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

SECTORAL REPORT VOLUME E

AGRICULTURE

December, 1995

Yachiyo Engineering Co., Ltd.
Tokyo, Japan

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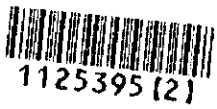

Cost Estimate is Based
on The Price Level of August, 1994,
According to The Following Exchange Rate.

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

COMPOSITION OF FINAL REPORT

1. EXECUTIVE SUMMARY

2. MAIN REPORT
   - I. Strategy for Paraná State
   - II. Master Plan for Iguaçu River Basin
   - III. Master Plan for Tibagi River Basin

3. SECTORAL REPORT
   - A. Socio-economy
   - B. Meteorology, Hydrology and Surface Water Resources
   - C. Hydrogeology and Groundwater Resources
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   - F. Hydroelectric Power Generation
   - G. Water Utilization Plan
   - H. Flood Control
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   - J. Soil Erosion and Forest
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4. DATA BOOK

THE MASTER PLAN STUDY ON
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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 STUDY OBJECTIVES AND METHODOLOGY

1.1 Study Objectives

The study consists of two phases, one for the strategy concerning the whole Paraná state and another for the master plan concerning the selected pilot river basins. The following objectives are common to both phases.

1) to identify agricultural characteristics

2) to project the water demands of agriculture sector for the year of 2005 and 2015 in accordance with future agriculture development plan

1.2 Methodology

The future water demands for the agriculture sector were studied as shown in the flow chart, Figure-1.1. The study was divided in 6 steps, identification of current agriculture, identification of current water consumption, evaluation of agriculture potential, planning, evaluation of proposals and water demand projection.

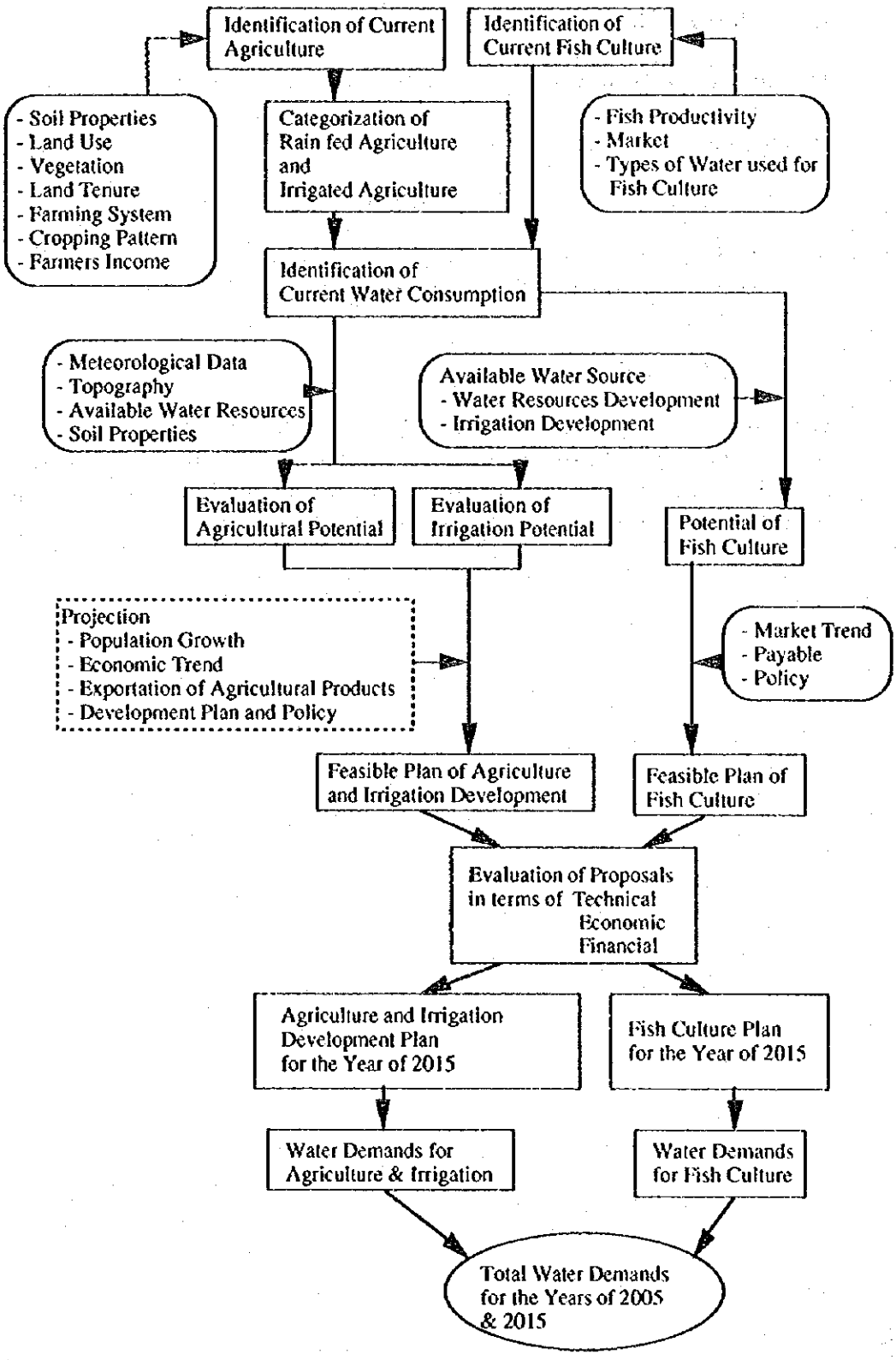


Figure-1.1 Conceptual Flow Chart of Study of Agriculture

CHAPTER 2 HISTORY OF AGRICULTURE IN PARANÁ STATE

The agriculture development of Paraná state has started since 17 century when the gold mining begun in the coastal area and Riveira valley. At the beginning, the agriculture was a small scale just to supply food to local inhabitants.

