urban Areas: Population more than 100,000 in 2015			74.90				
(a) Ponta Grossa			13.50				
Tibagi River I	18,000	Direct Intake	6.70				
Tibagi River II	19,000	Direct Intake	6.80				
(b) Londrina & Cambe			46.50				
Tibagi River I	35,000	Direct Intake	15.50				
Tibagi River II	35,000	Direct Intake	15.50				
Tibagi River III	36,000	Direct Intake	15.50				
(c) Apucarana			14.90				
Well Stage I	22,000	4 Wells	7.30				
Well Stage II	23,000	4 Wells	7.60				
2) Medium Urban Areas: Population more than 50,000 in 2015			52.00				
(a) Castro			5.50				
Iapo River I	11,000	Direct Intake	2.80				
Iapo River II	11,000	Direct Intake	2.70				
(b) Telemaco Borba			6.80				
Tibagi River I	9,000	Direct Intake	3.40				
Tibagi River II	9,000	Direct Intake	3.40				
(c) Cornelio Procopio							
Congonhas River	6,000	Direct Intake	7.40				
(d) Arapongas			15.90				
Wells Stage I	11,000	1 Well	7.20				
Pirapo River	9,000	Direct Intake	8.70				
(e) Ibipora							
Tibagi River	9,000	Direct Intake	7.40				
(f) Irati							
Imbituvinha River	6,000	Direct Intake	9.00				
3) Other 26-Urban Areas	30,000	Direct Intake & Wells	32.90				
(2) Agricultural Water Supply							
Whole River Basin	8,000	Direct Intake	1.00				
2. Flood Control							
(1) Non-structural Measures (Zoning and Evacuation for Irati & Ipiranga)			N.A.				
3. Sewerage Treatment			88.60				
(1) Development of Sewerage Treatment							
Area	Sewerage Treatment Volume (m³/day)						
(a) Ponta Grossa	30,000		29.20				
(b) Londrina	70,000		59.40				
4. Soil Erosion Control			52.80				
(1) Terrace for Crop Land	3,344 km²		13.40				
(2) Non Tillage	2,530 km²		18.70				
(3) Improvement of Farm Road	6,690 km		10.00				
(4) Maintenance of Farm Road & Terrace			10.70				
(5) Agronomic Measures and Soil Management			N.A				

Table-2.1 (2) Summary of Master Plan for Tibagi River Basin

Contents of Master Plan	Cost 10^4 US$	Implementation Schedule: Present - 2000	2001 - 2005	2006 - 2010	2011 - 2015
5. Ecosystem Conservation	3.71				
(1) Preservation Program	1.94				
1) Fish Population Inventory	0.66				
2) Fish Population Dynamics	0.49				
3) Endemic Fish Reproduction	0.49				
4) Management Plans for Conservation Units	0.05				
5) Inundated Lowlands Study	0.25				
(2) Monitoring Programs	1.77				
1) Bioindicator Monitoring	1.10				
2) River Margin Vegetation	0.67				
6. Afforestation	157.00				
(1) Afforestation for Conservation of the Water Environment: 400 km²	15.00				
(2) Commercial Afforestation: 2,000 km²	142.00				
7. Establishment of Monitoring System	0.70				
(1) Completion of SIMEPAR's System	(35.00)				
(2) Strengthening Monitoring System ; 19 rain gauges	0.03				
(3) Provision of 7 Stream Gauges	0.07				
(4) Provision of 3 Stream Gauges for Sediment Observation	0.03				
(5) Groundwater Monitoring	0.23				
1) 4 Boreholes in Londrina	0.06				
2) 2 Boreholes in Apucarana	0.03				
3) 10 Boreholes in Other Urban Area	0.14				
(6) Aquatic Ecology Monitoring	0.29				
(7) Integrated Data Base System with 7 Sets of Computer System and Telephone Line Network	0.07				
8. Institutional Improvement Program					
(1) Organizational Strengthening through Implementation of the Current Re-organization					
(2) Strengthened Groundwater Management					
(3) Enhancement in the Enforcement of Environmental Regulations	N.A.				
(4) Legal Arrangement for the Control of Soil, Sand and Stone Taking in River Areas			to be continued		
(5) Cost Recovery of Water Environment Management					
(6) Promotion of Residents Participation through Information Publication					
(7) Introduction of River Basin Management and Establishment of Competent Entities					
(8) Promotion of Coordination for Comprehensive Management					
(9) Establishment of Public Hearing System into the Water Granting Procedure	N.A.				
(10) Comprehensive Water Quality Management by River Basin					
(11) Enhanced Administration of Water Resources Development					
(12) Water Pricing and Charging for Optimal Water Allocation and Demand Control					
Sub Total	453.60				
9. Hydropower					
5-stations: Total Installation Capacity; 1,096 MW	1,147.30				
Grand Total	1,610.90				

Note (1) Price level in August 1994 is applied with the exchange rate of 1 US$ = 0.89 R$.
(2) Cost for SIMEPAR's System is not included in the total.

CHAPTER 3 NATURAL AND SOCIO - ECONOMIC BACKGROUND

3.1 Topography

The area of the Tibagi River Basin is bordered by the Paraná-Panema River in the north, and the Iguacu River Basin in the south, and the Tibagi River is flowing from the south to the north and into the Paraná-Pamera River.

The topographic features of the Tibagi River Basin in Paraná State are generally characterized by the following two areas from south to north (Figure-3.1) :

- the Second Plateau
- the Third Plateau

The Second Plateau consists of the planes and hills with gentle gradients ranging in altitude from 600 to 1,000 meters. It is restricted to two cuesta mountains in the east and west. Some of major municipalities such as Ponta Grossa and Telemaco Borba are located in this plateau.

The Third Plateau consist of the planes and hills ranging in altitude from 300 to 800 meters. It is restricted to the cuesta mountains in the south. Some of major municipalities such as Londrina, Apucarana and Cornelio Procopio are located in this area.

3.2 Meteorology

3.2.1 Rainfall

The rainfall data in Tibagi river basin has been measured with different agencies and different observation periods by stations. Using the last 20 years annual mean rainfall data, an Iso-hyetal map was developed as shown in Figure-3.2. In Tibagi river basin, annual rainfall distribution is between 1,400 mm and 1,700 mm.

3.2.2 Temperature

Annual mean temperature in Paraná has generally range between 16°C and 22°C throughout the year. Figure-3.3 shows Iso-thermal map of annual mean temperature, and annual mean temperature in Tibagi river basin has a range between 17°C and 21°C. Annual temperature increases toward lower Tibagi basin.

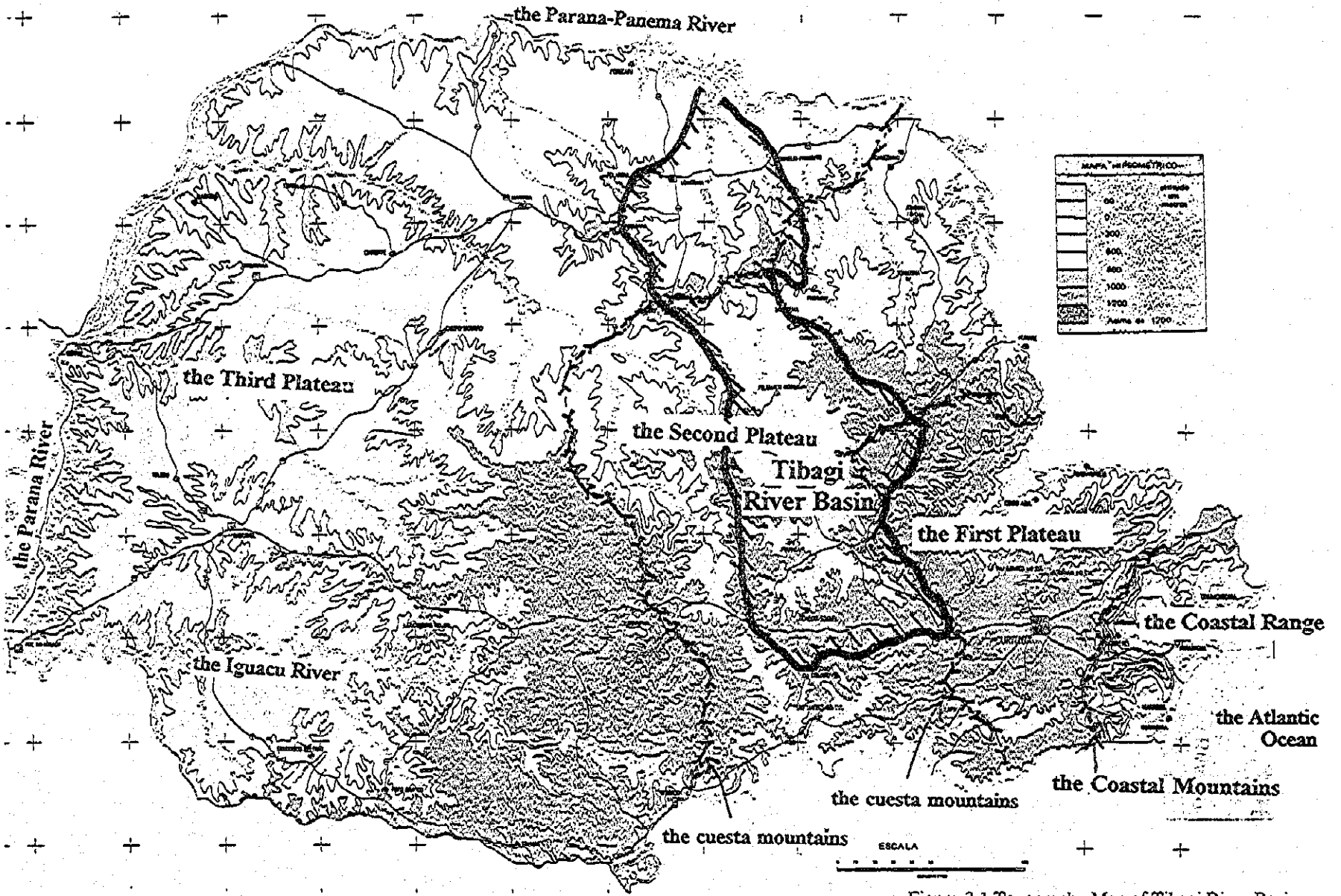


Figure-3.1 Topography Map of Tibagi River Basin

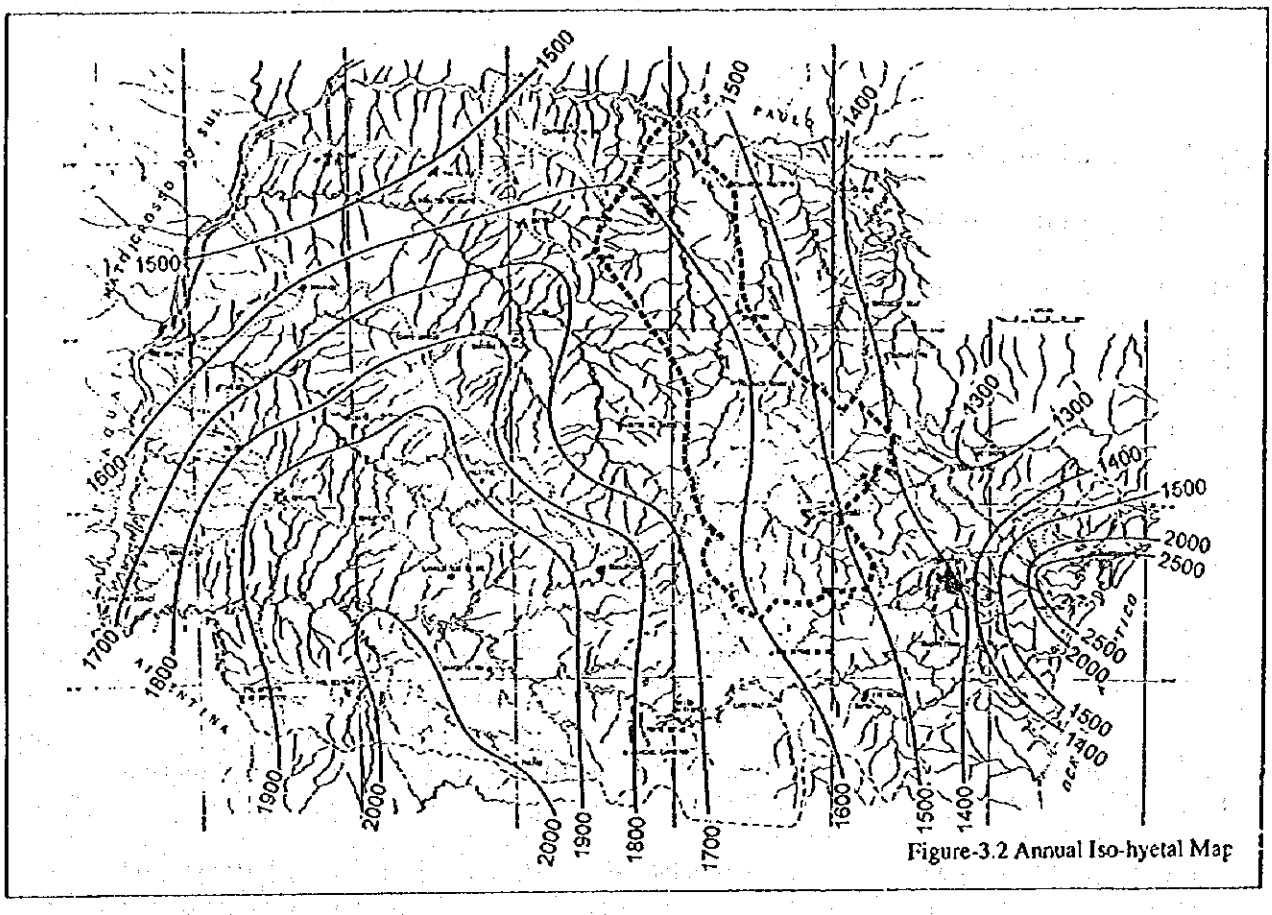


Figure-3.2 Annual Iso-hyetal Map

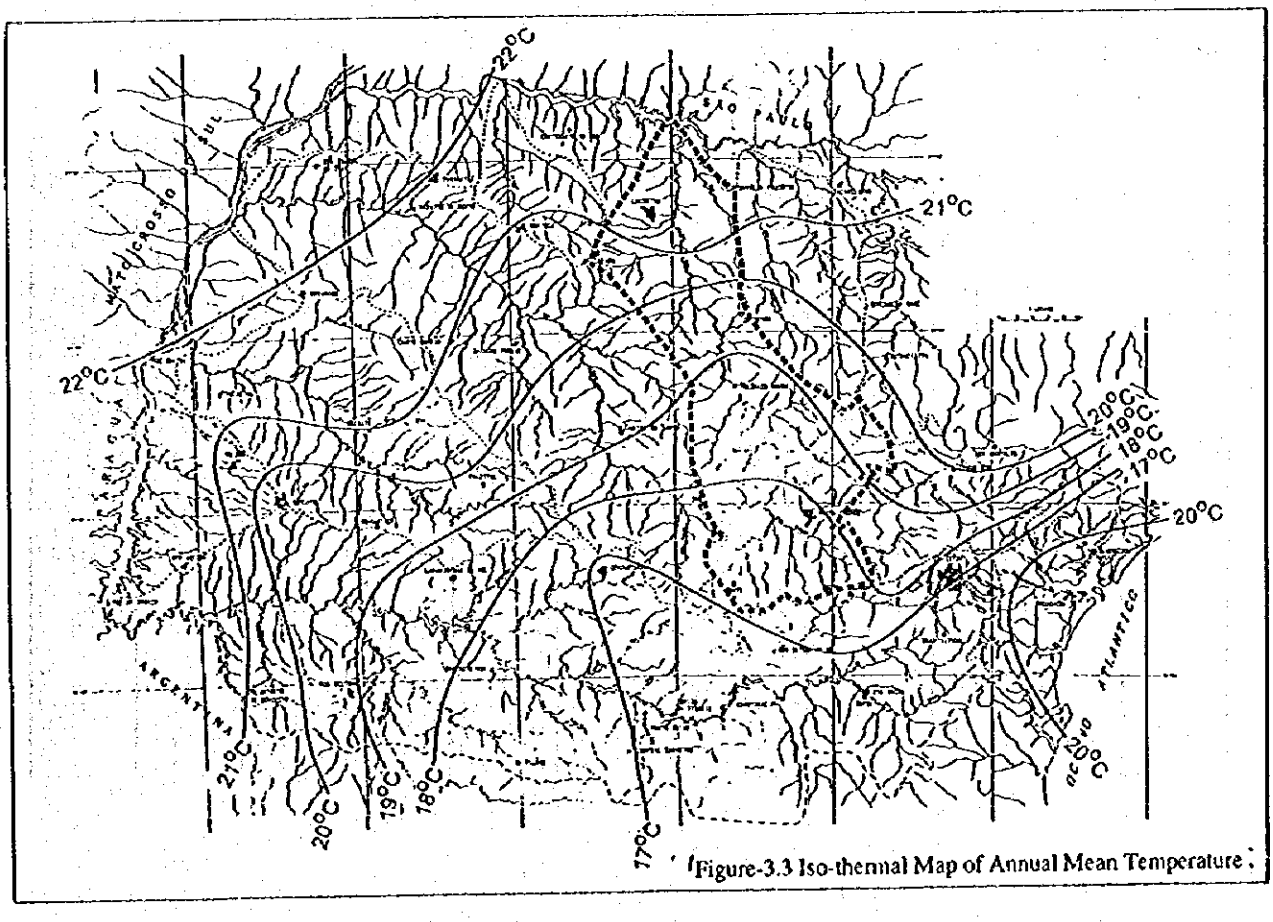


Figure-3.3 Iso-thermal Map of Annual Mean Temperature

3.3 Hydrology

3.3.1 Runoff Analysis

Based on the river flow data for the last 20 years period (1974-1993), daily discharge at each discharge reference point were determined, and the missing daily discharge were determined by monthly discharge correlation analysis among the stations.

The flow regime shows the annual condition using the calculated daily discharge at a certain hydrological station and shall be indicated by the daily discharge and number of exceeded days. The annual flow regime of each selected stations in the Study area shows as follows;

- High Discharge (95th daily discharge from the greatest)
- Normal Discharge (185th daily discharge from the greatest)
- Low Discharge (275th daily discharge from the greatest)
- Drought Discharge (355th daily discharge from the greatest)

The flow regime is commonly used to find the fluctuation in the daily discharge, and utilized for determining the potential water characteristics in Japan.

The flow regime computed by station was adapted for 20 years period (1974-1993), and mean value of the 95th, 185th, 275th and 355th daily discharge for the last 20 years period were calculated. The results of mean flow regime for the last 20 years period are summarized in Table-3.1.