From the middle of 18 century to the latter half of 19 century, Paraná was developed as the route to convey cattle from Rio Grande do Sul to Sao Paulo, stipulating the livestock raising in Paraná. Other major industries in this period were timber and mate extraction.

In 1860's, coffee cultivation was introduced in the northern part of Paraná and spread over the state rapidly. By 1960, the coffee cultivation occupied approximately 40 % of the total cultivation area of the state. This is a major period of agrarian evolution in Paraná state accelerating the immigration.

After 1960's, the over production of coffee induced the low price in the world market and its quality in Paraná was degraded as a result of improper land use. Consequently, the coffee plantation has shifted to pasture and other crop cultivation, such as maize, beans, soybean and so on. The exhaustion of coffee cultivation has diversified varieties of crops in Paraná state.

IBGE defines "Estabelecimento" as the unit of the farm operated by one manager regardless of ownership. Therefore, even the leased farm and the farm without any legal possession are also counted as one unit. With this definition, the transition of number and area of the farm from 1920 to 1985 was summarized in Table-2.1. The farm here includes both lands for crop and livestock.

Table-2.1 Change in Number and Area of Farm Land

Year	No. of Farm "Estabelecimento"	Area of Farm (1,000 ha)
1920	30,951	5,302.7
1940	64,397	6,252.5
1950	89,461	8,032.7
1960	269,146	11,384.9
1970	554,488	14,625.5
1980	454,863	16,613.3
1985	466,397	16,698.9

Source: Anuario Estatistico

The number and area of farm in Paraná increased 15 times and 3 times respectively in the last 65 years. These figures denote that the enormous immigration started from 1950's has split the large farm. In 1920, the average farm size is approximately 171 ha, while in 1985, it is 36 ha.

IBGE categorizes the scale of farm as follows.

1) "Mini Fundio" (Mini Scale Farm)

The area of the unit farm is less than 10 ha. From the economic point of view, this type

of farm should be used for horticulture in the suburb of the large city, fruit culture or poultry farming.

2) "Pequeno Propriedade" (Small Scale Farm)

The area of the unit farm is between 10 and 100 ha. This scale is suitable for family cultivation.

3) "Medio Propriedade" (Medium Scale Farm)

The area of the unit farm is between 100 and 500 ha. The scale over 120 ha requires laborers beside family.

4) "Grande Propriedade" (Large Scale Farm)

The area of the unit farm is between 500 and 1,000 ha. Instead of the maximum use of the whole land, the suitable land is selected for specific cultivation. It requires the mechanization and laborers.

5) "Lati Fundio" (Extremely Large Scale Farm)

The area of the unit farm is greater than 1,000 ha.

Table-2.2 shows the change of the farm scale. By the year of 1980, there is no significant change in the percentage of each farm scale to the total area of farms, except slight decline of the small scale farm. Between 1980 and 1985, the change is obvious. "Lati Fundio", the extremely large scale farm, was split into the large and medium scale farm. This is due to the difficulty to handle the agriculture in such large scale. It induces inadequate use of land and machinery and consequently the productivity decreases. Since the farm has been concentrated on the medium and large scale farm, the land from 100 to 1,000 ha is the adequate size in terms of management, productivity and profit in Paraná.

Table-2.2 Area of Farm with Scale

Area Unit: 1,000 ha

Scale	1960		1970		1980		1985	
	Area	%	Area	%	Area	%	Area	%
< 10 ha	523.9	4.6	1,583.1	10.7	1,107.4	6.7	1,129.7	6.8
10 - 100	4,741.4	41.6	6,139.5	41.6	5,874.2	35.4	5,843.8	35.0
100 - 500	2,820.4	24.8	3,158.1	21.4	4,134.5	24.9	6,017.7	36.0
500 - 1,000	864.2	7.6	1,098.7	7.4	1,617.2	9.7	3,014.6	18.1
> 1,000	2,435.0	21.4	2,796.5	18.9	3,880.0	23.3	693.0	4.1
Total	11,384.9	100.0	14,775.9	100.0	16,613.3	100.0	16,698.8	100.0

Source: Agriculture Census

Literature Cited

1. IBGE. (1985). Censo Agropecuário (Agriculture Census). Rio de Janeiro.

CHAPTER 3 CURRENT AGRICULTURE IN PARANÁ STATE

3.1 Paraná Participation in Brazil Agriculture

According to the Cropping Calendar of Paraná (DERAL/SEAB and CEPA, 1990), the participation of Paraná agriculture in Brazil is very high. As shown in Table-3.1, Paraná is one of the leading state in agriculture.

Table-3.1 Paraná Participation in Brazil Agriculture

	Participation in Brazil (%)		production rank
	area	production	in Brazil
cotton	17.0	37.0	1
rice	3.1	3.0	9
potato	27.3	26.7	3
coffee	16.3	16.8	4
sugarcane	3.8	4.5	5
beans	19.5	21.1	1
cassava	5.0	8.0	4
maize	18.5	25.7	1
soybean	19.7	21.0	2
wheat	56.0	61.0	1
	Participation in Brazil (%)		production rank
	heads	production	in Brazil
cattle (meat)	6.1	10.4	4
cattle (milk)		8.3	5
chicken (meat)	13.1	15.6	2
Chicken (egg)		9.7	3

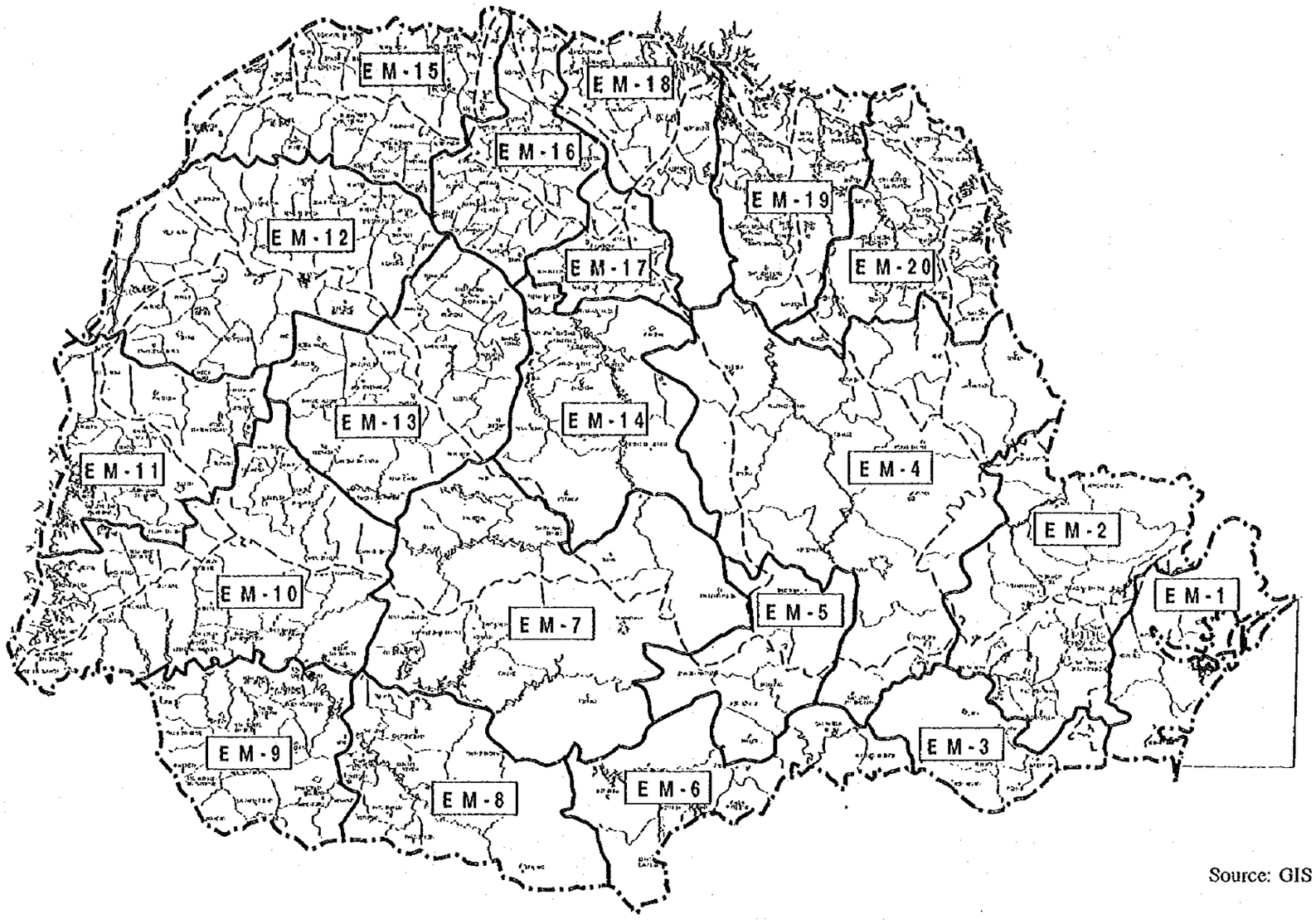
Source: DERAL/SEAB, and CEPA (1990)

3.2 Agriculture in Paraná

3.2.1 Characteristics of Crop Cultivation

(1) Variation of Crops

Since the area of Paraná state is quite large, approximately 200 thousand km^2, the agriculture in Paraná varies with region due to different climatic, topographic and market conditions. EMATER divides Paraná in 20 regions as shown in Figure-3.1 and has conducted agriculture extension services. Based on agriculture statistics as of 1993 available in EMATER, the current agriculture in Paraná was summarized with EMATER division to grasp local characteristics of agriculture as shown in Appendix-1. To identify the local characteristics clearly, crops which more than 1,000 farm households are involved or whose areas in a EMATER division are more than 1,000 ha were extracted from each EMATER region.