Table-3.1 Flow Regime (mean values for the last 20 years period (1974 - 1993))

Basin	River	No.	St. No.	St.Name	Area	Daily Discharge (m3/sec)			
					(km2)	95 day	185 day	275 day	355 day
Itarare	Jaguariaiva	1	64-242-000	Tamandua	1,622	33.86	23.56	18.13	13.04
Cinzas	Cinzas	2	64-360-000	Tomazina	2,015	38.19	25.11	18.09	12.20
		3	64-370-000	Andira	5,622	88.26	50.03	34.18	22.32
Tibagi	Tibagi	4	64-444-000	Uvala	4,450	116.02	64.61	40.56	24.83
		5	64-465-000	Tibagi	8,948	229.39	132.92	87.08	51.89
		6	64-491-000	Barra Rib.das Antas	15,600	381.96	230.94	153.34	95.24
		7	64-507-011	Jataizinho (Extendido)	21,955	502.08	312.46	211.73	128.70
Pirapo	Pirapo	8	64-550-000	Vila Silva Jardim	4,627	79.54	61.38	49.43	37.74
Ival	Ival	9	64-625-000	Tereza Cristina	3,572	80.26	38.23	21.57	10.98
		10	64-645-000	Porto Espanhol	8,600	220.04	115.48	67.89	37.24
		11	64-675-002	Porto Bananeiras	24,200	561.65	311.55	199.13	120.84
		12	64-685-000	Porto Paraiso do Norte	28,427	650.69	381.95	262.71	173.59
		13	64-693-000	Novo Porto Taquara	34,432	777.78	491.69	355.97	246.35
Piquiri	Piquiri	14	64-771-500	Porto Guarani	4,223	120.83	60.39	33.58	16.61
		15	64-795-000	Ponte do Piquiri	11,303	345.65	186.73	111.87	65.20
		16	64-820-000	Porto Formosa	17,500	498.85	315.78	219.41	143.22
		17	64-830-000	Balsa do Santa Maria	20,982	551.77	368.49	262.97	172.25
Iguacu	Iguacu	18	65-010-000	Fazendinha	110	3.13	1.86	1.29	0.85
		19	65-025-000	Guajuvira	2,304	58.29	35.78	22.03	12.53
		20	65-035-000	Porto Amazonas	3,662	84.96	49.48	30.73	17.17
		21	65-060-000	Sao Mateus do Sul	6,065	136.44	78.47	50.85	30.30
		22	65-310-000	Uniao da Vitoria	24,211	656.67	365.42	232.03	131.34
		23	65-895-002	Salto Osorio	45,824	1310.22	829.86	532.17	262.67
		24	65-993-000	Salto Cataratas	67,317	1690.20	1126.20	792.05	436.78
	Negro	25	65-175-000	Divisa	7,970	195.67	112.64	76.21	49.60
	Timbo	26	65-260-000	Foz do Cachoeira	693	22.90	12.47	7.92	4.52
	Jordao	27	65-825-000	Santa Clara	3,913	128.17	77.18	49.67	28.19
	Chopim	28	65-960-000	Aguas do Vere	6,696	224.80	131.11	78.13	40.14
Ribeira	Ribeira	29	81-200-000	Capela do Ribeira	7,252	130.63	101.75	86.87	72.80
Litoranea	Nhundiaquara	30	82-170-000	Morretes	217	14.43	8.04	4.86	2.56
	Marumbi	31	82-195-002	Morretes	63	5.02	2.77	1.61	0.77

3.3.2 Runoff Ratio

Using the annual rainfall depth and annual surface runoff over the same catchment area, surface runoff volume and surface runoff ratio by stations were determined. Table-3.2 and Figure-3.4 show relation between catchment area and runoff ratio. The runoff ratio of Tibagi river basin shows at the ranges from 38 % to 41 %. It is smaller than other river basins, because high evapotranspiration condition as compared with other basins.

Table-3.2 Summary of Mean Annual Surface Runoff Ratio
(Simulation Period: 1974 - 1993, 20 Years)

Basin	River	No.	St. No.	St.Name	Area (km2)	Rainfall (mm/year)	Runoff (mm/year)	Balance (mm/year)	Runoff Ratio
Itarare	Jaguariaiva	1	64-242-000	Tamandua	1,622	1335.4	632.4	703.0	0.47
Cinzas	Cinzas	2	64-360-000	Tomazina	2,015	1491.3	565.8	925.4	0.38
		3	64-370-000	Andira	5,822	1440.3	480.5	959.8	0.33
Tibagi	Tibagi	4	64-444-000	Uvaia	4,450	1560.2	640.7	919.4	0.41
		5	64-465-000	Tibagi	8,948	1565.7	639.8	925.9	0.41
		6	64-491-000	Barra Rib.das Antas	15,600	1569.7	622.3	947.4	0.40
		7	64-507-011	Jataizinho (Extendido)	21,955	1587.6	604.9	982.6	0.38
Pirapo	Pirapo	8	64-550-000	Vila Silva Jardim	4,827	1615.2	492.7	1122.4	0.31
Ivai	Ivai	9	64-625-000	Tereza Cristina	3,572	1694.5	715.8	978.6	0.42
		10	64-645-000	Porto Espanhol	8,600	1659.9	729.7	930.3	0.44
		11	64-675-002	Ponte Bananeiras	24,200	1665.1	648.9	1016.2	0.39
		12	64-685-000	Porto Paraiso do Norte	28,427	1657.6	648.9	1010.7	0.39
		13	64-693-000	Novo Porto Taquara	34,432	1642.2	645.1	997.1	0.39
Piquiri	Piquiri	14	64-771-500	Porto Guarani	4,223	1928.9	855.6	1073.2	0.44
		15	64-795-000	Ponte do Piquiri	11,303	1936.9	926.2	1010.8	0.48
		16	64-820-000	Porto Formosa	17,500	1865.1	823.7	1041.4	0.44
		17	64-830-000	Balsa do Santa Maria	20,982	1843.0	763.6	1079.4	0.41
Iguacu	Iguacu	18	65-010-000	Fazendinha	510	1557.3	741.2	816.0	0.48
		19	65-025-000	Guajuvira	2,304	1416.5	634.8	781.8	0.45
		20	65-035-000	Porto Amazonas	3,662	1445.9	591.8	854.0	0.41
		21	65-060-000	Sao Mateus do Sul	6,065	1483.6	574.8	908.8	0.39
		22	65-310-000	Uniao da Vitoria	24,231	1584.2	663.8	920.4	0.42
		23	65-895-002	Salto Osorio	45,824	1725.6	765.3	960.3	0.44
		24	65-993-000	Salto Cataratas	67,317	1802.9	724.7	1078.3	0.40
	Negro	25	65-175-000	Divisa	7,970	1515.8	616.9	899.0	0.41
	Timbo	26	65-260-000	Foz do Cachoeira	693	1738.7	884.9	853.7	0.51
	Jordao	27	65-825-000	Santa Clara	3,913	1893.4	895.8	997.6	0.47
	Chopim	28	65-950-000	Aguas do Vere	6,695	2003.2	958.8	1044.4	0.48
Ribeira	Ribeira	29	81-200-000	Capela do Ribeira	7,252	1378.1	545.8	832.3	0.40
Litoranea	Nhundiaquara	30	82-170-000	Morretes	217	2537.7	1745.5	792.2	0.69
	Marumbi	31	82-195-002	Morretes	53	3300.0	2646.9	653.1	0.80
Mean	All Basins					1723.9	787.9	936.0	46%
						100%	46%	54%	
	Basins except for Litoranea Area					1641.5	690.8	950.7	42%
						100%	42%	58%	

Note : *) : It was determined by using an existing Iso-hyetal Map (COPEL)

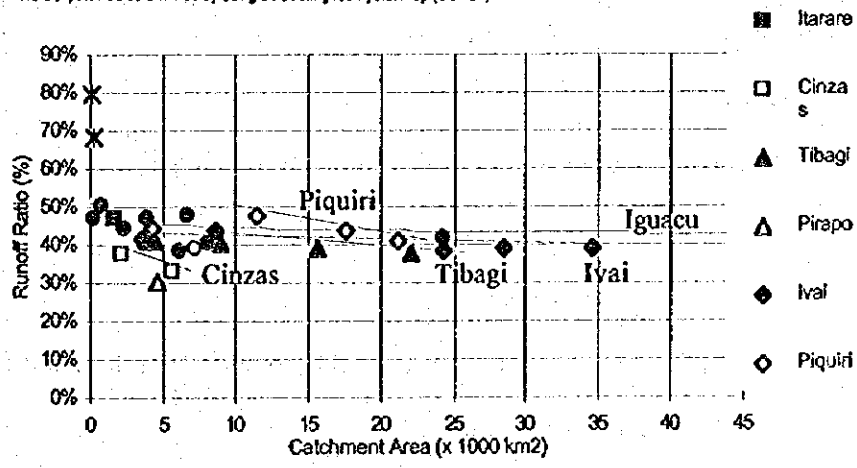


Figure-3.4 Relations between Catchment area and Runoff Ratio

3.4 Geology and Hydrogeology

3.4.1 Geology

The area of Tibagi River Basin and the neighbor areas are mainly underlain by Granitic Rocks, Paleozoic and Mesozoic volcanics.

Granitic Rocks and Paleozoic occupy the Second Plateau and Mesozoic occupies the Third Plateau. Granitic Rocks and Paleozoic are cut by dolerite dikes and the dikes are concentrating in the area from Ponta Grossa to Apucarana. The distribution of Paleozoic shows a arc structure with the axis trending to NW-SE in direction and it is called "Ponta Grossa Arc".

3.4.2 Hydrogeology

In Tibagi River Basin and the surroundings there are six kinds of aquifers as shown in Figure-3.5. The hydrogeological characteristics of these aquifers are described hereunder.

(1) Crystalline rocks

The lithology of this aquifer is composed of Granitic Rocks in the age from Proterozoic to Cambrian and the reservoirs of it are formed from fracture porosity due to open fractures in the rocks.

(2) Lower to Middle Paleozoic

The lithology of this aquifer is composed of Castro Group and Paraná Group.

(3) Middle to Upper Paleozoic

The lithology of this aquifer is composed of Itarare Group and Guata Group and the groups are chiefly composed of argilous layers.

(4) Late Paleozoic

This aquifer is composed of Passa Dois Group with partial porous media.

(5) Mesozoic

1) Botucatu Formation

This aquifer is overlain by Serra Geral Formation over the Third Plateau.

2) Serra Geral Formation north;

This aquifer is composed of basalt lavas accompanied various kinds of lava occurrence and it is classified into two areas of the northern area and the southern area by geological setting and the borehole yield.

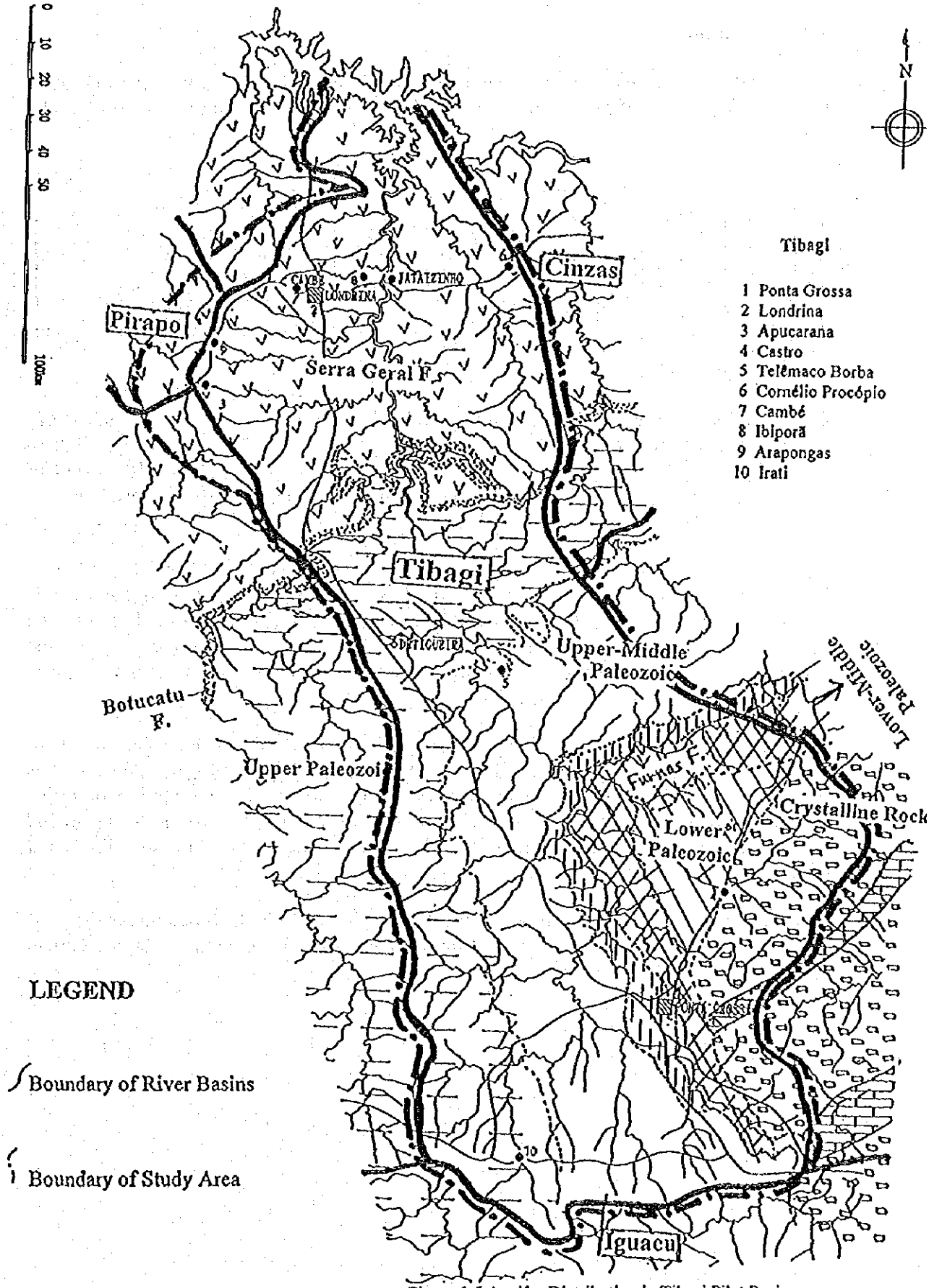


Figure-3.5 Aquifer Distribution in Tibagi Pilot Basin

3.5 Landuse

SANEPAR conducted the GIS computation based on IAP satellite imagery analysis (1990 & 1994) in order to identify the landuse in Tibagi river basin. The result is shown in Table-3.3.

Table-3.3 Landuse in Tibagi River Basin

	Total Area (km^2)	Swamp (%)	Sand Bank (%)	Forest (%)	2nd Veg.(%)	Ref. (%)	Pasture (%)	Crop (%)	Others (%)
Tibagi river basin	24,630	—	—	3.8	27.6	9.4	18.1	40.1	1.0
Parana State	197,880	0.1	0.2	9.0	26.0	3.2	23.1	37.6	0.8

2nd Veg.: Secondary Vegetation, Ref.: Reforestation

Source: SANEPAR GIS Computation based on IAP Satellite Imagery Analysis (1990 & 1994)

40.1 % (9,900 km^2) and 18.1 % (4,500 km^2) of Tibagi river basin are currently utilized as crop land and pasture, while the state average is 37.6 % and 23.1 %, respectively. 29.8 % of crop land and 21.9 % of pasture in the state belongs to Tibagi river basin. More than half of the river basin area is used for agriculture and it spreads over the basin; however, it is more dense in the downstream.

Natural forest and reforestation in Tibagi river basin cover 3.8 % (900 km^2) and 9.4 % (2,300 km^2) of its area, respectively. The total area of reforestation in the state is approximately 6,300 km^2 and 36.5 % of them belongs to Tibagi river basin. Reforestation is well practiced in Tibagi river basin compared to others and located mainly in the middle stream, around Telemaco Borba. In contrast to reforestation, the area of natural forest is limited and scattered in up and down stream.

Secondary vegetation where the natural bush grows after some use, such as slash and burn farming, extends 27.6 % (6,800 km^2) of the river basin area. The proper landuse of this area is recommended, for example conversion into reforestation, preservation of native vegetation and so on. It spreads over the basin; however it is more dense in the upstream, around Ipiranga, middle stream, around Sao Jeronimo da Serra, and downstream, around Londrina.

The satellite imagery analysis is based on the data of 1989 and 1990. Since this is the most recent landuse available, it was adopted throughout the study assuming that the current landuse does not vary from the one in 1990.

3.6 SOCIO-ECONOMY

3.6.1 Regional Unit and Zoning of the Study

According to the regional unit of collected data concerning the socio-economic area, it was decided to use the municipalities as a regional unit. Therefore, the zoning lines for the Study should be drawn following the boundary lines of the municipalities. However, as the Study should be made by river basin, it was decided to use the following criteria for inclusion (or exclusion) of municipalities that straddle other river basins, in the zoning of the Study:

- All municipalities that have their urban center located within the river basin, regardless if only a part of the urban area is inside the river basin, were included in the zoning.
- If the urban center of the municipality is not included in this basin, but there is a chance that this municipality will start to use a small river that belongs to this river basin in the future, the municipality is included in the zoning.
- In the case of only a small part of the rural area of the municipality, approximately less than 10% of total area, be included in this river basin, the municipality is excluded of the zoning as, for example, Bela Vista do Paraíso in MRH 281/N. N. Londrina.
- The recommendation of the Counterpart Team was considered as to the inclusion of municipalities in the zoning, in accordance to the criteria, such as water supply system of undertakers.

The zoning for this river basin is composed of 43 municipalities, and is presented in Figure-3.6.

3.6.2 Population per Municipality

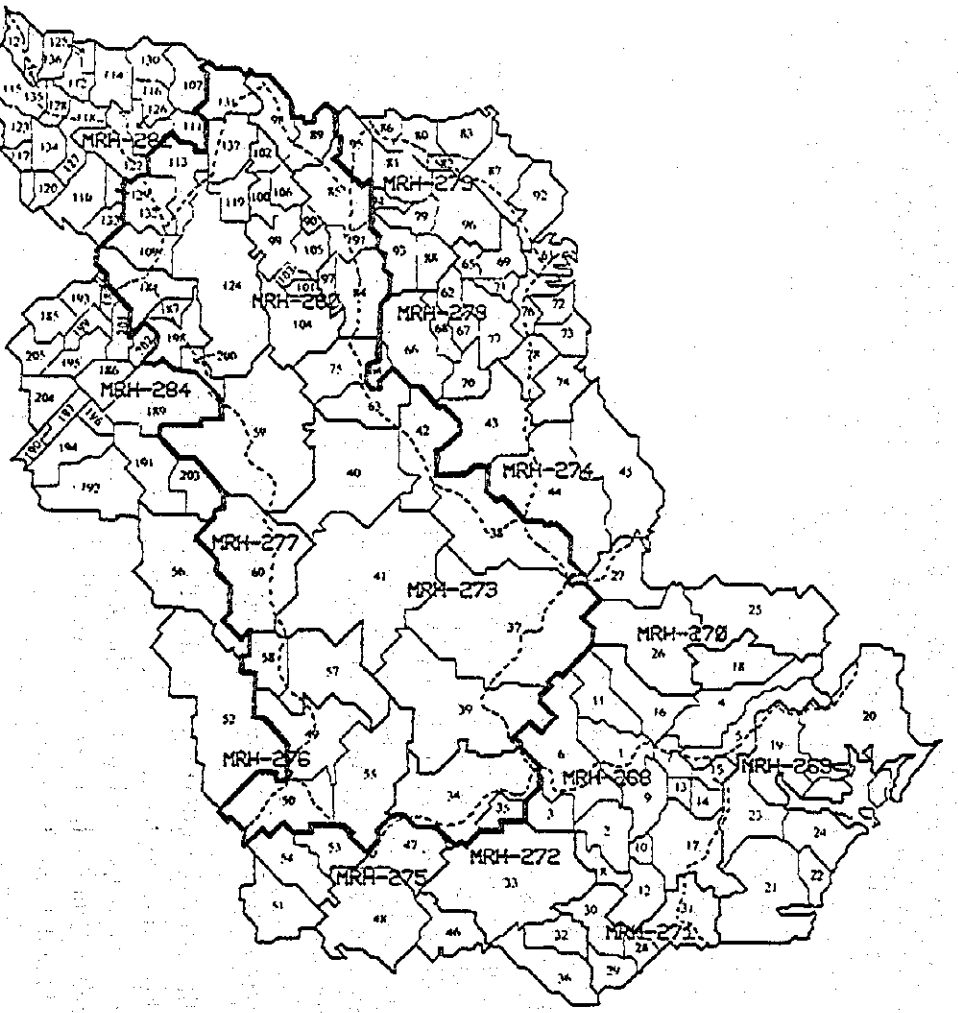
Based on the census of 1970, 1980 and 1991, issued by IBGE and provided by IPARDES, the population per Municipality, in each year, of the 43 municipalities that compose the Study's zoning area are shown in Table-3.4 (1) and Table-3.4 (2) divided per MRH (Homogeneous Micro-Regions) - refer to Main Report I for data concerning population per MRH. It is important to say that some municipalities have been created recently and, therefore, these new municipalities do not have the number of inhabitants included in the table mentioned above.