EMATER Division

E M - 1	Paranagua
E M - 2	Curitiba
E M - 3	Lapa
E M - 4	Ponta Grossa
E M - 5	Irati
E M - 6	Uniao da Vitoria
E M - 7	Guarapuava
E M - 8	Pato Branco
E M - 9	Francisco Beltrao
E M - 10	Cascavel
E M - 11	Toledo
E M - 12	Umuarama
E M - 13	Campo Mourao
E M - 14	Ivaipora
E M - 15	Paranavai
E M - 16	Maringa
E M - 17	Apucarana
E M - 18	Londrina
E M - 19	Cornelio Procopio
E M - 20	Jacarezinho

Legend

Boundary of River Basin

Boundary of EMATER Division

Scale 1:2,500,000

Source: GIS Digitization by SANEPAR (1994)

Figure-3.1 EMATER Division

Appendix-1 denotes that primary crops in Paraná are cotton, rice (paddy and upland), potato, sugarcane, beans, cassava, coffee, maize, soybean and wheat. One of the significant features is that the crop cultivation is not dominant in the Paranagua region (EM-1).

In Guarapuava (EM-7), Pato Branco (EM-8) and Francisco Beltrao (EM-9) regions, more than 1,000 farm households are involved in the fruit culture, such as orange and grape, despite the fact that their area is pretty limited, in the order of 100 ha. On the other hand, in Curitiba (EM-2), Paranavai (EM-15) and Maringa (EM-16), the area of orange cultivation is more than 1,000 ha in spite of small number of producers. The fruit cultivation is considered as an alternative to coffee plantation. It has just introduced in Paraná and its area is still limited; however, it is expected to expand together with agro-industry, such as juice and can factories.

Mulberry cultivation is practiced in Umuarama (EM-12), Campo Mourao (EM-13), Paranavai (EM-15), Maringa (EM-16) and Jacarezinho (EM-20). In some locations, there are textile factories near the cultivation site to produce silk.

Table-3.2 Region for Fruit Culture

No.	Region	Items	No. of Producers	Area (ha)
9	Francisco Beltrao	Grape	3,603	552
8	Pato Branco	Grape	1,490	144
16	Maringa	Mulberry	1,652	12,876
12	Umuarama	Mulberry	1,962	9,657
15	Paranavai	Mulberry	1,107	7,437
20	Jacarezinho	Mulberry	968	4,565
13	Campo Mourao	Mulberry	269	1,202
15	Paranavai	Orange	140	3,873
2	Curitiba	Orange	976	2,016
16	Maringa	Orange	60	1,038
9	Francisco Beltrao	Orange	3,934	609
8	Pato Branco	Orange	1,070	191
7	Guarapuava	Orange	1,185	31
8	Pato Branco	Peach	1,007	34

Source: EMATER Database for Data in 1993

To identify the major production region for the 11 primary crops, the ratios of crop area and production of each region to the state total were computed as shown in Table-3.3. There are clear distinctions of crop cultivation among the EMATER regions. Major production regions of each primary crop is described as follows.

Table-3.3 Crop Variation with EMATER Region

No.	Region	Beans		Beans (winter)		Cassava		Coffee		Cotton		Maize		Maize (Saf)		Potato		Potato(winter)		Rice		Rice(paddy)		Soybean		Soybean(saf)		Sugarcane		Wheat	
		A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)	A (%)	P (%)
1	Paranagua						1	1																							
2	Curitiba	6	5	6	3	2	2					3	2			55	52	73	61	1	1										
3	Lapa	5	6									2	2			23	22			1	1										
4	Ponta Grossa	12	13	15	28	2	2					10	10	2	2	5	6			9	12			7	8	2	4			6	9
5	Irati	11	11	2	2							4	3			6	7			7	6			1	1						
6	Uniao da Vitoria	7	8	2	1	1	1					2	2			5	6			7	6										
7	Guarapuava	13	11	4	3							14	13	1	1	4	5	27	39	12	15			4	5					2	3
8	Pato Branco	4	6	1	1	2	2					7	7	3	3	1	1			4	4			6	5					3	3
9	Francisco Beltrao	12	13	8	6	9	11	1	1			12	10	16	15	1	1			9	10			5	5			2	1	5	6
10	Cascavel	3	4			12	15			8	9	10	14	13	11					8	10			14	14	9	7	1	1	12	10
11	Toledo	1	1			14	16	3	7	12	12	6	9	23	25					1	1	13	14	16	15	77	76			17	12
12	Umuarama	2	1	4	2	18	17	22	9	14	15	1	1	1	1					2	1	17	13	1	1			15	12	1	1
13	Campo Mourao	3	2			10	9	10	9	25	27	6	6	5	5					6	5			17	17	4	3	8	8	22	20
14	Ivaipora	15	12	7	4	2	1	7	8	10	10	9	7	5	5					12	9			3	3			3	3	4	3
15	Paranavai			10	7	20	18	11	12	6	7									1	1	25	20					9	11		
16	Maringa			3	1	4	3	5	5	6	5	1	1	8	8					2	1			8	8	1	1	15	16	9	7
17	Apucarana	1	1					7	5	3	3	3	3							3	3			2	2			3	1	2	2
18	Londrina			5	4	2	1	11	10	4	4	2	2	10	11					3	3	9	13	8	8	2	3	16	17	6	8
19	Cornelio Procopio			11	9			9	15	11	7	3	4	9	10					1	2	22	23	7	7	5	6	12	13	9	14
20	Jacarezinho	5	6	22	29	1	1	14	19	1	1	5	4	4	3					11	9	14	17	1	1			16	17	2	2
	Total (%)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	Total*	522	431	74	63	153	3,343	222	169	316	455	2,236	7,133	513	1,158	25	368	11	137	88	126	13	54	1,944	4,525	76	72	249	17,327	934	1,358

A: Area, P: Production, Saf: Second Cropping in Summer (Safrinha)
*: Unit of Total A: 1000 ha, P: 1000 ton
Source: adapted and enlarged from EMATER (1993)

1) Beans
Since beans are one of the staple food in Brazil, their cultivation in summer spreads over the state, exclusive of the northern part of the state. Its winter cultivation is practiced mainly in Jacarezinho (EM-20) and Ponta Grossa (EM-4).