3.6.3 Gross Regional Domestic Product (GRDP) per Municipality

Based on the estimated GRDP per MRH (Table-5.10 of Main Report I), on the data of Financial Economic Statistics - 74/85, 86/87, 88/89 issued by SEFA and on the Municipalities' Participation Fund - Preliminary Indexes - 95, issued by SEFA, the GRDP of the 43 municipalities from the years of 1981 to 1991 was estimated and is shown in Table-3.5 (1) and Table-3.5 (2).

3.6.4 GRDP by Secondary Sector per Municipality

GRDP by Secondary Sector per Municipality, during the year of 1981 to 1991, was estimated based on the same data mentioned above, while this estimation was presented in the Sectorial Report Vol. A.



Municipalities in the Tibagi River Basin

No. and Name of MRH	No.	Name	Urban Area
MRH 272	34	Palmeira	Y
Campos de Lapa	35	Ponta Amazonas	N
MRH 273	37	Castro	Y
Campos de Ponta Grossa	38	Final do Sul	Y
	39	Ponta Grossa	Y
	40	Telêmaco Borba	Y
	41	Tibagi	Y
	42	Ventania	N
MRH 276	49	Imbituva	Y
Col. Irati	50	Irati	Y
	55	Teixeira Soares	Y
MRH 277	57	Ipiranga	Y
Alto Ivaí	58	Ivaí	N
	59	Ortigueira	Y
	60	Reserva	Y
MRH 278	63	Curitiba	Y
N. V. Wenceslau Braz	75	Sapopema	Y
MRH 279	84	Congonhas	P
N. V. Jacarezinho	85	Cornélio Procópio	P
	89	Leópolis	N
	90	N. América Colina	Y
	91	Nova Fátima	N
	97	S. Antônio Paraiso	Y
	98	Sertaneja	Y
MRH 280	99	Assaí	Y
Algodoeira de Assaí	100	Jataizinho	Y
	101	N. Santa Bárbara	Y
	102	Rancho Alegre	Y
	103	Santa Cecília Pavão	Y
	104	São Jerônimo Serra	Y
	105	S. Sebastião Amoreira	Y
	106	Uraí	Y
MRH 281	109	Arapongas	P
N, N, Londrina	113	Cambé	P
	119	Ibiporã	Y
	124	Londrina	Y
	131	Primeiro de Maio	Y
	132	Rolândia	N
	137	Sertanópolis	Y
MRH 284	184	Apucarana	P
N, N, Apucarana	187	Califórnia	Y
	198	Marilândia do Sul	N
	200	Mauá da Serra	P

Source : IPARDES

Remark : Urban Area
Y : Urban Area in the River Basin
P : Part of the Urban Area in River Basin
N : Urban Area not included in the River Basin

Figure-3.6 Zoning of the Study

Table-3.4 (1) Population per Municipality in 1970, 1980 and 1991/Tibagi River Basin

No. and Name of MRH	No. and Name of Municipality		Population 1970			Population 1980			Population 1991		
	No.	Name	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
MRH 272		TOTAL of MRH	34,492	43,417	77,909	44,843	42,862	87,705	58,986	45,345	104,331
Campos de Lapa	34	Palmeira	8,129	11,901	20,030	11,672	12,563	24,235	14,878	14,168	29,046
	35	Porto Amazonas	0	0	0	0	0	0	0	0	0
	Subtotal of Municipalities of Basin		8,129	11,901	20,030	11,672	12,563	24,235	14,878	14,168	29,046
	Subtotal of Municipalities not of Basin		26,363	31,516	57,879	33,171	30,299	63,470	44,108	31,177	75,285
MRH 273		TOTAL of MRH	159,410	77,703	237,113	249,833	78,883	328,716	338,225	66,953	405,178
Campos de Ponta Grossa	37	Castro	12,919	24,617	37,536	25,590	24,226	49,816	39,125	24,933	64,058
	38	Piraí do Sul	7,156	7,857	15,013	9,463	7,613	17,076	12,314	7,100	19,414
	39	Ponta Grossa	113,074	13,866	126,940	172,946	13,701	186,647	221,671	12,313	233,984
	40	Telêmaco Borba	22,813	14,425	37,238	36,188	18,389	54,577	54,649	10,314	64,963
	41	Tibagi	3,448	16,938	20,386	5,646	14,954	20,600	10,466	12,293	22,759
	42	Ventania	—	—	—	—	—	—	—	—	—
	Subtotal of Municipalities of Basin		159,410	77,703	237,113	249,833	78,883	328,716	338,225	66,953	405,178
	Subtotal of Municipalities not of Basin		0	0	0	0	0	0	0	0	0
MRH 276		TOTAL of MRH	36,598	98,159	134,757	49,976	98,491	148,467	69,230	102,442	171,672
Col. Irati	49	Imbituva	4,598	15,734	20,332	5,791	16,194	21,985	7,874	17,747	25,621
	50	Irati	15,809	20,662	36,471	22,765	19,469	42,234	31,278	16,576	47,854
	55	Teixeira Soares	2,589	10,290	12,879	3,076	9,815	12,891	4,556	9,465	14,021
	Subtotal of Municipalities of Basin		22,996	46,686	69,682	31,632	45,478	77,110	43,708	43,788	87,496
	Subtotal of Municipalities not of Basin		13,602	51,473	65,075	18,344	53,013	71,357	25,522	58,654	84,176
MRH 277		TOTAL of MRH	7,733	84,050	91,783	14,839	97,959	112,798	22,734	75,505	98,239
Alto Ivaí	57	Ipiranga	1,754	7,769	9,523	2,192	7,894	10,086	3,214	9,376	12,590
	58	Ivaí	1,029	9,078	10,107	1,741	8,769	10,510	2,958	8,496	11,454
	59	Ortigueira	1,754	34,935	36,689	4,552	45,561	50,113	5,412	22,092	27,504
	60	Reserva .	2,212	18,705	20,917	4,047	19,556	23,603	7,192	17,892	25,084
	Subtotal of Municipalities of Basin		6,749	70,487	77,236	12,532	81,780	94,312	18,776	57,856	76,632
	Subtotal of Municipalities not of Basin		984	13,563	14,547	2,307	16,179	18,486	3,958	17,649	21,607
MRH 278		TOTAL of MRH	45,784	154,817	200,601	65,574	119,824	185,398	92,920	76,431	169,351
N. V. Wenceslau Braz	63	Curiúva	1,315	16,411	17,724	5,112	14,546	19,658	3,989	6,514	10,503
	75	Sapopema	796	7,826	8,622	1,517	6,900	8,417	2,861	4,234	7,095
	Subtotal of Municipalities of Basin		2,109	24,237	26,346	6,629	21,446	28,075	6,850	10,748	17,598
	Subtotal of Municipalities not of Basin		43,675	130,580	174,255	58,945	98,378	157,323	86,070	65,683	151,753
MRH 279		TOTAL of MRH	134,767	254,191	388,958	169,589	132,989	302,578	216,130	91,437	307,567
N. V. Jacarezinho	84	Congonhinhas	3,165	15,307	18,472	2,745	5,567	8,312	4,044	3,729	7,773
	85	Cornélio Procópio	25,827	23,969	49,796	31,802	10,779	42,581	40,036	6,608	46,644
	89	Leópolis	1,138	10,883	12,021	1,559	3,624	5,183	2,248	2,513	4,761
	90	N. América Colina	975	5,916	6,891	1,333	3,142	4,475	1,828	2,277	4,105
	91	Nova Fátima	3,513	8,990	12,503	4,723	3,475	8,198	5,979	2,406	8,385
	97	S. Antônio Paraíso	1,017	6,115	7,132	1,069	2,303	3,372	1,206	1,282	2,488
	98	Sertaneja	3,582	10,713	14,295	4,112	2,814	6,926	4,880	1,828	6,708
	Subtotal of Municipalities of Basin		39,217	81,893	121,110	47,345	31,704	79,047	60,221	20,643	80,864
	Subtotal of Municipalities not of Basin		95,550	172,298	267,848	122,246	101,285	223,531	155,909	70,794	226,703

(To be continued)

Table-3.4 (2) Population per Municipality in 1970, 1980 and 1991/Tibagi River Basin

(Continuation)

No. and Name of MRH	No. and Name of Municipality		Population 1970			Population 1980			Population 1991		
	No.	Name	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
MRH 280		TOTAL of MRH	28,255	88,143	116,398	35,990	47,713	83,703	47,969	30,452	78,421
Algodoeira de Assai	99	Assai	8,567	20,523	29,090	10,124	11,972	22,096	12,964	7,361	20,325
	100	Jataizinho	4,239	6,587	10,826	6,646	2,912	9,558	8,390	2,038	10,428
	101	N. Santa Bárbara	—	—	—	—	—	—	—	—	—
	102	Rancho Alegre	1,942	5,557	7,499	2,355	2,525	4,880	3,264	1,245	4,509
	103	Santa Cecília Pavão	2,980	10,333	13,313	4,198	5,668	9,866	4,748	3,894	8,642
	104	São Jerônimo Serra	2,057	22,403	24,460	2,974	13,415	16,389	4,892	8,383	13,275
	105	S. Sebastião Amoreira	1,803	11,006	12,809	2,579	4,356	6,935	4,516	3,427	7,943
	106	Urai	6,667	11,734	18,401	7,114	6,865	13,979	9,195	4,104	13,299
	Subtotal of Municipalities of Basin		28,255	88,143	116,398	35,990	47,713	83,703	47,969	30,452	78,421
	Subtotal of Municipalities not of Basin		0	0	0	0	0	0	0	0	0
MRH 281		TOTAL OF MRH	333,024	351,924	684,948	527,638	177,793	705,431	713,505	103,335	816,840
N. N. Londrina	109	Arapongas	36,609	14,601	51,210	48,213	6,455	54,668	60,025	4,531	64,556
	113	Cambé	13,510	22,111	35,621	44,803	9,053	53,856	66,817	7,025	73,842
	119	Ibiporã	12,999	14,194	27,193	20,064	7,560	27,624	30,728	4,440	35,168
	124	Londrina	163,528	64,573	228,101	266,940	34,771	301,711	366,676	23,424	390,100
	131	Primeiro de Maio	6,076	19,662	25,738	7,913	5,301	13,214	9,773	2,137	11,910
	132	Rolândia	20,845	27,119	47,964	26,968	14,484	41,452	35,276	8,500	43,776
	137	Sertanópolis	5,887	15,990	21,877	7,970	8,510	16,480	9,998	4,293	14,291
	Subtotal of Municipalities of Basin		259,454	178,250	437,704	422,871	86,134	509,005	579,293	54,350	633,643
	Subtotal of Municipalities not of Basin		73,570	173,674	247,244	104,767	91,659	196,426	134,212	48,985	183,197
MRH 284		TOTAL of MRH	110,531	351,354	461,885	169,930	211,157	381,087	210,412	115,301	325,713
N. N. Apucarana	184	Apucarana	43,573	25,729	69,302	67,161	13,084	80,245	86,079	8,985	95,064
	187	Califórnia	2,999	8,563	11,562	3,405	4,680	8,085	4,525	2,804	7,329
	198	Marilândia do Sul	2,365	19,084	21,949	5,810	8,102	13,912	7,790	5,974	13,764
	200	Mauá da Serra	—	—	—	—	—	—	—	—	—
	Subtotal of Municipalities of Basin		49,437	53,376	102,813	76,376	25,866	102,242	98,394	17,763	116,157
	Subtotal of Municipalities not of Basin		61,094	297,978	359,072	93,554	185,291	278,845	112,018	97,538	209,556
TOTAL OF MUNICIPALITIES OF THE BASIN			575,756	632,676	1,208,432	894,878	431,567	1,326,445	1,208,314	316,721	1,525,035

Source: Census of 1970, 1980 and 1991 / IBGE, IPARDES

Remark: Municipalities without number of population had not been created until the respective year

: Figures of Porto Amazonas/MRH 272 are listed in Iguaçu River Basin

Table - 3.5 (1) GRDP per Municipality in 1981, 1983, 1985, 1987, 1989 and 1991 / Tibagi River Basin

No. and Name of MRH	No. and Name of Municipality		YEAR											
			1981		1983		1985		1987		1989		1991	
	No.	Name	%	US$ million	%	US$ millio	%	US$ million	%	US$ million	%	US$ million	% / Estado	% / MR	US$ million
MRH 272		TOTAL of MRH	100.00	164.30	100.00	151.20	100.00	187.40	100.00	214.50	100.00	271.50	1.08390	100.00	273.41
Campos da Lapa	34	Palmeira	30.14	49.52	25.28	38.22	28.95	54.26	34.25	73.46	25.49	69.19	0.29083	26.83	73.36
	35	Porto Amazonas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00
	Subtotal of Municipalities of Basin		30.14	49.52	25.28	38.22	28.95	54.26	34.25	73.46	25.49	69.19	0.29083	26.83	73.36
	Subtotal of Municipalities not of Basin		69.86	114.78	74.72	112.98	71.05	133.14	65.75	141.04	74.51	202.31	0.79307	73.17	200.05
MRH 273		TOTAL of MRH	100.00	1,040.70	100.00	1,177.80	100.00	1,208.80	100.00	1,516.20	100.00	1,719.30	6.09795	100.00	1,538.21
Campos Ponta Grossa	37	Castro	14.62	152.13	13.67	160.98	15.11	182.70	15.59	236.34	18.00	309.48	1.18418	19.42	298.71
	38	Piraí do Sul	2.78	28.91	1.85	21.82	2.96	35.75	3.15	47.73	3.03	52.08	0.18115	2.97	45.70
	39	Ponta Grossa	57.62	599.61	63.94	753.10	56.72	685.59	51.39	779.18	51.82	890.86	3.30030	54.12	832.50
	40	Telêmaco Borba	21.28	221.46	17.54	206.57	20.85	252.02	25.64	388.76	23.66	406.81	1.24121	20.35	313.10
	41	Tibagi	3.71	38.60	3.00	35.32	4.36	52.74	4.23	64.20	3.49	60.06	0.13012	2.13	32.82
	42	Ventania	0.00	0.00	0,00	0,00	0,00	0,00	0,00	0.00	0.00	0.00	0.06099	1.00	15.38
	Subtotal of Municipalities of Basin		100.00	1,040.70	100.00	1,177.80	100.00	1,208.80	100.00	1,516.20	100.00	1,719.30	6.09795	100.00	1,538.21
	Subtotal of Municipalities not of Basin		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0.00	0.00	0.00	0.00000	0.00	0.00
MRH 276		TOTAL of MRH	100.00	126.70	100.00	111.70	100.00	160.90	100.00	173.20	100.00	197.70	0.79235	100.00	199.87
Col. Irati	49	Imbituva	12.01	15.22	12.79	14.28	12.67	20.38	12.96	22.45	10.98	21.71	0.09247	11.67	23.33
	50	Irati	44.03	55.78	39.24	43.83	37.65	60.58	38.26	66.26	44.18	87.35	0.32196	40.63	81.21
	55	Teixeira Soares	9.87	12.50	7.88	8.80	12.15	19.54	10.74	18.60	9.51	18.80	0.08750	11.04	22.07
	Subtotal of Municipalities of Basin		65.90	83.50	59.90	66.91	62.46	100.51	61.96	107.32	64.67	127.86	0.50193	63.35	126.61
	Subtotal of Municipalities not of Basin		34.10	43.20	40.10	44.79	37.54	60.39	38.04	65.88	35.33	69.84	0.29042	36.65	73.26
MRH 277		TOTAL of MRH	100.00	36.20	100.00	29.70	100.00	53.70	100.00	39.50	100.00	46.90	0.17272	100.00	43.57
Alto Ivaí	57	Ipiranga	15.60	5.65	15.27	4.53	22.41	12.03	23.19	9.16	17.17	8.05	0.04526	26.20	11.42
	58	Ivaí	16.54	5.99	15.93	4.73	16.13	8.66	20.59	8.13	15.14	7.10	0.02959	17.13	7.46
	59	Ortigueira	28.27	10.23	31.63	9.39	26.91	14.45	19.63	7.76	30.35	14.23	0.02898	16.78	7.31
	60	Reserva	25.36	9.18	20.78	6.17	19.17	10.29	17.56	6.94	21.45	10.06	0.03202	18.54	8.08
	Subtotal of Municipalities of Basin		85.77	31.05	83.61	24.83	84.61	45.43	80.98	31.99	84.11	39.45	0.13585	78.65	34.27
	Subtotal of Municipalities not of Basin		14.23	5.15	16.39	4.87	15.39	8.27	19.02	7.51	15.89	7.45	0.03687	21.35	9.30
MRH 278		TOTAL of MRH	100.00	132.70	100.00	103.70	100.00	143.40	100.00	142.00	100.00	141.90	0.55211	100.00	139.27
N.V.Wenceslau Braz	63	Curiúva	4.62	6.13	3.61	3.75	3.92	5.62	3.73	5.29	3.42	4.86	0.01616	2.93	4.08
	75	Sapopema	1.78	2.36	1.70	1.76	2.50	3.58	1.87	2.66	3.75	5.32	0.02627	4.76	6.63
	Subtotal of Municipalities of Basin		6.40	8.49	5.31	5.51	6.41	9.20	5.60	7.96	7.17	10.17	0.04243	7.69	10.70
	Subtotal of Municipalities not of Basin		93.60	124.21	94.69	98.19	93.59	134.20	94.40	134.40	92.83	131.73	0.50968	92.31	128.57
MRH 279		TOTAL of MRH	100.00	595.50	100.00	603.30	100.00	884.70	100.00	800.30	100.00	795.60	2.68494	100.00	677.28
N. V. Jacarezinho	84	Congonhinhas	0.73	4.37	0.74	4.44	1.31	11.61	1.27	10.18	0.75	5.99	0.02380	0.89	6.00
	85	Cornélio Procópio	22.31	132.85	19.64	118.50	23.28	206.00	18.43	147.53	22.67	180.34	0.56545	21.06	142.63
	89	Leópolis	2.61	15.56	2.83	17.09	3.45	30.49	2.21	17.65	2.99	23.80	0.06772	2.52	17.08
	90	N. América Colina	0.88	5.23	1.43	8.64	1.93	17.07	1.40	11.17	1.31	10.45	0.03098	1.15	7.81
	91	Nova Fátima	1.84	10.97	1.38	8.33	1.54	13.61	1.52	12.20	1.65	13.16	0.04858	1.81	12.25
	97	S. Antônio Paraíso	0.70	4.19	0.77	4.63	0.64	5.65	0.60	4.84	0.62	4.97	0.01930	0.72	4.87
	98	Sertaneja	5.72	34.07	6.19	37.32	5.17	45.75	4.27	34.16	4.60	36.57	0.12772	4.76	32.22
	Subtotal of Municipalities of Basin		34.80	207.24	32.98	198.95	37.32	330.18	29.70	237.72	34.60	275.28	0.88355	32.91	222.88
	Subtotal of Municipalities not of Basin		65.20	388.26	67.02	404.35	62.68	554.52	70.30	562.58	65.40	520.32	1.80139	67.09	454.40

(To be continued)