2) Cassava
Cassava cultivation is concentrated in the western region of the state.

3) Coffee
The northern regions are major in coffee plantation. Due to the decline of price at the international market, coffee plantation has changed to other crops, such as fruit culture, pasture and so on.

4) Cotton
The major production regions are in the western region of the state, especially Campo Mourao (EM-13).

5) Maize
The maize cultivation spreads over the state, especially Ponta Grossa (EM-4), Guarapuava (EM-7), Francisco Beltrao (EM-9) and Cascavel (EM-10). Its second cultivation in summer, "safrinha", is mostly practiced in Francisco Beltrao (EM-9), Cascavel (EM-10), Toledo (EM-11), Londrina (EM-18) and Cornelio Procopio (EM-19).

6) Potato
This cultivation is very distinctive, concentrating in the Curitiba (EM-2) and Lapa (EM-3) regions for summer cultivation, and Curitiba (EM-2) and Guarapuava (EM-7) for winter cultivation.

7) Rice (upland)
This cultivation spreads over the state; however, major production regions are the central and southern regions, such as Ponta Grossa (EM-4), Guarapuava (EM-7), Francisco Beltrao (EM-9) and Cascavel (EM-10).

8) Rice (paddy)
In contrast to upland rice, paddy rice cultivation is concentrated in the western and northern regions, especially Paranavai (EM-15) and Cornelio Procopio (EM-19).

9) Soybean and Wheat
The popular crop sequence in Paraná is soybean in summer and wheat in winter. Therefore, the major production regions in soybean cultivation correspond to ones in wheat cultivation. The Cascavel (EM-10), Toledo (EM-11) and Campo Mourao (EM-13) are major production regions in both crops. Regarding soybean second cropping in summer, Toledo (EM-11) produces almost 80 % of the state production.

10) Sugarcane
Major production regions for sugarcane are located in the northern part of the state. It is due to the hot weather so as to increase the sugar contents of sugarcane.

(2) Mechanization

The average rates of mechanization for 11 primary crops were computed based on Annex-1, excluding EMATER regions where the production share to the state is less than 10 %. Table-3.4 shows the large extension of mechanization in major production regions. Among 11 primary crops, the mechanization rates for beans and coffee are the lowest, 58 %, while the rates for potato, soybean and wheat are almost 100 %. These figures imply that the intensive farming is dominant in Paraná.

Table-3.4 Average Mechanization Rate for 11 Primary Crops

Crop	Mechanization (%)
Beans	58
Cassava	78
Coffee	58
Cotton	91
Maize	71
Potato	99
Rice(upland)	68
Rice(paddy)	92
Soybean	99
Sugarcane	89
Wheat	98

Source: adapted and enlarged from EMATER(1993)

3.2.2 Livestock

Cattle, pig and chicken are the primary livestock in Paraná state. Livestock population in the last 20 years is available from IBGE. In 1993, the total population of cattle, pig and chicken in Paraná were 9,736,000, 2,815,000 and 60,744,000 heads, respectively.

The ratio of livestock population with SEAB division, 18 regions, is available in Cropping Calendar of Paraná (DERAL/SEAB and CEPA, 1990). Assuming the livestock population is uniformly spread within each region, the ratio was converted into EMATER division, 20 regions, by means of area weighted average. The result is in Table-3.5.

Toledo, Francisco Beltrao and Cascavel regions are the major regions in pig raising, Umuarama and Paranavai regions are in cattle raising, and Francisco Beltrao, Toledo and Ponta Grossa are in poultry farming (chicken). Pig raising is limited due to the its low price. Cattle raising and poultry farming (chicken) are the dominant livestock industry for Paraná state and they are ranked forth and second in Brazil agriculture, respectively.

To evaluate the carrying capacity of cattle which is the area required for raising cattle, the area of pasture was compared with the population of cattle. As shown in Table-3.6, the carrying capacity computed for each EMATER region is considered as too small. It implies that raising in cage has expanded in Paraná state.

Table-3.5 Livestock Population in 1993

Unit of Herd: 1,000 head

EMATER No.	EMATER Region	EMATER Area (km^2)	Pig		Cattle		Chicken	
			Herd	Share (%)	Herd	Share (%)	Herd	Share (%)
EM-1	Paranagua	5594	0.0	0.0	9.7	0.1	0.0	0.0
EM-2	Curitiba	11134	95.7	3.4	126.6	1.3	3,037.2	5.0
EM-3	Lapa	4681	53.5	1.9	77.9	0.8	1,700.8	2.8
EM-4	Ponta Grossa	24521	168.9	6.0	506.3	5.2	6,681.9	11.0
EM-5	Irati	5832	101.3	3.6	87.6	0.9	850.4	1.4
EM-6	Uniao da Vitoria	7366	84.5	3.0	97.4	1.0	728.9	1.2
EM-7	Guarapuava	19142	228.0	8.1	486.8	5.0	1,700.8	2.8
EM-8	Pato Branco	9462	205.5	7.3	340.8	3.5	5,284.8	8.7
EM-9	Francisco Beltrao	7718	349.1	12.4	379.7	3.9	10,083.6	16.6
EM-10	Cascavel	14420	295.6	10.5	662.1	6.8	4,859.5	8.0
EM-11	Toledo	7854	422.3	15.0	447.9	4.6	9,233.1	15.2
EM-12	Umuarama	15430	123.9	4.4	1,625.9	16.7	1,336.4	2.2
EM-13	Campo Mourao	12105	118.2	4.2	788.6	8.1	1,518.6	2.5
EM-14	Ivaipora	10776	137.9	4.9	516.0	5.3	1,093.4	1.8
EM-15	Paranavai	10039	39.4	1.4	1,236.5	12.7	1,336.4	2.2
EM-16	Maringa	6565	87.3	3.1	671.8	6.9	2,733.5	4.5
EM-17	Apucarana	3221	50.7	1.8	214.2	2.2	425.2	0.7
EM-18	Londrina	7029	84.5	3.0	535.5	5.5	3,644.7	6.0
EM-19	Cornelio Procopio	7518	56.3	2.0	321.3	3.3	1,457.9	2.4
EM-20	Jacarezinho	8153	112.6	4.0	603.6	6.2	3,037.2	5.0
	Total	198560	2,815	100	9,736	100	60,744	100

Source: EMATER for Region Area,
IBGE for Total Population,
Cropping Calendar of Parana (DERAL/SEAB and CEPA, 1990) for Share of Region

Table-3.6 Area of Pasture and Number of Livestock with EMATER Division as of 1993

No.	Region	No. of Producers	Pasture Area (ha)	No. of Cattle (1000 head)	Area/head (ha/head)
1	Paranagua			9.7	
2	Curitiba	14,565	121,639	126.6	1.0
3	Lapa	9,483	114,583	77.9	1.5
4	Ponta Grossa	15,260	504,060	506.3	1.0
5	Irati	13,146	69,725	87.6	0.8
6	Uniao da Vitoria	15,032	161,919	97.4	1.7
7	Guarapuava	20,032	371,066	486.8	0.8
8	Pato Branco	13,648	260,177	340.8	0.8
9	Francisco Beltrao	32,010	172,708	379.7	0.5
10	Cascavel	27,346	356,928	662.1	0.5
11	Toledo	18,642	141,955	447.9	0.3
12	**Umuarama**	**21,692**	**1,227,377**	**1,625.9**	0.8
13	**Campo Mourao**	**13,593**	**401,505**	**788.6**	0.5
14	Ivaipora	27,821	396,798	516.0	0.8
15	**Paranavai**	**7,158**	**901,779**	**1,236.5**	0.7
16	Maringa	5,276	282,165	671.8	0.4
17	Apucarana	2,956	112,053	214.2	0.5
18	Londrina	4,824	260,762	535.5	0.5
19	Cornelio Procopio	4,612	223,792	321.3	0.7
20	Jacarezinho	11,552	446,341	603.6	0.7
	Total	278,648	6,527,332	9,736	

No. of Cattle: include both milk and meat cattle
Pasture Area: total of both natural and planted pasture
Source: Number of Farmers and Area of Pasture; EMATER (1993)
Number of Cattle; IBGE

3.2.3 Inland Fish Culture

Number of producers and ponds, and area of ponds by EMATER division for the year of 1993 are available from EMATER. However, the total area is somehow unrealistically large. It may contain dam reservoirs. Therefore, the data from DEPEC/SEAB by municipality wise was adopted, summed by region, SEAB division, and converted to EMATER division with area weighted average, assuming fish ponds are spread uniformly in each SEAB region. The result is shown in Table-3.7.

Table-3.7 Area of Fish Pond with EMATER Division

NO.	EMATER Region	Year of 1993	
		Area (ha)	Share of Region (%)
EM-1	Paranagua	17	0.5
EM-2	Curitiba	156	4.2
EM-3	Lapa	87	2.3
EM-4	Ponta Grossa	320	8.5
EM-5	Irati	139	3.7
EM-6	Uniao da Vitoria	103	2.7
EM-7	Guarapuava	165	4.4
EM-8	Pato Branco	611	16.2
EM-9	Francisco Beltrao	736	19.6
EM-10	Cascavel	405	10.8
EM-11	Toledo	354	9.4
EM-12	Umuarama	4	0.1
EM-13	Campo Mourao	47	1.3
EM-14	Ivaipora	209	5.5
EM-15	Paranavai	11	0.3
EM-16	Maringa	36	1.0
EM-17	Apucarana	46	1.2
EM-18	Londrina	75	2.0
EM-19	Cornelio Procopio	119	3.2
EM-20	Jacarezinho	116	3.1
	Total	3,756	100.0

Source: DEPEC/SEAB

Francisco Beltrao, Pato Branco and Cascavel regions have a large share of inland fish culture compared to other regions. According to DEPEC/SEAB, the productivity of fish culture is 1.5 ton/ha·year and main species are carp and tilapia. Although the market of fresh water fish is considered as small, unauthorized information says that some of production is exported to foreign countries. Since there is no statistics regarding the fresh water fish culture, the above information could not be confirmed. Considering lots of annual rainfall, approximately 1,500 mm in average, the potential of fish culture is high but its expansion depends on the market and price.