Table - 3.5 (2) GRDP per Municipality in 1981, 1983, 1985, 1987, 1989 and 1991 / Tibagi River Basin

(Continuation)

No. and Name of MRH	No. and Name of Municipality		YEAR													
			1981		1983		1985		1987		1989		1991			
	No.	Name	%	US$ million	%	US$ million	%	US$ million	%	US$ million	%	US$ million	% / Estado	% / MR	US$ million	
MRH 280		TOTAL of MRH	100.00	158.10	100.00	160.90	100.00	219.40	100.00	202.90	100.00	208.00	0.55597	100.00	140.24	
Algodoeira de Assaí	99	Assaí	44.98	71.11	42.80	68.87	33.29	73.03	40.43	82.04	45.13	93.88	0.27193	48.91	68.59	
	100	Jataizinho	18.26	28.87	19.52	31.42	24.30	53.31	18.98	38.51	4.84	10.07	0.06220	11.19	15.69	
	101	N. Santa Bárbara	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01442	2.59	3.64	
	102	Rancho Alegre	7.61	12.04	7.57	12.18	10.91	23.93	7.99	16.20	17.52	36.45	0.06504	11.70	16.41	
	103	Santa Cecília Pavão	6.67	10.54	5.54	8.92	5.42	11.89	5.81	11.78	5.14	10.70	0.02269	4.08	5.72	
	104	São Jerônimo Serra	5.81	9.19	4.71	7.59	6.94	15.22	5.42	10.99	3.65	7.58	0.02513	4.52	6.34	
	105	S. Sebastião Amoreira	6.68	10.55	6.78	10.90	5.95	13.05	7.29	14.79	8.30	17.27	0.04111	7.39	10.37	
	106	Uraí	9.99	15.79	13.07	21.03	13.20	28.96	14.09	28.59	15.41	32.06	0.05345	9.61	13.48	
	Subtotal of Municipalities of Basin		100.00	158.10	100.00	160.90	100.00	219.40	100.00	202.90	100.00	208.00	0.55597	100.00	140.24	
	Subtotal of Municipalities not of Basin		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00000	0.00	0.00	
MRH 281		TOTAL of MRH	100.00	1,551.50	100.00	1,781.30	100.00	2,594.00	100.00	2,359.90	100.00	2,252.60	8.65165	100.00	2,182.38	
N. N. Londrina	109	Arapongas	8.06	125.08	7.66	136.43	6.87	178.21	9.75	229.98	7.24	163.11	0.96809	11.19	244.20	
	113	Cambé	5.81	90.09	11.17	198.98	5.99	155.46	6.20	146.39	7.66	172.65	0.67311	7.78	169.79	
	119	Ibiporã	4.02	62.39	3.77	67.23	2.59	67.13	3.77	88.86	2.58	58.01	0.27165	3.14	68.52	
	124	Londrina	51.66	801.47	48.56	864.99	53.60	1,390.31	51.09	1,205.57	46.91	1,056.75	4.27549	49.42	1,078.49	
	131	Primeiro de Maio	2.05	31.82	1.71	30.51	1.65	42.82	1.09	25.61	1.37	30.77	0.12923	1.49	32.60	
	132	Rolândia	5.00	77.52	5.10	90.89	5.99	155.46	5.88	138.71	6.90	155.52	0.53295	6.16	134.44	
	137	Sertanópolis	2.48	38.54	2.02	36.06	2.14	55.46	1.56	36.90	1.99	44.74	0.15870	1.83	40.03	
	Subtotal of Municipalities of Basin		79.08	1,226.92	80.00	1,425.10	78.83	2,044.86	79.33	1,872.01	74.65	1,681.56	7.00922	81.02	1,768.08	
	Subtotal of Municipalities not of Basin		20.92	324.58	20.00	356.20	21.17	549.14	20.67	487.89	25.35	571.04	1.64243	18.98	414.30	
MRH 284		TOTAL of MRH	100.00	464.40	100.00	425.60	100.00	692.70	100.00	597.90	100.00	632.20	2.02660	100.00	511.21	
N. N. Apucarana	184	Apucarana	33.78	156.87	33.86	144.09	44.70	309.63	38.13	227.95	43.36	274.10	0.81628	40.28	205.91	
	187	Califórnia	1.18	5.49	1.16	4.93	0.98	6.76	1.07	6.38	1.71	10.80	0.02262	1.12	5.71	
	198	Marilândia do Sul	4.92	22.86	7.04	29.98	4.45	30.81	7.93	47.40	5.09	32.20	0.04318	2.13	10.89	
	200	Mauá da Serra	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07923	3.91	19.99	
	Subtotal of Municipalities of Basin		39.88	185.21	42.06	178.99	50.12	347.20	47.12	281.73	50.16	317.10	0.96131	47.43	242.49	
	Subtotal of Municipalities not of Basin		60.12	279.19	57.94	246.61	49.88	345.50	52.88	316.17	49.84	315.10	1.06529	52.57	268.72	
TOTAL OF MUNICIPALITIES OF THE BASIN				2,990.74		3,277.21		4,359.83		4,331.29		4,447.92			4,156.84	

Source : Estatística Econômico Financeira (Finance Economic Statistics) 74/85, 86/87, 88/89 - SEFA; Fundo de Participação dos Municípios-Índices Provisórios-95 (Municipalities' Participation Fund-Preliminary Indexes - 95) - SEFA

Remark : Figures of Porto Amazonas/MRH 272 are listed in Iguaçu River Basin

: In the figures of 1989 and 1991 was included the value added of contribution of Hydroelectric Power Stations

CHAPTER 4 FUTURE SOCIO-ECONOMIC FRAMEWORK

4.1 Population Projection Per Municipality

The population projection per municipality was carried out based on the preliminary estimation by IPARDES for the years of 1993, 1995 and 2000 (estimated rural population, urban population and total population per municipality).

The projection for the target years was carried out by JICA Team, as follows: 1) the population of all municipalities of each MRH, which includes any of the municipalities belonging to the zoning, was estimated based on the trend of increase (or decrease) of the municipalities' population in 1993, 1995 and 2000, divided into urban population and rural population; 2) the total of urban and rural population of these municipalities was adjusted tentatively to the estimated urban and rural population of the MRH to which they belong; 3) finally, the municipalities of each MRH that are included by the zoning and, therefore, belong to the river basin, were separated from those that are not included in the river basin. The estimated population per municipality in 1993 by IPARDES and 2005 and 2015 by JICA Team are shown in Table-4.1 (1) and Table-4.1 (2).

4.2 Projection of Gross Regional Domestic Production (GRDP) per Municipality and GRDP by Secondary Sector per Municipality

4.2.1 GRDP per Municipality

GRDP per municipality in 1993 was estimated by the same method mentioned in Section-3.6.3, but by excluding the contribution of hydroelectric power stations of some municipalities. And the GRDP per Municipality for the target years 2005 and 2015 was estimated individually, based on the past trend of GRDP per municipality during the years of 1981 to 1991 (shown in Table-3.5 (1) and Table-3.5 (2)) also excluding the contribution of hydroelectric power stations of some municipalities in 1989 and 1991, and on 1993, by adjusting the estimated GRDP per MRH to the years to which they belong.

The estimated GRDP per Municipality of the 43 municipalities in 1993, 2005 and 2015 are shown in Table-4.2.

4.2.2 GRDP by Secondary Sector per Municipality

GRDP by Secondary Sector per Municipality in 1993, 2005 and 2015 was estimated using the same method mentioned in Section-4.2.1. This estimation, however, is presented in Section-5.2.

Table-4.1 (1) Projected Population per Municipality in 1993, 2005 and 2015, and Area per Municipality/Tibagi River Basin

No. and Name of MRH	No. and Name of Municipality		Population									Urban Area	Area		
			1993			2005			2015				Total Area	Area Involved	
	No.	Name	URBAN	RURAL	TOTAL	URBAN	RURAL	TOTAL	URBAN	RURAL	TOTAL			%	Km²
MRH 272		Total of MRH	60,616	46,044	106,660	73,600	46,400	120,000	84,800	44,100	128,900				
C. da LAPA	34	Palmeira	15,221	14,533	29,754	17,900	15,500	33,400	20,230	15,340	35,570	Y	1,500.8	81.78	1,227.4
	35	Porto Amazonas	0	0	0	0	0	0	0	0	0	N	206.8	26.02	53.8
	Subtotal of Municipalities of Basin		15,221	14,533	29,754	17,900	15,500	33,400	20,230	15,340	35,570	—	—	—	—
	Subtotal of Municipalities not of Basin		45,395	31,511	76,906	55,700	30,900	86,600	64,570	28,760	93,330	—	—	—	—
MRH 273		Total of MRH	349,228	65,327	414,555	441,200	55,400	496,600	519,800	44,800	564,600				
C. de PONTA GROSSA	37	Castro	41,065	24,987	66,052	57,250	24,710	81,960	71,080	22,520	93,600	Y	3,089.8	73.74	2,278.4
	38	Piraí do Sul	12,568	6,964	19,532	15,060	6,130	21,190	17,190	5,000	22,190	Y	1,367.3	70.59	965.2
	39	Ponta Grossa	226,775	12,133	238,908	269,880	10,480	280,360	306,720	8,340	315,060	Y	2,269.6	82.43	1,870.8
	40	Telêmaco Borba	57,538	9,397	66,935	80,350	4,990	85,340	99,820	2,710	102,530	Y	1,625.3	100.00	1,625.30
	41	Tibagi	7,631	8,995	16,626	12,760	6,660	19,420	17,150	4,310	21,460	Y	2,938.1	99.61	2,926.6
	42	Ventania	3,651	2,851	6,502	5,900	2,430	8,330	7,840	1,920	9,760	N	824.2	46.12	380.1
	Subtotal of Municipalities of Basin		349,228	65,327	414,555	441,200	55,400	496,600	519,800	44,800	564,600	—	—	—	—
	Subtotal of Municipalities not of Basin		0	0	0	0	0	0	0	0	0	—	—	—	—
MRH 276		Total of MRH	71,821	103,597	175,418	90,400	103,300	193,700	105,900	97,300	203,200				
Col. de IRATI	49	Imbituva	8,119	18,063	26,182	9,970	18,650	28,620	11,520	18,040	29,560	Y	1,073.8	75.55	811.3
	50	Irati	32,420	16,180	48,600	40,450	12,840	53,290	47,140	9,670	56,810	Y	896.8	15.57	139.6
	55	Teixeira Soares	4,771	9,455	14,226	6,330	8,680	15,010	7,620	7,630	15,260	Y	1,343.3	97.04	1,303.5
	Subtotal of Municipalities of Basin		45,310	43,698	89,008	56,750	40,170	96,920	66,290	35,340	101,630	—	—	—	—
	Subtotal of Municipalities not of Basin		26,511	59,899	86,410	33,650	63,130	96,780	39,610	61,960	101,570	—	—	—	—
MRH 277		Total of MRH	23,934	72,182	96,116	32,600	59,500	92,100	39,700	46,600	86,300				
ALTO IVAI	57	Ipiranga	3,345	9,532	12,877	4,280	10,800	15,080	5,050	10,430	15,480	Y	932.3	99.97	932.0
	58	Ivaí	3,145	8,325	11,470	4,530	7,570	12,100	5,660	5,980	11,640	N	609.9	34.80	212.2
	59	Ortigueira	5,444	19,339	24,783	5,670	8,500	14,170	5,880	3,730	9,610	Y	2,471.6	64.27	1,588.5
	60	Reserva	7,753	17,333	25,086	11,800	14,740	26,540	15,110	10,720	25,830	Y	1,770.8	31.39	555.9
	Subtotal of Municipalities of Basin		19,687	54,529	74,216	26,280	41,610	67,890	31,700	30,860	62,560	—	—	—	—
	Subtotal of Municipalities not of Basin		4,247	17,653	21,900	6,320	17,890	24,210	8,000	15,740	23,740	—	—	—	—
MRH 278		Total of MRH	96,440	71,394	167,834	123,300	45,000	168,300	145,700	28,900	174,600				
N. V. DE WENCESLAU B.	63	Curiúva	4,380	6,274	10,654	7,290	4,820	12,110	9,690	3,770	13,460	Y	581.7	62.19	361.8
	75	Sapopema	3,119	3,928	7,047	5,000	2,370	7,370	6,560	1,520	8,080	Y	694.2	76.62	531.9
	Subtotal of Municipalities of Basin		7,499	10,202	17,701	12,290	7,190	19,480	16,250	5,290	21,540	—	—	—	—
	Subtotal of Municipalities not of Basin		88,941	61,192	150,133	111,010	37,810	148,820	129,450	23,610	153,060	—	—	—	—
MRH 279		Total of MRH	220,756	86,480	307,236	262,100	50,900	313,000	298,200	30,600	328,800				
N. V. JACAREZINHO	84	Congonhinhas	4,211	3,505	7,716	5,700	1,960	7,660	6,990	1,000	7,990	P	588.1	17.78	104.6
	85	Cornélio Procópio	40,907	6,132	47,039	48,060	3,050	51,110	54,290	1,040	55,330	P	627.8	53.65	336.7
	89	Leópolis	2,361	2,365	4,726	3,220	1,360	4,580	3,960	750	4,710	N	344.7	19.98	68.9
	90	N. América da Colina	1,880	2,173	4,053	2,370	1,360	3,730	2,800	880	3,680	Y	133.3	100.00	133.3
	91	Nova Fátima	6,099	2,265	8,364	7,190	1,310	8,500	8,140	730	8,870	N	232.1	35.99	83.5
	97	S. Antônio do Paraíso	1,210	1,168	2,378	1,250	560	1,810	1,300	340	1,640	Y	151.9	100.00	151.9
	98	Sertaneja	4,941	1,707	6,648	5,460	970	6,430	5,910	680	6,590	Y	433.0	52.35	226.7
	Subtotal of Municipalities of Basin		61,609	19,315	80,924	73,250	10,570	83,820	83,390	5,420	88,810	—	—	—	—
	Subtotal of Municipalities not of Basin		159,147	67,165	226,312	188,850	40,330	229,180	214,810	25,180	239,990	—	—	—	—

(To be continued)

Table-4.1 (2) Projected Population per Municipality in 1993, 2005 and 2015, and Area per Municipality/Tibagi River Basin

(Continuation)

No. and Name of MRH	No. and Name of Municipality		Population									Urban Area	Area		
			1993			2005			2015				Total Area	Area Involved	
	No.	Name	URBAN	RURAL	TOTAL	URBAN	RURAL	TOTAL	URBAN	RURAL	TOTAL			%	Km²
MRH 280		Total of MRH	49,386	28,412	77,798	60,200	15,900	76,100	69,500	9,200	78,700	—	—	—	—
ALG. DE ASSAI	99	Assaí	13,249	6,819	20,068	15,380	3,720	19,100	17,230	2,370	19,600	Y	450.5	100.00	450.5
	100	Jataizinho	8,565	1,918	10,483	9,820	1,180	11,000	10,910	830	11,740	Y	199.1	100.00	199.1
	101	N. Santa Barbara	2,115	1,552	3,667	2,170	1,040	3,210	2,230	710	2,940	Y	112.2	100.00	112.2
	102	Rancho Alegre	3,365	1,105	4,470	4,120	480	4,600	4,780	250	5,030	Y	187.4	100.00	187.4
	103	Santa Cecília do Pavão	2,639	2,141	4,780	2,670	1,200	3,870	2,700	780	3,480	Y	68.5	100.00	68.5
	104	São Jerônimo Serra	5,234	7,795	13,029	7,710	4,040	11,750	9,800	1,440	11,240	Y	851.7	99.95	851.3
	105	S. Sebastião Amoreira	4,859	3,316	8,175	7,470	2,280	9,750	9,680	1,620	11,300	Y	217.4	100.00	217.4
	106	Uraí	9,360	3,766	13,126	10,860	1,960	12,820	12,170	1,200	13,370	Y	209.6	100.00	209.6
	Subtotal of Municipalities of Basin		49,386	28,412	77,798	60,200	15,900	76,100	69,500	9,200	78,700	—	—	—	—
	Subtotal of Municipalities not of Basin		0	0	0	0	0	0	0	0	0	—	—	—	—
MRH 281		Total of MRH	738,500	94,994	833,494	935,700	48,600	984,300	1,103,700	26,000	1,129,700				
N. N. LONDRINA	109	Arapongas	61,063	4,275	65,338	70,520	2,480	73,000	78,620	1,220	79,840	P	395.0	48.59	191.9
	113	Cambé	70,214	6,743	76,957	96,450	4,460	100,910	118,770	2,880	121,650	P	478.9	29.96	143.5
	119	Ibiporã	32,425	4,079	36,504	45,730	2,000	47,730	57,060	1,140	58,200	Y	295.4	100.00	295.4
	124	Londrina	380,979	21,995	402,974	488,390	12,880	501,270	579,760	8,330	588,090	Y	2,095.6	100.00	2,095.6
	131	Primeiro de Maio	9,922	1,853	11,775	11,340	640	11,980	12,560	270	12,830	Y	371.7	38.41	142.8
	132	Rolândia	34,929	6,774	41,703	42,280	3,370	45,650	48,550	1,880	50,430	N	473.7	12.11	57.4
	137	Sertanópolis	10,188	3,842	14,030	11,930	1,660	13,590	13,420	840	14,260	Y	493.0	97.13	478.9
	Subtotal of Municipalities of Basin		599,720	49,561	649,281	766,640	27,490	794,130	908,740	16,560	925,300	—	—	—	—
	Subtotal of Municipalities not of Basin		138,780	45,433	184,213	169,060	21,110	190,170	194,960	9,440	204,400	—	—	—	—
MRH 284		Total of MRH	214,052	104,770	318,822	257,900	53,900	311,800	297,300	29,200	326,500				
N. N. APUCARANA	184	Apucarana	88,221	8,449	96,670	110,160	5,150	115,310	129,880	2,610	132,490	P	554.9	32.83	182.2
	187	Califórnia	4,646	2,570	7,216	5,950	1,430	7,380	7,120	910	8,030	Y	130.9	74.27	97.2
	198	Marilândia do Sul	4,912	4,261	9,173	6,450	2,850	9,300	7,840	2,110	9,950	N	385.3	39.51	152.2
	200	Mauá da Serra	3,098	1,404	4,502	3,830	1,010	4,840	4,490	730	5,220	P	153.4	31.27	48.0
	Subtotal of Municipalities of Basin		100,877	16,684	117,561	126,390	10,440	136,830	149,330	6,360	155,690	—	—	—	—
	Subtotal of Municipalities not of Basin		113,175	88,086	201,261	131,510	43,460	174,970	147,970	22,840	170,810	—	—	—	—
TOTAL OF MUNICIPALITIES OF THE BASIN			1,248,537	302,261	1,550,798	1,580,900	224,270	1,805,170	1,865,230	169,170	2,034,400	—	—	—	—

Source: IPARDES - Population in 1993, SANEPAR - Area of Municipality

Remark: Population in 1993 projected by IPARDES, and in 2005 and 2015 were projected by JICA Team.