3.3 Consumption in the State, Export and Import of Agricultural Products

Importation and exportation of agricultural products at Paranagua port is available and shows in Table-3.8; however, the flow of the products on land is unknown for both in and out of the state. Therefore, it is difficult to assess the total amount of internal and external trade of the agricultural products.

Table-3.8 Exportation and Importation at Paranagua Port

Unit: ton

Exportation				
Product	Year 1990	Year 1991	Year 1992	Year 1993
Soybean grain	2,103,500	1,056,600	1,412,600	1,860,000
Coffee grain	70,668	36,321	31,750	15,673
Cotton	59,186	107,973	48,407	9,020
Soybean bran	4,520,500	4,908,000	4,983,700	5,001,600
Maize bran	204,600	219,100	299,200	311,500
Cotton bran	82,900	23,000	54,000	31,100
Soybean oil	312,200	261,400	306,500	256,400
Maize oil	6,000	2,200	12,300	10,000
Cotton oil	–	–	–	5,500
Peanut oil	500	1,900	1,500	1,500
Instant coffee	30,457	18,416	27,256	16
Importation				
Product	Year 1990	Year 1991	Year 1992	Year 1993
Rice	29,513	68,500	–	–
Maize	–	23,168	–	–
Wheat	–	–	–	120,000

Source: Ministry of Industry and Commerce

Amount of food consumed and its varieties are changeable with the economic development and other factors. Although average food consumption estimated by IBGE/EMDEF (1976) may be different from current one, this is only data available. Based on the population estimate by IPARDES (1994) and the rate of food consumption by IBGE/EMDEF (1976), the current food consumption was estimated and shown in Table-3.9.

Table-3.9 Current Consumption of Food (1993)

Population by IPARDES: 8,604,000

Food	Crop	F. C. R. kg per capita /year	C. F.	Annual Consumption (ton) Year 1993
Rice		43.2		371,693
	Unhulled Rice		1.4700	546,389
Beans		22.5		193,590
Potato		25.4		218,542
Coffee Powder		4.0		34,416
	Coffee Beans		2.3800	81,910
Flour		51.0		438,804
	Wheat		1.3300	583,609
Cassava Powder		3.5		30,114
	Cassava		3.7000	111,422
	Raw Cassava	15.8		135,943
	Cassava Total			247,365
Soybean Oil		4.0		34,416
	Soybean		5.5600	191,353
Sugar		30.5		262,422
	Sugarcane		11.1100	2,915,508
Maize		15.0		129,060
Beef		18.4		158,314
Pork		7.0		60,228
Chicken		17.7		152,291

F. C. R.: Food Consumption Rate

C. F.:Conversion Factor, Amount of Crop = Food Consumption x C. F.

Data Source: EMDEF/IBGE(1976) for Food Consumption per capita,
DERAL/SEAB for C.F., IPARDES(1994) for population

3.4 Ongoing Development Project

Paraná Rural, Paraná rural development program, is only the ongoing project. Although the main objective of the project is the soil conservation, it includes the improvement of crop cultivation and its extension service. Since soil conservation benefits to increase productivity of crop, the success of this project contributes to the progress of agriculture in Paraná. The program of Paraná Rural includes the following items.

1) Adaptive research for improving soil cover and soil structure

2) Rural extension

3) Incentive program for land management, soil conservation and pollution control

4) Erosion control along rural roads

5) Lime distribution facilities

6) Forestry development and environmental studies

7) Land use monitoring and control

8) Project administration, monitoring and evaluation

9) Training

The total budget of Paraná Rural is US$ 138.3 million consisting of US$ 63.0 million loan from the World Bank and US$ 75.3 million at the state's own expense and it covers 5 million ha, which is equivalent to 21 % of the state area and 40 % of the agriculture land inclusive of pasture. The implementation of the project was started in 1989 and will be ended in 1995.

3.5 Water Consumption

The current water consumption of agriculture in Paraná consisting of water for crop, livestock and inland fish culture was examined to assess whether the further water resources development is necessary or not. After the assessment of the water requirement, it was compared with precipitation and assumed that the water requirement not covered by the precipitation is supplied by either surface water or groundwater. The utilization of surface water or groundwater for agriculture is defined as the water consumption.

3.5.1 Irrigation

In general, the crop water requirement not satisfied by precipitation is supplemented by irrigation. Therefore, irrigation requirement is equal to the water consumption of crop cultivation.

Since the data regarding irrigation is not available, current water consumption of crop was estimated by means of comparison between crop water requirement assessed and precipitation data observed. Crop water requirement is defined as the sum of evapotranspiration of a specific crop and evaporation from soil surface in a crop field. Therefore, it depends on climate, type of crop, cropping calendar, soil properties etc. The climatic factors were examined using the precipitation data and reference crop evapotranspiration calculated by Penman Methods. Although crops in Paraná state have been diversified, cotton, rice (paddy and upland), potato, coffee, sugarcane, beans, cassava, maize, soybean and wheat are the primary crops in Paraná as mentioned before. Therefore, the current water consumption was examined only for the 11 primary crops. Although soil properties such as, water holding capacity, are important to agricultural practices, at the strategy or master plan level they are negligible and required for the detail design level.