Figures of Porto Amazonas/MRH 272 are listed in Iguaçu River Basin

Urban Area: Y = Urban Area in the River Basin, P = Part of the Urban Area in the River Basin, N = Urban Area not included in the River Basin, (P)N = Topografically the Urban Area does not belong to the River Basin, but the Study will consider it as part of the Basin

Table-4.2 Estimated GRDP per Municipality in 1993, 2005 and 2015 - Excluding Contribution of Hydroelectric Power Stations / Tibagi River Basin

Unit: US$ million

No. and Name of MRH	No. and Name of Municipality	1993	2005	2015
MRH 272	TOTAL of MRH	362.82	667.94	1,163.22
Campos da Lapa	34 Palmeira	76.49	145.74	241.12
	35 Porto Amazonas	0.00	0.00	0.00
	Subtotal of Municipalities of Basin	76.49	145.74	241.12
	Subtotal of Municipalities not of Basin	286.33	522.20	922.10
MRH 273	TOTAL of MRH	1,545.30	2,870.83	4,632.53
C. Ponta Grossa	37 Castro	334.63	687.32	1,196.61
	38 Piraí do Sul	49.06	101.20	171.60
	39 Ponta Grossa	852.12	1,427.23	2,230.33
	40 Telêmaco Borba	254.83	558.33	881.22
	41 Tibagi	49.79	87.10	135.50
	42 Ventania	4.87	9.65	17.27
	Subtotal of Municipalities of Basin	1,545.30	2,870.83	4,632.53
	Subtotal of Municipalities not of Basin	0.00	0.00	0.00
MRH276	TOTAL of MRH	200.53	383.82	637.75
Col. Irati	49 Imbituva	26.95	47.74	79.49
	50 Irati	91.85	171.30	289.31
	55 Teixeira Soares	15.60	34.82	56.57
	Subtotal of Municipalities of Basin	134.39	253.86	425.37
	Subtotal of Municipalities not of Basin	66.14	129.96	212.38
MRH 277	TOTAL of MRH	42.78	69.22	104.06
Alto Ivaí	57 Ipiranga	9.85	20.03	33.30
	58 Ivaí	9.51	15.18	24.48
	59 Ortigueira	6.66	6.50	4.11
	60 Reserva	8.66	11.52	15.90
	Subtotal of Municipalities of Basin	34.68	53.23	77.78
	Subtotal of Municipalities not of Basin	8.10	15.98	26.28
MRH 278	TOTAL of MRH	149.02	216.28	332.69
N.V. Wenceslau Braz	63 Curiúva	5.90	5.88	7.40
	75 Sapopema	8.31	16.78	29.97
	Subtotal of Municipalities of Basin	14.21	22.66	37.36
	Subtotal of Municipalities not of Basin	134.81	193.62	295.33
MRH 279	TOTAL of MRH	664.90	1,013.13	1,436.03
N.V. Jacarezinho	84 Congonhinhas	8.57	13.26	20.47
	85 Cornélio Procópio	141.43	211.26	292.88
	89 Leópolis	11.84	16.24	17.02
	90 N. América Colina	8.59	13.10	17.80
	91 N. Fátima	9.64	15.76	21.79
	97 S. Antônio Paraíso	3.85	5.42	6.79
	98 Sertaneja	31.98	31.70	37.27
	Subtotal of Municipalities of Basin	215.90	306.74	414.02
	Subtotal of Municipalities not of Basin	449.00	706.39	1,022.01
MRH 280	TOTAL of MRH	135.06	171.29	191.06
Alg. Assaí	99 Assaí	69.50	84.29	90.63
	100 Jataizinho	12.03	11.83	11.48
	101 N.Santa Barbara	2.38	2.76	2.98
	102 Rancho Alegre	16.75	32.54	41.68
	103 Santa Cecília Pavão	7.71	8.29	8.92
	104 São Jerônimo Serra	5.12	5.12	5.12
	105 S. Sebastião Amoreira	12.33	17.22	21.01
	106 Uraí	9.24	9.24	9.24
	Subtotal of Municipalities of Basin	135.06	171.29	191.06
	Subtotal of Municipalities not of Basin	0.00	0.00	0.00
MRH 281	TOTAL of MRH	2,344.76	3,862.85	5,990.97
N.N. Londrina	109 Arapongas	187.55	368.87	576.08
	113 Cambé	298.00	438.75	718.50
	119 Ibiporã	66.83	85.19	110.43
	124 Londrina	1,127.00	1,874.24	2,952.12
	131 Primeiro de Maio	24.00	22.70	22.70
	132 Rolândia	193.57	332.33	542.60
	137 Sertanópolis	45.83	57.99	79.75
	Subtotal of Municipalities of Basin	1,942.78	3,180.07	5,002.18
	Subtotal of Municipalities not of Basin	401.98	682.78	988.79
MRH 284	TOTAL of MRH	556.78	857.07	1,253.83
N.N. Apucarana	184 Apucarana	219.72	382.64	580.41
	187 Califórnia	5.87	10.83	16.12
	198 Marilândia do Sul	11.76	18.21	29.45
	200 Mauá da Serra	35.27	54.61	87.63
	Subtotal of Municipalities of Basin	225.59	393.47	596.53
	Subtotal of Municipalities not of Basin	331.19	463.60	657.30
TOTAL OF THE MUNICIPALITIES OF THE BASIN		4,324.40	7,391.90	11,617.96

Source: Fundo de Participação dos Municípios - Índices Preliminares/95 (Municipalities' Participation Fund - Preliminary Indexes/95) SEFA
Remark: Values in US$ were estimated by JICA Team
: Figures of Porto Amazonas/MRH 272 are listed in Iguaçu River Basin

4.2.3 Future Socio-Economic Framework

Based on the population projection per municipality (shown in Table-4.1 (1) and Table-4.1 (2)), and GRDP projection per municipality in 1993, 2005 and 2015 (shown in Table-4.2), the future socio-economic framework of this river basin can be estimated and conceived through the classification of the 43 municipalities into four categories. There are three remarkable points, as follows:

1) 4 large size municipalities (classified in 1st and 2nd classes) will occupy approximately 66% of the total urban population and 63% of the GRDP of this river basin in 2015, respectively.

2) 11 large and medium size municipalities will occupy 85% of the urban population and 89% of the GRDP of this river basin in 2015, respectively.

3) 6 municipalities which compose the urban axis with Maringá will share about 54% of the urban population and 47% of the GRDP of this river basin in 2015, respectively.

The classification of these 43 municipalities with their participation, in percentage, in this river basin's urban population and GRDP in 1993, 2005 and 2015, are shown in Table-4.3, Table-4.4 and Table-4.5.

Table - 4.3 Classification of Municipalities Related to Urban Population and GRDP per Municipality in 1993 / Tibagi River Basin

Classification	No. and Name of MRH	No. and Name of Municipality	Urban Population		GRDP per Municipality	
			Population	%	US$ million	%
1st Class	281/N. N. Londrina	124 Londrina	380,980	30.51	1,127.00	26.06
2nd Class	273/C. Ponta Grossa	39 Ponta Grossa	226,780	18.16	852.12	19.70
		40 Telêmaco Borba	57,540	4.61	254.83	5.89
		113 Cambé	70,210	5.62	298.00	6.89
		183 Apucarana	88,220	7.07	219.72	5.08
		Subtotal	442,750	35.46	1,624.67	37.57
3rd class	273/C. Ponta Grossa	37 Castro	41,070	3.29	334.63	7.74
	276/Col. Irati	50 Irati	32,420	2.60	91.85	2.12
	279/N. V. Jacarezinho	85 Cornélio Procópio	40,910	3.28	141.43	3.27
	281/N. N. Londrina	109 Arapongas	61,060	4.89	187.55	4.34
		119 Ibiporã	32,430	2.60	66.83	1.55
		132 Rolândia	34,930	2.80	193.57	4.48
		Subtotal	242,820	19.45	1,015.86	23.49
4th Class	Other 32 Municipalities	Subtotal	181,990	14.58	556.87	12.88
TOTAL OF MUNICIPALITIES OF BASIN			1,248,540	100.00	4,324.40	100.00

Remark: GRDP per Municipality not including contribution of Hydroelectric Power Stations

Table - 4.4 Classification of Municipalities Related to Urban Population and GRDP per Municipality in 2005 / Tibagi River Basin

Classification	No. and Name of MRH	No. and Name of Municipality	Urban Population		GRDP per Municipality	
			Population	%	US$ million	%
1st Class	281/N. N. Londrina	124 Londrina	488,390	30.89	1,874.24	25.33
2nd Class	273/C. Ponta Grossa	39 Ponta Grossa	269,880	17.07	1,427.23	19.29
		40 Telêmaco Borba	80,350	5.08	558.33	7.55
		113 Cambé	96,450	6.10	438.75	5.93
		183 Apucarana	110,160	6.97	382.64	5.17
		Subtotal	556,840	35.22	2,806.95	37.94
3rd class	273/C. Ponta Grossa	37 Castro	57,250	3.62	687.32	9.29
	276/Col. Irati	50 Irati	40,450	2.56	171.30	2.32
	279/N. V. Jacarezinho	85 Cornélio Procópio	48,060	3.04	211.26	2.86
	281/N. N. Londrina	109 Arapongas	70,520	4.46	368.87	4.99
		119 Ibiporã	45,730	2.89	85.19	1.15
		132 Rolândia	42,280	2.67	332.33	4.49
		Subtotal	304,290	19.25	1,856.27	25.09
4th Class	Other 32 Municipalities	Subtotal	231,380	14.64	860.44	11.63
TOTAL OF MUNICIPALITIES OF BASIN			1,580,900	100.00	7,397.90	100.00

Remark: GRDP per Municipality not including contribution of Hydroelectric Power Stations

Table - 4.5 Classification of Municipalities Related to Urban Population and GRDP per Municipality in 2015 / Tibagi River Basin

Classification	No. and Name of MRH	No. and Name of Municipality	Urban Population		GRDP per Municipality	
			Population	%	US$ million	%
1st Class	281/N. N. Londrina	124 Londrina	579,760	31.08	2,952.12	25.41
2nd Class	273/C. Ponta Grossa	39 Ponta Grossa	306,720	16.44	2,230.33	19.20
		40 Telêmaco Borba	99,820	5.35	881.22	7.58
		113 Cambé	118,770	6.37	718.50	6.18
		183 Apucarana	129,880	6.96	580.41	5.00
		Subtotal	655,190	35.13	4,410.46	37.96
3rd class	273/C. Ponta Grossa	37 Castro	71,080	3.81	1,196.61	10.30
	276/Col. Irati	50 Irati	47,140	2.53	289.31	2.49
	279/N. V. Jacarezinho	85 Cornélio Procópio	54,290	2.91	292.88	2.52
	281/N. N. Londrina	109 Arapongas	78,620	4.22	576.08	4.96
		119 Ibiporã	57,060	3.06	110.43	0.95
		132 Rolândia	48,550	2.60	542.60	4.67
		Subtotal	356,740	19.13	3,007.91	25.89
4th Class	Other 32 Municipalities	Subtotal	273,540	14.67	1,247.47	10.74
TOTAL OF MUNICIPALITIES OF BASIN			1,865,230	100.00	11,617.96	100.00

Remark: GRDP per Municipality not including contribution of Hydroelectric Power Stations

CHAPTER 5 PRESENT SITUATION AND WATER DEMAND PROJECTION FOR 2005 AND 2015

5.1 Domestic Water

As described in Main Report I, the present average unit consumption rate of Paraná State and the present unit consumption rate per MRH, and future unit consumption rate, were estimated as shown below in Table-5.1, Table-5.2 and Table-5.3.

Table-5.1 Average Unit Consumption Rate of Paraná State - 1993, 2005 and 2015

	Average Unit Consumption Rate (l / person . day)								
	Residential Water			Non-Residential Water			Total Domestic Water		
	1993	2005	2015	1993	2005	2015	1993	2005	2015
Urban Population	90	115	140	25	30	40	115	145	180
Rural Population	70	75	80	0	0	0	70	75	80

Remark : Unit rate of residential water for rural population was estimated as unit rate of the 3rd Category of the classification of MRH (shown in Table-5.2 and Table -5.3)

Table-5.2 Unit Consumption Rate per MRH - 1993

	Classification	No. of MRH	Unit Consumption Rate (l / person . day)		
			Residential Water	Non-Residential Water	Total Domestic Water
Urban Population	1st Category	MRH 268, 281, 282	100	30	130
	2nd Category	MRH 269, 270 MRH 272 to MRH 276, MRH 279 to MRH 280 MRH 283 to MRH 286 MRH 288 to MRH 291	85	20	105
	3rd Category	MRH 271, 277, 278, 287	70	15	85
Rural Population	—	All MRH	70	—	70

Table-5.3 Unit Consumption Rate per MRH - 2005 and 2015

	Classification	No. of MRH	Unit Consumption Rate (l / person . day)					
			Residential Water		Non-Residential Water		Total Domestic Water	
			2005	2015	2005	2015	2005	2015
Urban Population	1st Category	MRH 268, 281, 282, 288	125	155	35	45	160	200
	2nd Category	MRH 269, 270, MRH 272 to MRH 276, MRH 279 to MRH 280, MRH 283, MRH 285 to MRH 286, MRH 289 to MRH 291	100	125	30	35	130	160
	3rd Category	MRH 271, 277, 278, 284, 287	75	80	20	25	95	105
Rural Population	—	All MRH	75	80	—	—	75	80

5.1.1 Present Unit Consumption Rate per Municipality

Each MRH was composed of municipalities with different sizes in terms of population and GRDP, therefore the Team collected the data of present unit consumption volume of residential water of some large-medium size municipalities in this river basin. Based on the information provided by ABC/SANEPAR, the unit consumption volume of 6 selected municipalities is presented in Table-5.4.

(1) Unit Consumption Rate of Residential Water for Urban Population per Municipality

According to Table-5.2 and Table-5.4, this unit rate was estimated tentatively between unit rate of large-medium size municipalities and other municipalities, by adjusting it to the total water demand per MRH to which they belong, calculated by multiplying the unit rate per MRH by the urban population per MRH.

(2) Unit Consumption Rate of Non-Residential Water for Urban Population per Municipality

This unit was estimated by the same method mentioned above, approximately in the same proportion between the unit rate of residential water and non-residential water of the MRH to which they belong.

(3) Unit Consumption Rate for Rural Population per Municipality

This unit rate was estimated using the same figure of the unit consumption rate per MRH and average unit consumption rate of Paraná State. It means that the same unit rate was applied to all municipalities.

According to what was mentioned above, present unit consumption rate per municipality for urban population and rural population is shown in Table-5.5.

Table-5.4 Present Unit Consumption Volume of Large and Medium Size Municipalities - 1993

No. and Name of MRH	No. and Name of Municipality		Average Consumption Volume per Month (m³)	Service Population Estimated by SANEPAR	Estimated Consumption Volume per Capita (l/day)
MRH 273/C. Ponta Grossa	39	Ponta Grossa	564,134	223,790	84.03
MRH 276/Colonial Irati	50	Irati	64,754	29,747	73.68
MRH 279/N. V. Jacarezinho	85	Comélio Procópio	132,239	43,651	100.98
	87	Jacarezinho	91,976	31,262	98.07
MRH 281/N. N. Londrina	124	Londrina	1,309,459	420,143	103.89
MRH 284/N. N. Apucarana	184	Apucarana	250,610	89,737	93.09

Source : APC/SANEPAR

5.1.2 Future Unit Consumption Rate per Municipality

(1) Unit Consumption Rate per Municipality of Residential Water for Urban Population

Based on the unit rate consumption rate per MRH in 2005 and 2015 (shown in Table-5.3) and present unit consumption rate per municipality (shown in Table-5.4), this unit rate was estimated by the same method mentioned in Section-5.1.1 (1), approximately in the same proportion of present unit consumption rate between large-medium size municipalities and other municipalities.

(2) Unit Consumption Rate per Municipality of Non-Residential Water for Urban Population

Based on the unit consumption rate per MRH in 2005 and 2015, this unit rate was estimated by the same method of present unit consumption rate per municipality.

(3) Unit Consumption Rate per Municipality for Rural Population

This unit rate in 2005 and 2015 was estimated using the same figure of the unit consumption rate per MRH in 2005 and 2015, respectively.

According to what was mentioned above, the unit consumption rate per municipality in 2005 and 2015 is shown in Table-5.6 and Table-5.7, respectively.

5.1.3 Water Demand Projection

Water Demand in 1993, 2005 and 2015 was estimated by multiplying the urban and rural population per municipality of each year (shown in Table-4.1 (1) and Table-4.1 (2), by the unit consumption rate per municipality of the corresponding year (shown in Table-5.5, Table-5.6 and Table-5.7), and is presented in Section-5.4.

Table-5.5 Present Unit Consumption Rate of Domestic Water per Municipality - 1993

Classification of MRH	No. and Name of MRH	Classification of Municipality	Unit Consumption Rate (l / person . day)			
			Urban Population			Rural Population
			Residential Water	Non-Residential Water	Total Domestic Water	Domestic Water
1st Category	MRH 281/N. N. Londrina	Londrina	105	35	140	
		Other Municipalities	95	25	120	70
2nd Category	MRH 272/Campos da Lapa					
	MRH 273/C. Ponta Grossa					
	MRH 276/Col. Irati	All Municipalities	85	20	105	70
	MRH 279/N. V. Jacarezinho	Cornélio Procópio	100	25	125	
		Other Municipalities	80	15	95	70
	MRH 280/Algodoeira Assaí	All Municipalities	85	20	105	70
	MRH 284/N.N. Apucarana	Apucarana	95	25	120	
		Other Municipalities	70	15	85	70
3rd Category	MRH 277/Alto Ivaí					
	MRH 278/N. V. Wenceslau Braz	All Municipalities	70	15	85	70

Source : APC/SANEPAR

Remark: Jacarezinho in MRH 279 does not belong to the Basin but is estimated in the same way as Cornélio Procópio

Unit rate of Residential Water for rural population was estimated as the same figure as the unit rate of the 3rd Category of MRH Classification

Table-5.6 Future Unit Consumption Rate of Domestic Water per Municipality - 2005

Classification of MRH	No. and Name of MRH	Classification of Municipality	Unit Consumption Rate (l / person . day)			
			Urban Population			Rural Population
			Residential Water	Non-Residential Water	Total Domestic Water	Domestic Water
1st Category	MRH 281/N. N. Londrina	Londrina	135	40	175	
		Other Municipalities	115	30	145	75
2nd Category	MRH 272/Campos da Lapa					
	MRH 273/C. Ponta Grossa					
	MRH 276/Col. Irati	All Municipalities	100	30	130	75
	MRH 279/N. V. Jacarezinho	Cornélio Procópio	115	35	150	
		Other Municipalities	95	25	120	75
	MRH 280/Algodoeira Assaí	All Municipalities	100	30	130	75
	MRH 284/N.N. Apucarana	Apucarana	115	35	150	
		Other Municipalities	90	25	115	75
3rd Category	MRH 277/Alto Ivaí					
	MRH 278/N. V. Wenceslau Braz	All Municipalities	75	20	95	75

Remark: Jacarezinho in MRH 279 does not belong to the Basin but is estimated in the same way as Cornélio Procópio

Unit rate of Residential Water for rural population was estimated as the same figure as the unit rate of the 3rd Category of MRH Classification

Table-5.7 Future Unit Consumption Rate of Domestic Water per Municipality - 2015

Classification of MRH	No. and Name of MRH	Classification of Municipality	Unit Consumption Rate (l / person . day)			
			Urban Population			Rural Population
			Residential Water	Non-Residential Water	Total Domestic Water	Domestic Water
1st Category	MRH 281/N. N. Londrina	Londrina	160	50	210	
		Other Municipalities	145	40	185	80
2nd Category	MRH 272/Campos da Lapa					
	MRH 273/C. Ponta Grossa					
	MRH 276/Col. Irati	All Municipalities	125	35	160	80
	MRH 279/N. V. Jacarezinho	Cornélio Procópio	145	40	185	
		Other Municipalities	115	35	150	80
	MRH 280/Algodoeira Assaí	All Municipalities	125	35	160	80
	MRH 284/N.N. Apucarana	Apucarana	140	40	180	
		Other Municipalities	115	30	145	80
3rd Category	MRH 277/Alto Ivaí					
	MRH 278/N. V. Wenceslau Braz	All Municipalities	80	25	105	80

Remark: Jacarezinho In MRH 279 does not belong to the Basin but is estimated in the same way as Cornélio Procópio
Unit rate of Residential Water for rural population was estimated as the same figure as the unit rate of the 3rd Category of MRH Classification

5.2 Industrial Water

5.2.1 Unit Consumption Rate per Value Added (V.A.) per Municipality

During the study of the "Master Plan for Pilot River Basin(s)", complementary data regarding industrial water consumption could not be collected, therefore the Team decided to use the same unit consumption rate used for the estimation per MRH for the estimation of industrial water per municipality, as shown in Table-5.8.

Table-5.8 Average Unit Consumption Rate per Value Added (V.A.) - 1993, 2005 and 2015

Unit Rate - 1993 Unit Rate with Present Recovery Rate m^3/day . US$ 1,000.00 (V.A.)	Unit Rate - 2005 Increase of Water Recovery Rate: 19% m^3/day . US$ 1,000.00 (V.A.)	Unit Rate - 2015 Increase of Water Recovery Rate: 37.50% m^3/day . US$ 1,000.00 (V.A.)
0.059	0.048	0.037

5.2.2 Gross Regional Domestic Product (GRDP) by Secondary Sector per Municipality

For the estimation of industrial water demand for the target years, GRDP by Secondary Sector per Municipality was estimated as follows:

(1) GRDP by Secondary Sector per Municipality in 1993

Based on the estimated GRDP by Secondary Sector per MRH (shown in Table-5.10 of Main Report I) and on the Municipalities' Participation Fund - Preliminary Indexes/95 issued by SEFA, the GRDP by Secondary Sector of 43 municipalities in 1993 was estimated by excluding the contribution of hydroelectric power stations, and is presented in Table-5.9.

(2) GRDP by Secondary Sector per Municipality in 2005 and 2015

Based on the past trend of GRDP by Secondary Sector per Municipality during the years 1981 to 1991 (shown in Sectorial Report Vol. A) by excluding the contribution of hydroelectric power stations in the values of 1989 and 1991, and on the one of 1993 mentioned above, the GRDP of the Secondary Sector per Municipality was estimated per each municipality, adjusting the estimated GRDP by Secondary Sector per MRH (shown in Table-5.10 of Main Report I) to the years to which they belong, and is presented also in Table-5.9.

5.2.3 Water Demand Projection in 1993, 2005 and 2015

Water demand of industrial water per municipality was estimated by multiplying the average unit consumption rate per value added by GRDP by Secondary Sector per Municipality of each year, and is presented in Section-5.4.

In this Study, it was considered that all industrial activity was located in the urban area. Therefore, some municipalities included in the study zoning, but with their urban area outside this river basin, were considered as having industrial water demand equal to zero.

Table - 5.9 Estimated GRDP by Secondary Sector per Municipality in 1993, 2005 and 2015
excluding contribution of Hydroelectric Power Station / Tibagi River Basin

Unit: US$ million

No. and Name of MRH	No and Name of Municipality	1993	2005	2015
MRH 272	TOTAL of MRH	144.48	259.40	461.01
Campos da Lapa	34 Palmeira	20.30	47.81	86.64
	35 Porto Amazonas	0.00	0.00	0.00
	Subtotal of Municipalities of Basin	20.30	47.81	86.64
	Subtotal of Muncipalities not of Basin	124.18	211.59	374.37
MRH 273	TOTAL of MRH	530.69	1,076.90	1,753.81
C. Ponta Grossa	37 Castro	81.18	240.52	469.30
	38 Piraí do Sul	16.53	44.54	84.70
	39 Ponta Grossa	294.20	517.72	779.55
	40 Telêmaco Borba	137.70	271.21	414.72
	41 Tibagi	0.81	2.13	3.91
	42 Ventania	0.27	0.77	1.63
	Subtotal of Municipalities of Basin	530.69	1,076.90	1,753.81
	Subtotal of Muncipalities not of Basin	0.00	0.00	0.00
MRH 276	TOTAL of MRH	53.75	102.17	179.22
Col. Irati	49 Imbituva	6.37	11.24	19.38
	50 Irati	32.81	61.20	107.00
	55 Teixeira Soares	1.47	1.23	0.88
	Subtotal of Municipalities of Basin	40.65	73.67	127.26
	Subtotal of Muncipalities not of Basin	13.10	28.50	51.96
MRH 277	TOTAL of MRH	4.78	8.30	14.90
Alto Ivaí	57 Ipiranga	0.32	0.35	0.58
	58 Ivaí	2.08	3.30	5.64
	59 Ortigueira	0.90	1.44	2.58
	60 Reserva	0.56	1.04	2.00
	Subtotal of Municipalities of Basin	3.86	6.13	10.80
	Subtotal of Muncipalities not of Basin	0.92	2.17	4.10
MRH 278	TOTAL of MRH	10.44	29.97	61.21
N.V.Wenceslau B.	63 Curiúva	0.32	0.48	0.84
	75 Sapopema	0.31	0.55	0.99
	Subtotal of Municipalities of Basin	0.63	1.03	1.83
	Subtotal of Muncipalities not of Basin	9.81	28.94	59.38
MRH 279	TOTAL of MRH	147.34	289.03	472.99
N.V. Jacarezinho	84 Congonhinhas	0.22	0.92	1.77
	85 Cornélio Procópio	49.71	75.46	112.18
	89 Leopolis	0.63	3.27	7.96
	90 N. Américica Colina	1.90	4.89	9.01
	91 Nova Fatima	0.28	0.42	0.48
	97 S. Antônio Paraíso	0.03	0.07	0.12
	98 Sertaneja	0.09	10.40	26.63
	Subtotal of Municipalities of Basin	52.86	95.42	158.15
	Subtotal of Muncipalities not of Basin	94.48	193.61	314.84
MRH 280	TOTAL of MRH	32.52	40.37	49.03
Alg. Assai	99 Assai	19.22	23.85	26.09
	100 Jataizinho	3.59	0.79	0.17
	101 N. Santa Barbara	0.05	0.09	0.14
	102 Rancho Alegre	4.96	8.98	13.43
	103 Santa Cecília Pavão	2.80	5.19	8.00
	104 São Jerônimo Serra	0.18	0.23	0.32
	105 S. Sebastiao Amoreira	0.21	0.26	0.37
	106 Uraí	1.51	0.98	0.51
	Subtotal of Municipalities of Basin	32.52	40.37	49.03
	Subtotal of Muncipalities not of Basin	0.00	0.00	0.00
MRH 281	TOTAL of MRH	654.41	1,235.39	2,060.31
N.N. Londrina	109 Arapongas	61.74	134.00	228.20
	113 Cambé	143.08	233.62	416.82
	119 Ibiporã	18.99	39.09	68.12
	124 Londrina	274.81	468.06	704.51
	131 Primeiro de Maio	0.52	1.29	3.34
	132 Rolândia	48.92	113.31	204.10
	137 Sertanópolis	6.04	17.30	36.48
	Subtotal of Municipalities of Basin	554.10	1,006.67	1,661.57
	Subtotal of Muncipalities not of Basin	100.31	228.72	398.74
MRH 284	TOTAL of MRH	152.55	359.04	632.91
N.N. Apucarana	184 Apucarana	75.71	172.41	286.04
	187 Califórnia	0.83	2.53	4.85
	198 Marilândia do Sul	0.26	0.39	0.71
	200 Maua da Serra	13.76	20.80	37.17
	Subtotal of Municipalities of Basin	90.56	196.13	328.76
	Subtotal of Muncipalities not of Basin	61.99	162.91	304.15
TOTAL OF THE MUNICIPALITIES OF THE BASIN		1,326.17	2,544.14	4,177.85

Source: Fundo de Participação dos Municípios - Índices Provisórios - 95 (Municipalities' Participation Fund - Preliminary Indexe 95) SEFA

Remark: Values in US$ were estimated by the JICA Team

: Figures of Porto Amazonas are listed in Iguaçu River Basin

5.3 Agricultural Water inclusive of Livestock and Fishery

The data concerning agriculture was collected from EMATER database with municipality wise. In the case that a municipality extends over other river basins, the data was split by the area weighted average assuming that the data is uniformly spread in the municipality.

5.3.1 Current Agriculture

According to SANEPAR GIS computation (1994) based on IAP satellite imagery analysis (1990 and 1994), 40.1 % (9,900 km^2) and 18.1 % (4,500 km^2) of Tibagi river basin are currently utilized as crop land and pasture, while the state average is 37.6 % and 23.1 %, respectively. Dividing the river basin into two as shown in Figure-5.1, characteristics of agriculture was identified and the result is shown in Table-5.10.

Table-5.10 Agricultural Characteristics of Tibagi River Basin (1994)

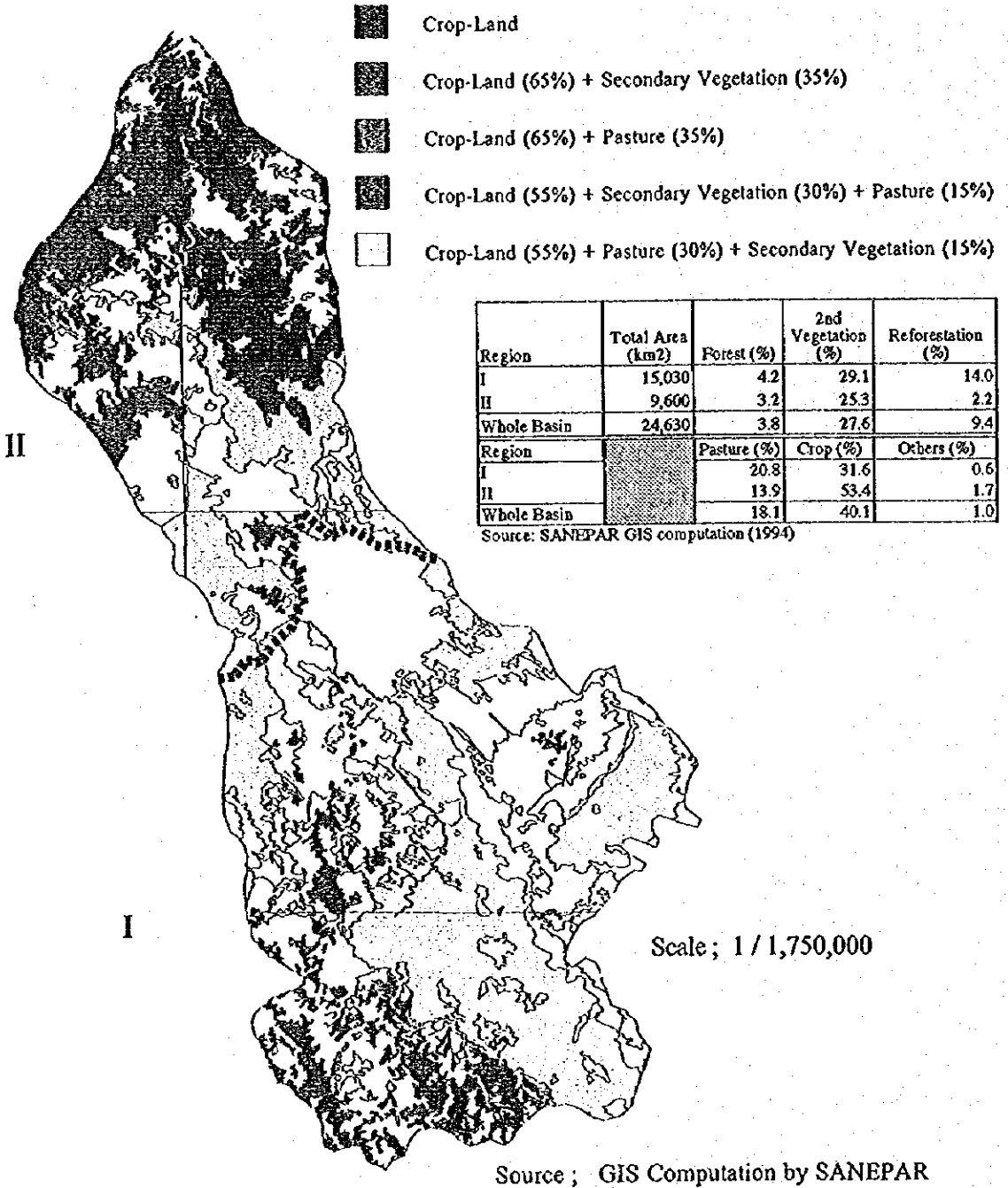
Region	Total Crop Area (km^2)	Item	Cotton	Sugarcane	Beans	Maize	Soybean	Cassava	Potato	Coffee	Wheat
I	5,180	Area Ratio to Total (%)	0.0	0.0	11.2	44.2	43.7	0.5	0.4	0.0	8.6
		Productivity (ton/ha)	-	-	1.0	4.1	2.7	21.8	16.2	-	2.1
		Mechanization (%)	-	-	79.3	79.6	99.8	79.5	99.0	-	100.0
		Implementation of Conservation (%)	-	-	36.3	62.0	85.1	25.9	10.0	-	89.7
		Implementation of Non-tillage (%)	-	-	11.3	38.1	78.8	-	-	-	81.6
II	6,780	Area Ratio to Total (%)	4.0	2.5	5.6	34.7	45.2	0.5	0.0	7.5	13.7
		Productivity (ton/ha)	0.9	56.8	0.8	2.9	2.2	19.5	-	1.0	1.4
		Mechanization (%)	50.7	99.5	51.2	73.3	97.9	54.6	-	33.4	99.3
		Implementation of Conservation (%)	35.8	91.1	33.8	52.0	88.6	37.7	-	35.1	86.9
		Implementation of Non-tillage (%)	0.2	-	0.0	5.5	7.2	-	-	-	11.8
River Basin Average	9,880	Area Ratio to Total (%)	2.1	1.3	8.3	39.3	44.4	0.5	0.2	3.9	11.2
		Productivity (ton/ha)	0.9	56.8	0.9	3.6	2.4	20.6	16.2	1.0	1.7
		Mechanization (%)	50.7	99.5	69.5	76.7	98.8	66.0	99.0	33.4	99.6
		Implementation of Conservation (%)	35.8	91.1	35.4	57.4	86.9	32.3	10.0	35.1	87.9
		Implementation of Non-tillage (%)	0.2	-	7.3	23.1	41.1	-	-	-	37.3

I	Scale of Farmers	Small	Medium	Large	Total (household)	
	Number of Household (%)	77.2	16.5	6.3	20,900	
II	Scale of Farmers	Small	Medium	Large	Total (household)	
	Number of Household (%)	80.4	14.1	5.5	20,400	
River Basin	Scale of Farmers	Small	Medium	Large	Total (household)	
	Number of Household (%)	78.8	15.3	5.9	41,300	

Note: Size of Farmers; Small < 50 ha, Medium 50 - 250 ha, Large >250 ha
Source: adapted and enlarged from EMATER for Agricultural Data as of 1994
SANEPAR GIS computation based on IAP satellite imagery analysis for Crop Area

The most distinct characteristic of agriculture in Tibagi river basin is maize and soybean culture. Wheat is well cultivated as a second crop after either maize or soybean. Another important characteristic is that coffee is still major crop in spite of the low price in the international market and several damages by frost. Recent trend shows the conversion of coffee culture to fruit culture.

TIBAGI RIVER BASIN



Region	Total Area (km2)	Forest (%)	2nd Vegetation (%)	Reforestation (%)
I	15,030	4.2	29.1	14.0
II	9,600	3.2	25.3	2.2
Whole Basin	24,630	3.8	27.6	9.4

Region	Pasture (%)	Crop (%)	Others (%)
I	20.8	31.6	0.6
II	13.9	53.4	1.7
Whole Basin	18.1	40.1	1.0

Source: SANEPAR GIS computation (1994)

Source ; GIS Computation by SANEPAR
Landuse Map by IAP (1990 & 1994)

Figure-5.1 Sub-division and Landuse in Tibagi River Basin

The total number of farmers in Tibagi river basin is 41,300 in 1994. Among them, 78.8 % is classified as the small size, which owes less than 50 ha, and the medium (between 50 and 250 ha) and large (greater than 250 ha) size are limited to 15.3 and 5.9 %, respectively. Since the mechanization is high in soybean and maize culture (98.8 and 76.7 % of its area, respectively), it is a transition period from small farmers to medium size farmers due to the expansion of intensive agriculture.

Non-tillage is well adopted, especially in the region I, the upstream, denoted in Figure-5.1. In the region I, 78.8 % of soybean, 81.6 % of wheat and 38.1 % of maize field are cultivated with non-tillage, while the state average of its application is 12 % of the crop land. Since one of advantages of non-tillage is suppression of soil erosion resulting in amendment of soil properties, its application is expected to expand even in the region II.

5.3.2 Current Water Consumption and Future Water Demand

(1) Current Water Consumption

The necessity of irrigation was examined in the Strategy study. Crop water requirements of dominant crops in Paraná were computed and compared with effective rainfall to examine the necessity of irrigation. Its conclusion was that rain-fed agriculture is practically adequate in Paraná as long as the favorable weather will continue. Considering the current dominant crops and future trend of crop cultivation, the agricultural water in Tibagi river basin consists of water for livestock and fish pond.

(2) Future Agriculture

The population growth of livestock and expansion of fish pond were projected for the year of 2005 and 2015 in accordance with the Strategy formulated. Each municipality may differ in future livestock growth and expansion of fish pond area. Trend analysis for each municipality requires individually to specify the market, price, raising method and so on, however, such detail study should follow after the master plan. And further, the state trend integrating all relevant information is considered to be more reliable. Therefore, the state trend was applied to project the future livestock population and fish pond area.

The growth of cattle and chicken population was assessed during the Strategy study by means of the linear regression of population in the last 20 years. As a result, cattle and chicken are expected to increase approximately 174 thousand and 1.837 million heads/year respectively in the whole Paraná state. And pig population in the state will be stabilized at around 4 million heads by the year of 2000. Applying the same rate, the population of livestock was projected with the following equation.

Cattle (1,000 head) = 174.256 x Year - 337839

Chicken (million head) = 1.83697 x Year - 3591.68

During the Strategy study, it was assumed that the annual expansion of fish pond area is 2 %. The same rate was applied to pilot river basins to estimate its area in 2005 and 2015.

The result of projection is shown in Table-5.12 with the current livestock population and fish pond area as of 1994.

(3) Water Demand Projection

Although the rates of water consumption of livestock and fish pond may vary with location due to the difference of climate, variety of livestock species, soil properties etc., such variation is negligible at this study. Therefore, the rates determined during the Strategy study was adopted with the following assumptions.

1) An livestock of 100 kg live weight requires 10 liter/day as the total water requirement.

2) Natural pasture contains as much as 80 % of water during the growth period. Therefore, amount of water actually supplied to cattle is a part of total water requirement which cannot be provided by moisture content of forage. It was assumed that the actual water supply to cattle is 33 % of total water requirement.

3) Since pigs and chickens are not herbivores, it was assumed that there is no water intake by means of food. Therefore, their water requirements depend on an average live weight.

The rates of water requirement of each livestock is shown in Table-5.11.

Table-5.11 Water Requirement of Livestock

Livestock	Average Live Weight (kg)	Total Water Requirement (liter/head/day)	Actual Water Supply (liter/head/day)
Pig	40	4.0	4.0
Cattle	300	30.0	10.0
Chicken	2	0.2	0.2

Total water requirement includes water intake by forage.
Actual water supply is a supply in liquid phase.

For the water consumption of fish ponds, the rate of 1 mm/day was adopted with the following assumptions.

1) There is no change of water in a pond.

2) The bottom of a pond is well coated with clay. Therefore, no seepage occurs or seepage ceases after the long use.

3) 60 % of annual rainfall is stored in a pond and 40 % is overflowed. An average rainfall and evaporation are 1,700 mm and 1,300 mm, respectively. Thus, annual water loss from a fish pond is approximately 300 mm (= 1,300 - 1,700 x 0.6).

The current water consumption and future water demand are just multiplication of livestock population or fish pond area by the above rates. The result is discussed in the section 5.4.

Table-5.12 Projection of Livestock Population and Fish Pond Area

Div	No.	Municipality	Area Involed (km²)	1994 Cattle (1,000 head)	2005 Cattle (1,000 head)	2015 Cattle (1,000 head)	1994 Pig (1,000 head)	2005 Pig (1,000 head)	2015 Pig (1,000 head)	1994 Chicken (1,000 head)	2005 Chicken (1,000 head)	2015 Chicken (1,000 head)	1994 Fish Pond Area (ha)	2005 Fish Pond Area (ha)	2015 Fish Pond Area (ha)
	T-001	Porto Amazonas	53.8	0.8	1.0	1.2	0.9	1.0	1.0	61.1	78.6	94.2	0	0	0
	T-002	Palmeira	1,227.4	29.8	35.8	41.2	21.3	23.7	23.7	408.9	525.0	630.5	17	21	26
	T-003	Teixeira Soares	1,303.5	20.3	24.3	28.0	19.4	21.7	21.7	0.0	0.0	0.0	24	30	37
	T-004	Irati	139.6	1.6	1.9	2.2	2.8	3.1	3.1	0.0	0.0	0.0	4	5	6
	T-005	Imbituva	811.3	14.1	17.0	19.5	13.6	15.2	15.2	0.0	0.0	0.0	2	3	4
	T-006	Ipiranga	932.0	18.3	21.9	25.2	7.5	8.4	8.4	0.0	0.0	0.0	34	42	52
I	T-007	Ponta Grossa	1,870.8	42.6	51.0	58.8	11.1	12.3	12.3	1,205.1	1,547.2	1,858.0	10	12	15
	T-008	Castro	2,278.4	65.7	78.8	90.7	11.2	12.5	12.5	1,443.1	1,852.3	2,224.7	26	32	39
	T-009	Ivai	212.2	2.8	3.4	3.9	2.1	2.3	2.3	0.0	0.0	0.0	35	43	53
	T-010	Reserva	555.9	15.2	18.3	21.0	3.1	3.5	3.5	0.0	0.0	0.0	25	31	38
	T-011	Tibagi	2,926.6	110.7	132.8	152.8	27.9	31.1	31.1	0.0	0.0	0.0	34	42	52
	T-012	Pirai do Sul	965.2	31.3	37.5	43.2	12.0	13.4	13.4	988.3	1,268.5	1,523.3	5	6	8
	T-013	Ventania	380.1	9.6	11.5	13.2	0.4	0.4	0.4	0.0	0.0	0.0	2	3	4
	T-014	Telemaco Borba	1,625.3	8.3	10.0	11.5	2.4	2.7	2.7	0.0	0.0	0.0	50	62	76
		Sub-total	15,292.1	371.1	445.2	512.4	135.7	151.3	151.3	4106.5	5271.6	6330.7	268.0	332.0	410.0
	T-015	Ortigueira	1,588.5	69.4	83.2	95.8	19.3	21.5	21.5	0.0	0.0	0.0	48	60	73
	T-016	Curiuva	361.8	1.4	1.7	2.0	0.0	0.0	0.0	37.3	47.9	57.2	1	1	1
	T-017	Sapopema	531.9	27.8	33.4	38.4	1.5	1.7	1.7	0.0	0.0	0.0	0	0	0
	T-018	Sao Jeronimo da Serra	851.3	47.2	56.6	65.1	7.5	8.4	8.4	0.0	0.0	0.0	3	4	5
	T-019	Maua da Serra	48.0	1.5	1.8	2.1	0.5	0.5	0.5	25.0	32.2	38.5	0	0	0
	T-020	Marilandia do Sul	152.2	10.2	12.2	14.1	0.8	0.9	0.9	56.9	73.1	87.7	3	4	4
	T-021	California	97.2	9.2	11.0	12.7	0.1	0.1	0.1	0.0	0.0	0.0	0	0	0
	T-022	Apucarana	182.2	9.6	11.6	13.3	2.5	2.8	2.8	61.7	79.1	95.2	2	2	3
	T-023	Arapongas	191.9	7.1	8.5	9.8	22.9	25.6	25.6	236.1	303.2	363.9	7	9	11
	T-024	Londrina	2,095.6	162.4	194.7	224.1	25.0	27.9	27.9	2,343.0	3,008.0	3,612.0	18	22	27
	T-025	Nova Santa Barbara	112.2	0.5	0.6	0.7	0.1	0.1	0.1	0.0	0.0	0.0	1	1	2
	T-026	Santa Cecilia do Pavao	68.5	0.5	0.5	0.6	0.1	0.1	0.1	0.0	0.0	0.0	2	2	3
	T-027	Santo Antonio do Paraiso	151.9	8.3	10.0	11.5	1.0	1.1	1.1	0.0	0.0	0.0	2	2	3
	T-028	Congonhinhas	104.6	5.2	6.3	7.2	0.3	0.3	0.3	13.3	17.1	20.6	0	0	0
II	T-029	Nova Fatima	83.5	7.9	9.5	10.9	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0
	T-030	Sao Sebastiao da Amoreira	217.4	9.5	11.4	13.2	0.6	0.7	0.7	0.0	0.0	0.0	1	1	2
	T-031	Assai	450.5	10.6	12.8	14.7	3.0	3.4	3.4	131.0	168.0	202.0	4	5	6
	T-032	Nova America da Colina	133.3	7.6	9.1	10.4	1.7	1.9	1.9	0.0	0.0	0.0	2	2	3
	T-033	Cornelio Procopio	336.7	23.6	28.3	32.6	0.2	0.2	0.2	0.0	0.0	0.0	2	3	3
	T-034	Urai	209.6	9.3	11.2	12.8	6.0	6.7	6.7	0.0	0.0	0.0	15	19	23
	T-035	Jataizinho	199.1	11.5	13.8	15.9	0.4	0.5	0.5	0.0	0.0	0.0	0	0	0
	T-036	Ibipora	295.4	10.5	12.6	14.5	6.7	7.5	7.5	72.0	92.0	111.0	16	20	24
	T-037	Rolandia	57.4	1.9	2.3	2.6	2.5	2.8	2.8	107.9	138.5	166.4	1	1	2
	T-038	Cambe	143.5	4.4	5.2	6.0	2.5	2.8	2.8	65.0	83.6	100.4	0	0	0
	T-039	Sertanopolis	478.9	17.7	21.2	24.4	7.2	8.1	8.1	1,328.7	1,705.6	2,048.5	19	24	29
	T-040	Rancho Alegre	187.4	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3	4	5
	T-041	Leopolis	68.9	2.8	3.4	3.9	1.3	1.5	1.5	0.0	0.0	0.0	0	0	0
	T-042	Sertaneja	226.7	3.4	4.1	4.8	0.9	1.1	1.1	0.0	0.0	0.0	0	0	0
	T-043	Primeiro de Maio	142.8	3.5	4.2	4.9	1.3	1.5	1.5	112.9	144.8	174.0	0	0	0
		Sub-total	9,768.9	484.6	581.3	669.1	115.9	129.7	129.7	4590.8	5898.1	7077.4	150.0	186.0	229.0
		Total	25,051.0	856.0	1,027.0	1,182.0	252.0	281.0	281.0	8,697.0	11,165.0	13,408.0	418.0	518.0	639.0

Area: Area within the river basin

Note: The total area of the river basin is slightly different from the area adopted by the Study Team due to roundup during the computation.

Source: SANEPAR GIS Computation based on IAP Satellite Imagery Analysis for Area of Municipality
EMATER for the Population of Livestock and Fish Pond Area as of 1994

5.4 Water Demand Projection by Sector and by Region

5.4.1 Demand Distribution of Municipalities Located in the Basin Boundary

(1) Urban Areas (Domestic and Industrial Water)

There are some urban areas which straddle boundaries of several basins such as Apucarana and others. Water demand for these urban areas are to belong to Tibagi river basin.

(2) Rural Areas (Domestic and Agricultural Water)

Water demand for rural areas which straddle boundaries of several basins are distributed from municipality unit to Tibagi river basin in accordance with the following equation:

$$D_P = D_M \times \frac{A_P}{A_M}$$

where:

D_P; rural water demand of Tibagi river basin
D_M; rural water demand of municipality
A_P; area of municipality in Tibagi river basin
A_M; area of municipality

5.4.2 Water demand Projection in Tibagi River Basin

The water demand projection by sector and by region in Tibagi river basin was calculated for both base and alternative cases as shown in Table-5.13.

Table-5.13 Water Demand by Sector and by Region in TIBAGI River Basin [m^3/s]

MRH	No.	Municipality Name	Type	Zone	1993				2005				2015			
					Urban		Rural		Urban		Rural		Urban		Rural	
					Domestic	Industrial	Domestic	Agricultural	Domestic	Industrial	Domestic	Agricultural	Domestic	Industrial	Domestic	Agricultural
MRH 273	39	Ponta Grossa	A		23.810	17.360	700	810	35.080	24.850	650	990	49.080	28.840	550	1.160
MRH 281	124	Londrina	A		53.340	16.210	1.540	2.370	85.470	22.470	970	2.880	121.750	26.070	670	3.340
MRH 284	184	Apucarana	A		10.590	4.470	190	140	16.520	8.280	130	170	23.380	10.580	70	190
MRH 273	37	Castro	B		4.310	4.790	1.290	1.250	7.440	11.550	1.370	1.530	11.370	17.360	1.330	1.790
MRH 273	40	Telemaco Borba	B		6.040	8.120	660	590	10.450	13.020	370	730	15.970	15.340	220	890
MRH 276	50	Irati	B		3.400	1.940	180	70	5.260	2.940	150	80	7.540	3.960	120	90
MRH 279	85	Cornelio Procopio	B		5.110	2.930	230	260	7.210	3.620	120	310	10.040	4.150	50	360
MRH 281	109	Arapongas	B		7.330	3.640	150	280	10.230	6.430	90	340	14.540	8.440	50	380
MRH 281	113	Cambe	B		8.430	8.440	140	60	13.990	11.210	100	80	21.970	15.420	70	90
MRH 281	119	Ibipora	B		3.890	1.120	290	310	6.630	1.880	150	380	10.560	2.520	90	440
MRH 273	38	Piraí do Sul	C	a	1.320	980	340	610	1.960	2.140	320	740	2.750	3.130	280	860
MRH 273	41	Tibagi	C	a	800	50	630	1.560	1.660	100	500	1.870	2.740	140	340	2.170
MRH 277	57	Ipiranga	C	a	280	20	670	550	410	20	810	670	530	20	830	800
MRH 277	59	Ortigueira	C	a	460	50	870	1.250	540	70	410	1.520	620	100	190	1.780
MRH 278	75	Sapopema	C	a	270	20	210	290	480	30	140	340	690	40	90	390
MRH 280	100	Jataizinho	C	a	900	210	130	120	1.280	40	90	140	1.750	10	70	160
MRH 280	101	Nova Santa Barbara	C	a	220	0	110	20	280	0	80	20	360	10	60	30
MRH 280	104	Sao Jeronimo da Serra	C	a	550	10	550	530	1.000	10	300	640	1.570	10	120	730
MRH 281	131	Primeiro de Maio	C	a	1.190	30	50	70	1.640	60	20	80	2.320	120	10	90
MRH 272	34	Palmeira	C	b	1.600	1.200	830	640	2.330	2.300	950	770	3.240	3.210	1.000	890
MRH 277	60	Reserva	C	b	660	30	380	410	1.120	50	350	500	1.590	70	270	600
MRH 279	90	N. America da Colina	C	b	180	110	150	110	280	230	100	120	420	330	70	140
MRH 279	97	Santo Antonio do Paraiso	C	b	110	0	80	100	150	0	40	120	200	0	30	150
MRH 280	103	Santa Cecilia do Pavao	C	b	280	170	150	30	350	250	90	30	430	300	60	40
MRH 280	105	Sao Sebastiao da Amoreir	C	b	510	10	230	110	970	10	170	120	1.550	10	130	150
MRH 280	106	Urai	C	b	980	90	260	260	1.410	50	150	330	1.950	20	100	390
MRH 281	137	Sertanopolis	C	b	1.220	360	260	670	1.730	830	120	820	2.480	1.350	70	970
MRH 276	49	Imbituva	C	c	850	380	960	210	1.300	540	1.060	260	1.840	720	1.090	300
MRH 276	55	Teixeira Soares	C	c	500	90	640	520	820	60	630	630	1.220	30	590	740
MRH 278	63	Curiuva	C	c	370	20	270	30	690	20	220	40	1.020	30	190	40
MRH 279	84	Congonhinhas	C	c	400	10	40	50	680	40	30	60	1.050	70	10	70
MRH 279	98	Sertaneja	C	c	470	10	60	30	660	500	40	40	890	990	30	50
MRH 280	99	Assai	C	c	1.390	1.130	480	190	2.000	1.140	280	220	2.760	970	190	260
MRH 280	102	Rancho Alegre	C	c	350	290	80	30	540	430	40	40	760	500	20	50
MRH 284	187	California	C	c	390	50	130	90	680	120	80	110	1.030	180	50	130
MRH 284	200	Maua da Serra	C	c	260	810	30	30	440	1.000	20	30	650	1.380	20	30
MRH 272	35	Porto Amazonas			0	0	20	20	0	0	30	30	0	0	30	30
MRH 273	42	Ventania			0	0	90	120	0	0	80	150	0	0	70	170
MRH 277	58	Ivai			0	0	200	390	0	0	200	470	0	0	170	580
MRH 279	89	Leopolis			0	0	30	40	0	0	20	40	0	0	10	50
MRH 279	91	Nova Fatima			0	0	60	80	0	0	40	100	0	0	20	110
MRH 281	132	Rolandia			0	0	60	60	0	0	30	70	0	0	20	90
MRH 284	198	Marilandia do Sul			0	0	120	140	0	0	80	170	0	0	70	200
Total					142.760	75.150	14.540	15.500	223.680	116.290	11.620	18.780	322.610	146.420	9.520	21.970

CHAPTER 6 WATER RESOURCES DEVELOPMENT

6.1 Surface Water Potential

6.1.1 Zoning for Surface Water Potential

In order to compare required water supply with surface water potential, Tibagi river basin was divided into 18 blocks as shown in Figure-6.1.

Discharge reference point was determined downstream of each block. Each reference point is the same as the point of water quality study. Surface water potential was calculated at each discharge reference point.

6.1.2 Surface Water Potential

Surface water potential was calculated by deducting maintenance discharge(50%$Q_{10,7}$) from the low water flow($Q_{10,7}$) at each reference point. Low water flow was applied as follows:

(1) catchment area < 5,000km² ------ HG52(CEHPAR,1982)

(2) catchment area ≥ 5,000km² ------ MINIMUM DISCHARGE VALUES FOR THE STATIONS STUDIED BY JICA IN PARANÁ STATE(COPEL,1995)

The results are shown in Table-6.1.

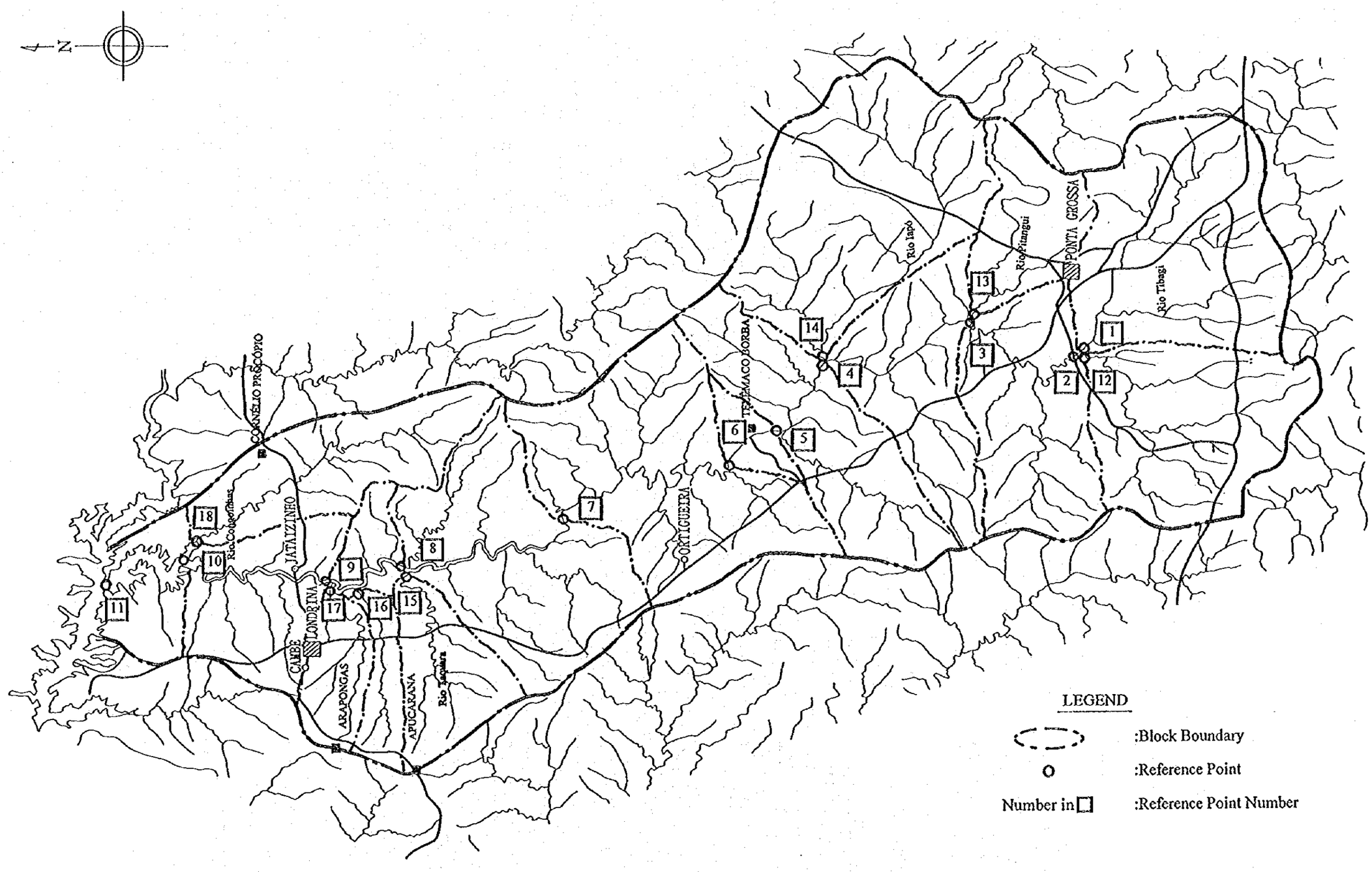


Figure-6.1 Tibagi River Basin Division

Table-6.1 Surface Water Potential and Quality

Reference Point	River Name	Location	Catchment Area (km2)	Surface Water Quality in 1993 BOD(mg/l)	Surface Water Potential (m3/sec)	Required Water Supply (m3/sec) * 1993 Urban	2005 Urban	2015 Urban
1	Rio Tibagi	upstream confluence of Rio Imbituva (include Ponta Grossa)	2,805	3.17	2.66	0.78 1.88 3.39	1.01 1.65 2.62	1.27 1.39 2.10
2	Rio Tibagi	downstream confluence of Rio Imbituva	4,774	2.62	4.52	0.94 3.58 4.79	1.22 3.30 3.70	1.53 2.99 2.95
3	Rio Tibagi	downstream confluence of Rio Pitangui	7,340	0.53	9.19	0.97 8.22 9.51	1.25 7.94 7.37	1.56 7.63 5.88
4	Rio Tibagi	downstream confluence of Rio Fortaleza	11,925	0.79	15.26	1.25 14.01 12.21	1.70 13.57 9.00	2.18 13.08 7.00
5	Rio Tibagi	downstream confluence of Rio Imbau (upstream Telemaco Borba)	13,743	0.42	17.30	1.27 16.03 13.58	1.73 15.57 10.02	2.22 15.08 7.80
6	Rio Tibagi	upstream confluence of Rio Imbauzinho (down-stream Telemaco Borba)	14,125	1.29	17.71	1.52 16.19 11.65	2.08 15.63 8.50	2.68 15.03 6.61
7	Rio Tibagi	between Terra Nova and Natingui	16,840	0.00	20.32	1.58 18.74 12.84	2.15 18.17 9.45	2.76 17.57 7.38
8	Rio Tibagi	downstream confluence of Rio Taquara	20,491	0.00	23.12	1.94 21.18 11.94	2.64 20.49 8.77	3.39 19.73 6.82
9	Rio Tibagi	downstream confluence of Rio Tres Bocas	21,587	0.92	23.80	2.13 21.67 11.16	2.89 20.91 8.23	3.73 20.07 6.38
10	Rio Tibagi	downstream confluence of Rio Congonhas	24,227	0.31	25.14	4.15 20.99 6.05	5.57 19.57 4.51	7.24 17.90 3.47
11	Rio Tibagi	river mouth	24,635	0.17	25.31	4.18 21.13 6.06	5.60 19.71 4.52	7.28 18.04 3.48
12	Rio Imbituva	river mouth (include Irati)	1,969	1.83	1.87	0.16 1.71 11.69	0.21 1.66 9.08	0.26 1.61 7.11
13	Rio Pitangui	river mouth (include Ponta Grossa)	1,001	1.67	0.84	0.00 0.84 -	0.00 0.84 -	0.00 0.84 -
14	Rio Fortaleza Rio Iapo	river mouth (include Castro)	3,007	4.33	2.42	0.28 2.14 8.52	0.45 1.97 5.40	0.62 1.80 3.92
15	Rio Taquara	river mouth (include Apucarana)	1,068	10.7	0.56	0.28 0.28 1.99	0.40 0.16 1.40	0.52 0.04 1.07
16	Rio dos Apertados	river mouth (include Arapongas)	397	31.7	0.16	0.20 -0.04 0.81	0.26 -0.10 0.62	0.34 -0.18 0.47
17	Rio Tres Bocas	river mouth (include Londrina)	406	339	0.16	0.00 0.16 -	0.00 0.16 -	0.00 0.16 -
18	Rio Congonhas	river mouth (include Cornelio Procopio)	1,124	6.34	0.63	0.22 0.41 2.89	0.27 0.36 2.35	0.33 0.30 1.89

*Remark

first line
Required Water Supply (calculated in section 6.3)

second line
Surface Water Potential - Required Water Supply

third line
Possible Development Water / Required Water Supply

6.2 Groundwater Potential

6.2.1 Definition of Boundary of Study Area

The major municipal urban areas located in the Tibagi River Basins straddle over the boundary of other river basins. Therefore, the Tibagi river basins for the study of the groundwater resources is composed of such areas as Tibagi river, a part of the left bank of the Cinzas River, and upstream of Pirapo River including a part of the neighboring groundwater basins related to the major urban demand centers.

6.2.2 Assessment of Groundwater Potential for Tibagi River Basin

Tibagi River Basin is composed of Crystalline Rocks, Furnas Formation, Upper-Middle Paleozoic, Upper Paleozoic, Botsucatu Formation, Serra Geral Formation north.

The result of potential analysis is shown in Table-6.2 and is summarized as set out below.

(1) Botucatu Formation

The aquifer of Botucatu Formation is exposed on the ground surface in a limited area, but it lies broadly under Serra Geral Formation in the northern part of the Tibagi River Basin.

The development potential of groundwater of this aquifer is assessed to be high as well as that in the Iguaçu River Basin. Its groundwater is used as hot water in a coffee production factories in Londrina, and is anticipated to be widely used in the future.

(2) Serra Geral Formation north

The aquifer of Serra Geral Formation north is distributed broadly in the north of the Tibagi River Basin. It's development potential of groundwater is assessed to be high and appropriate for medium to large scale because its permissive yield and productivity is higher than those of the Iguaçu River Basin.

(3) Furnas Formation

The aquifer of Furnas Formation is assessed to be appropriate for small scale groundwater development based on productivity of borehole as well as that in the Iguaçu River Basin.

(4) Other Aquifers

Groundwater development of other aquifers not aforementioned is assessed to be unfeasible except for the rural areas facing shortage or lack of other fresh water sources because of its low permissive yield and productivity as well as those in the Iguaçu River Basin.

Table-6.2 Spatial Groundwater Potential of Tibagi River Basin Estimated by Water Circulation

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Aquifer	Location in River Basin	Study Area	Spatial mQ?	Permissive Yield		Require Recharge	Total Permissive Yield	Productivity of Borehole
		km^2	m^3/km^2 *1	%	x $10^{-3}m^3$ /skm^2	$km^2/s/3$	m^3/s	x $10^{-3}m^3/s$
Cristalline Rocks	Upper Tibagi	7,500	6.00	10	0.64	1,600	4.8	5.56
Lower Paleozoic	Middle Tibagi	900	3.61	10	0.36	2,800	0.32	2.78
Furnas Formation	Middle to Upper Tibagi	3,500	-	15	-	-	-	8.33
Lower-Middle Paleozoic	Middle to Upper Tibagi	2,500	6.37	10	0.64	1,600	1.6	2.78
Middle-Upper Paleozoic	Middle to Upper Tibagi	12,000	4.6	10	0.46	2,200	5.5	2.78
Upper Paleozoic	Upper to Middle Iguaçu	11,000	4.6	10	0.46	2,200	5.1	2.78
Botucatu Formation	Middle Tibagi and mainly L. Tibagi in underground	11,000	-	-	-	-	-	124
Serra Geral Formation north	Lower Tibagi	10,800	7.7	20	1.5	670	16.2	11.1

*1 same meaning as transitory Recharge of Groundwater

[4] - Spatial Specific mQ,

[7] - Total Permissive Yield of Aquifer in Study Area

6.3 Required Water Supply Amount

6.3.1 Water Demand and Sources

Water demands are estimated for urban domestic water, rural domestic water, industrial water and agricultural water. Water source which is appropriate for each water demand seems to be basically as shown in Table-6.3, from the view point of developed amount, technology, realization, etc.

Table-6.3 Water Demand and Sources

Water Demands	Region	Main Water Sources	Sub Water Sources
Domestic	Urban	Surface Water	Groundwater
	Rural	Groundwater	Surface Water
Industrial	Urban	Surface Water	Groundwater
Agricultural	Rural	Surface Water	Groundwater

Water sources of urban domestic water and industrial water will be established by considering the characteristics of the region, surface water potential, groundwater potential, etc.

6.3.2 Water Losses

Required water supply amount is calculated by adding various losses to each water demand. Percentage of total water loss which includes losses for intake, conveyance, treatment, distribution of water, etc., is assumed as shown in Table-6.4 taking into consideration present loss percentage, future improvement and type of water development.

Table-6.4 Percentage of Water Losses

Purpose of Water Use	Region	1993(%)	2005(%)	2015(%)
Domestic	Urban	40	30	25
	Rural	15	10	10
Industry	Urban	15	10	10
Agriculture	Rural	20	20	20

6.3.3 Classification and Zoning of Region

The urban areas were classified into the following categories by considering characteristics of each area:

(1) Type-A: Large urban areas

The large urban areas were defined that their population will be more than approximately 100,000 in 2015.

(2) Type-B: Medium urban areas

The medium urban areas were defined that their population will be more than approximately 50,000 in 2015.

(3) Type-C: Other urban areas

The other urban areas were classified into the following zoning by considering topographic conditions:

1) Zone-a: Urban areas located nearby main streams

These areas located nearby main stream or downstream of tributaries, therefore problems of the shortage of intake rate and water quality are few.

2) Zone-b: Urban areas located upstream of second or third tributaries

Although there are problems of possible water development volume and intake method, water quality problems are quite few.

3) Zone-c: Urban areas located at top or ridge of mountains

These areas require to intake the water from the downstream of urban town, and water volume, water quality and intake method have many problems.

Forty-three municipalities belong to Tibagi river basin, out of which 3 urban areas were classified into Type-A and other 7 urban areas were classified into Type-B. 26 urban areas belong to Type-C urban areas and 7 municipalities belong to only rural areas.

Type-C urban areas were classified into 3 zone by considering topographic conditions. Urban classification and zoning of Type-C urban areas are shown in Table-6.5

6.3.4 Required Water Supply

Assuming water loss percentage as shown in Table-6.4, based on water demand estimated in the Section-5.4, required water supply by sector and by region is calculated for both base and alternative cases as shown in Table-6.6.

Table-6.5 Classification and Zoning of Urban Area in Tibagi River Basin

No.	Municipality Name	Type	Zone	MRH
1	Ponta Grossa	A		MRH 273
2	Londrina	A		MRH 281
3	Apucarana	A		MRH 284
4	Castro	B		MRH 273
5	Telemaco Borba	B		MRH 273
6	Irati	B		MRH 276
7	Cornelio Procopio	B		MRH 279
8	Arapongas	B		MRH 281
9	Cambe	B		MRH 281
10	Ibipora	B		MRH 281
11	Pirai do Sul	C	a	MRH 273
12	Tibagi	C	a	MRH 273
13	Ipiranga	C	a	MRH 277
14	Orugueira	C	a	MRH 277
15	Sapopema	C	a	MRH 278
16	Jataizinho	C	a	MRH 280
17	Nova Santa Barbara	C	a	MRH 280
18	Sao Jeronimo da Serra	C	a	MRH 280
19	Primeiro de Maio	C	a	MRH 281
20	Palmeira	C	b	MRH 272
21	Reserva	C	b	MRH 277
22	N. America da Colina	C	b	MRH 279
23	Santo Antonio do Paraiso	C	b	MRH 279
24	Santa Cecilia do Pavao	C	b	MRH 280
25	Sao Sebastiao da Amoreira	C	b	MRH 280
26	Urai	C	b	MRH 280
27	Sertanopolis	C	b	MRH 281
28	Imbituva	C	c	MRH 276
29	Teixeira Soares	C	c	MRH 276
30	Curiuva	C	c	MRH 278
31	Congonhinhas	C	c	MRH 279
32	Sertaneja	C	c	MRH 279
33	Assai	C	c	MRH 280
34	Rancho Alegre	C	c	MRH 280
35	California	C	c	MRH 284
36	Maua da Serra	C	c	MRH 284
37	Porto Amazonas	*		MRH 272
38	Ventania	*		MRH 273
39	Ivai	*		MRH 277
40	Leopolis	*		MRH 279
41	Nova Fatima	*		MRH 279
42	Rolandia	*		MRH 281
43	Marilandia do Sul	*		MRH 284

* : Urban area is not included in Tbagi river basin. Only rural area spreaded in the basin.

Table-6.6 Required Water Supply by Sector and by Region [Base Case]

[m3/sec]

Municipality Name	Type	Zone	1993 Urban			2005 Urban			2015 Urban			2005-1993 Urban			2015-1993 Urban		
			Domestic	Industrial	Total	Domestic	Industrial	Total	Domestic	Industrial	Total	Domestic	Industrial	Total	Domestic	Industrial	Total
Ponta Grossa	A		0.459	0.236	0.695	0.580	0.320	0.900	0.757	0.371	1.128	0.121	0.084	0.205	0.298	0.135	0.433
Londrina	A		1.029	0.221	1.250	1.413	0.289	1.702	1.879	0.335	2.214	0.384	0.068	0.452	0.850	0.114	0.964
Apucarana	A		0.204	0.061	0.265	0.273	0.106	0.379	0.361	0.136	0.497	0.069	0.045	0.114	0.157	0.075	0.232
Castro	B		0.083	0.065	0.148	0.123	0.149	0.272	0.175	0.223	0.398	0.040	0.084	0.124	0.092	0.158	0.250
Telemaco Borba	B		0.117	0.111	0.228	0.173	0.167	0.340	0.246	0.197	0.443	0.056	0.056	0.112	0.129	0.086	0.215
Irati	B		0.066	0.026	0.092	0.087	0.038	0.125	0.116	0.051	0.167	0.021	0.012	0.033	0.050	0.025	0.075
Cornelio Procopio	B		0.099	0.040	0.139	0.119	0.047	0.166	0.155	0.053	0.208	0.020	0.007	0.027	0.056	0.013	0.069
Arapongas	B		0.141	0.050	0.191	0.169	0.083	0.252	0.224	0.109	0.333	0.028	0.033	0.061	0.083	0.059	0.142
Cambe	B		0.163	0.115	0.278	0.231	0.144	0.375	0.339	0.198	0.537	0.068	0.029	0.097	0.176	0.083	0.259
Ibirpora	B		0.075	0.015	0.090	0.110	0.024	0.134	0.163	0.032	0.195	0.035	0.009	0.044	0.088	0.017	0.105
Total of Type-C/Zone-a	C	a	0.114	0.018	0.132	0.153	0.032	0.185	0.206	0.046	0.252	0.039	0.016	0.055	0.092	0.031	0.123
Total of Type-C/Zone-b	C	b	0.107	0.025	0.132	0.139	0.049	0.188	0.183	0.067	0.25	0.032	0.024	0.056	0.076	0.043	0.119
Total of Type-C/Zone-c	C	c	0.097	0.037	0.134	0.128	0.051	0.179	0.174	0.061	0.235	0.031	0.014	0.045	0.077	0.028	0.105
Total			2.754	1.020	3.774	3.698	1.499	5.197	4.978	1.879	6.857	0.944	0.481	1.425	2.224	0.867	3.091

(2) Required Water Supply of Urban Area by Sector and by Region in Tibagi River Basin [Alternative Case]

[m3/sec]

Municipality Name	Type	Zone	1993 Urban			2005 Urban			2015 Urban			2005-1993 Urban			2015-1993 Urban		
			Domestic	Industrial	Total	Domestic	Industrial	Total	Domestic	Industrial	Total	Domestic	Industrial	Total	Domestic	Industrial	Total
Ponta Grossa	A		0.459	0.236	0.695	0.632	0.363	0.995	0.865	0.457	1.322	0.173	0.127	0.300	0.406	0.221	0.627
Telemaco Borba	B		0.117	0.111	0.228	0.189	0.183	0.372	0.279	0.224	0.503	0.072	0.072	0.144	0.162	0.113	0.275
Castro	B		0.083	0.065	0.148	0.135	0.158	0.293	0.200	0.242	0.442	0.052	0.093	0.145	0.117	0.177	0.294
Londrina	A		1.029	0.221	1.250	1.585	0.397	1.982	2.225	0.542	2.767	0.556	0.176	0.732	1.196	0.321	1.517
Cambe	B		0.163	0.115	0.278	0.260	0.166	0.426	0.400	0.241	0.641	0.097	0.051	0.148	0.237	0.126	0.363
Arapongas	B		0.141	0.050	0.191	0.188	0.098	0.286	0.265	0.135	0.400	0.047	0.048	0.095	0.124	0.085	0.209

(3) Required Water Supply of Rural Area by Sector and by Region in Tibagi River Basin

[m3/sec]

Municipality Name	Type	Zone	1993 Rural		2005 Rural		2015 Rural		2005-1993 Rural		2015-1993 Rural	
			Domestic	Agricult.	Domestic	Agricult.	Domestic	Agricult.	Domestic	Agricult.	Domestic	Agricult.
Total of Type-A	A		0.034	0.048	0.022	0.058	0.017	0.068	0.000	0.010	0.000	0.020
Total of Type-B	B		0.040	0.041	0.031	0.049	0.026	0.057	0.000	0.008	0.000	0.016
Total of Type-C/Zone-a	C	a	0.049	0.073	0.033	0.087	0.026	0.101	0.001	0.014	0.002	0.028
Total of Type-C/Zone-b	C	b	0.032	0.034	0.026	0.041	0.022	0.049	0.001	0.007	0.002	0.015
Total of Type-C/Zone-c	C	c	0.038	0.016	0.032	0.022	0.027	0.025	0.001	0.006	0.001	0.009
Total			0.193	0.212	0.144	0.257	0.118	0.300	0.003	0.045	0.005	0.088

6.4 Water Development in Large Urban Areas (Type-A)

The urban areas were defined that their population will be more than approximately 100,000 in 2015. The following urban areas belong to Type-A as large urban areas in Tibagi river basin.

- Ponta Grossa
- Londrina
- Apucarana

The current water supply system in Londrina covers the neighborhood urban area, Cambe (Type-B urban). Therefore, Cambe is to be included in the plan of future water system of Londrina.

6.4.1 Water Requirement

Required water supply in large urban areas is shown in Table-6.7.

Table-6.7 Required Water Supply in Large Urban Areas

Municipality	Year	
	2005	2015
Ponta Grossa	0.205	0.433
Londrina and Cambe	0.549	1.223
Apucarana	0.114	0.232

[Note] Water requirement for urban area is mainly composed of urban domestic water and industrial water.

6.4.2 Process of Water Resources Development Study

The process of water resources development in large urban areas is as shown below.

(1) In cities where main rivers are nearby and direct intake is easy, water supply shall be secured through surface water development.

(2) In cases where development by means of direct intake is difficult, careful consideration shall be given to the ease of development to the development capacity and the development cost, etc. for both surface water and groundwater.

(3) Regarding the development of surface water, more detailed examination shall be made on the promising alternatives stated in the Strategy (Main Report I) upon consideration of the local survey results and the state of existing facilities.

(4) Examination shall be given to the case where the whole water supply is provided by groundwater development.

(5) Based upon the examination results of (3) and (4), the optimal development plan shall be formulated upon first giving careful consideration to the conditions stated in (2).

6.4.3 Water Resources Development Policies

Based upon consideration of the topographical conditions in Type-A cities and the surface water and groundwater conditions in the target area, the water resources development policies as shown in Table-6.8 were decided upon.

Table-6.8 Water Resources Development Policies for Large Urban Areas

City	Topographical Conditions	State of Water Resources		Water Resources Development Policies
		Surface Water	Groundwater	
Ponta Grossa	Ponta Grossa is situated on the ridge area of the basin boundaries of the Tibagi river and Pitangui river.	If tributaries are utilized, a dam will have to be built in order to store water due to small catchment areas. If the Tibagi river mainstream is utilized, direct intake development will be feasible.	The Middle Paleozoic aquifer is located around the city, however, the productivity of existing wells is low and the permissive yield is small.	As the direct intake development of surface water is feasible and the surrounding aquifer is not suited to groundwater development, development will be carried out to exploit the surface water resources.
Londrina and Cambe	Londrina is situated in the midstream to upstream area of a tributary of the Tibagi river.	If the tributaries are used for development due to the large demand for water, dams will have to be built in order to store water. Even if two dams are built, they will still not be enough to obtain the required amount of water. Although a pipe line more than 10 km would be required, it would be possible to achieve the direct intake development of the mainstream waters of Tibagi river.	The Serra Geral Formation north aquifer and below that the Botucatu Formation aquifer are located around the city, and the productivity levels in each aquifer are high.	As both surface water development and groundwater development are feasible, the development plan shall be formulated upon examining both possibilities.
Apucarana	Apucarana is situated on the mountains and within the three river basins of the Tibagi, Pirapo and Ivai.	As the ratio of surface water that can be developed is low (50% $q_{10,7}$ or less) compared to the unit catchment area in this district, it would not be possible to supply the whole water demand through surface water development alone, even if direct intake from nearby rivers and dam construction were carried out.	Same as above	As the city is located in a region where surface water development is difficult and where suitable aquifers are situated, a water supply plan of groundwater development will be formulated.