Once reference crop evapotranspiration is determined, evapotranspiration of a specific crop is computed in the following equation.

$$ET_{crop} = K_C ET_O$$

where ET_{crop}: evapotranspiration of a specific crop (crop water requirement)

K_C: crop coefficient

ET_O: reference crop evapotranspiration or potential evapotranspiration

ET_O is defined as "the rate of evapotranspiration from an extensive surface of 8 to 15 cm tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water" (Doorenbos and Pruitt, 1977). ET_O was calculated by Penman methods. Doorenbos and Pruitt (1977) graded the Penman methods at the best with minimum possible error of plus or minus 10 % in summer and up to 20 % under low evaporative conditions, followed by the Pan method, Radiation method and Blaney-Criddle method.

Crop coefficient is the value in the ideal conditions, a diseases free crop grown in the large fields with optimum soil water and fertility and achieving full production potential under the given growing environment (Doorenbos and Pruitt, 1977). Actual conditions may deviate from the ideal condition; however, to take account of the ideal conditions implies to estimate the maximum crop water requirements and it is more secure for planning. K_C values for the different crops and different growing stage are available in FAO Irrigation and Drainage Paper 24 (Doorenbos and Pruitt, 1977). Periods and time of 4 growing stages, initial, crop development, mid-season and late season, of each primary crop were assumed referring to the Cropping Calendar issued by DERAL/SEAB and CEPA (1990). For instance, 4 growing stages of cotton were assumed to be 20, 40, 45 and 45 days respectively, and planting date was October 1. When K_C applied, detailed factors such as, climate variation with time and advection effect, level of available soil water, methods of

irrigation, etc. should be taken account at the design level. Since the Study involves in the master plan level, these factors were neglected.

33 stations are selected for meteorological analysis as shown in Figure-3.2. Mean rainfall and reference crop evapotranspiration as a result of analysis are shown in Table-3.10 and 3.11, respectively. For the sake of calculation, 33 stations were categorized with Koeppen classification. Godoy and Correa (1974), and Pinto and Alfonsi (1974) identified the climate in Paraná state in three types, Cfa, Cfb and Af(t), while according to the atlas of Paraná state (SEAB and ITCF, 1987), there are four types adding Cfa(h). Since the hyetograph of mean monthly rainfall for Cfa(h) is different from one for Cfa, the classification of the atlas as shown in Figure-3.3 was applied throughout the study.

Cfa:	humid subtropical climate with no dry season with hot summer (average temperature of the hottest month; above 22°C)
Cfa(h):	similar to Cfa, except its hyetograph
Cfb:	humid subtropical climate with no dry season with mild summer (average temperature of the hottest month; below 22°C)
Af(t):	humid tropical climate with no dry season

No.	Station No.	Station Name	Basin	Altitude (m)
1	02251027	Bela Vista	P.P. 3	600
2	02349030	Joaquim Tavora	Cinzas	512
3	02350017	Cambara	P.P. 1	450
4	02350018	Bandeirantes	Cinzas	440
5	02351003	Londrina	Tibagi	585
6	02351008	Apucarana	Pirapo	746
7	02351011	Ibipora	Tibagi	484
8	02352017	Paranavai	Ival	480
9	02352019	Cianorte	Ival	530
10	02353008	Umuarama	Piquiri	480
11	02449013	Cerro Azul	Ribeira	443
12	02450011	Telemaco Borba	Tibagi	768
(13)	02451051	Candido Abreu	Ival	600
13	02451052	Candido Abreu	Ival	645
14	02452050	Nova Cantu	Piquiri	540
15	02453003	Palotina	Piquiri	310
16	02453023	Cascavel	Parana	760
17	02548038	Morretes	Litoranea	59
18	02548039	Guaraquecaba	Litoranea	40
19	02548070	Antonina	Litoranea	60
20	02549041	Piraquara	Iguacu	930
(21)	02549025	Lapa	Iguacu	907
21	02549091	Lapa	Iguacu	910
22	02550024	Ponta Grossa	Tibagi	880
23	02550025	Teixeira Soares	Tibagi	893
24	02551010	Guarapuava	Iguacu	1,020
25	02552009	Laranjeiras	Iguacu	880
26	02553015	Planalto	Iguacu	400
27	02553018	Quedas Iguacu	Iguacu	513
28	02554026	Sao Miguel	Parana	260
(29)	02651000	Uniao da Vitoria	Iguacu	736
29	02651007	Porto Uniao	Iguacu	778
30	02651043	Palmas	Iguacu	1,100
31	02652003	Clevelandia	Iguacu	930
32	02652035	Pato Branco	Iguacu	700
33	02653012	Francisco Beltrao	Iguacu	650

( ) : only rainfall gauging stations

LEGEND
- Boundary of River Basin
- State Boundary

SCALE 0 10 20 30 40km

MATO GROSSO DO SUL
SÃO PAULO
PARAGUAI
ARGENTINA
SANTA CATARINA
ATLANTIC OCEAN
Paranapanema River
Paranavai
Londrina
Maringa
Arapongas
Apucarana
Umuarama
Telemaco Borba
Ivai River
Pirapo River
Piquiri River
Tibagi River
Ribeira River
Toledo
Cascavel
Ivai
Ponta Grossa
Guarapuava
Irati
Curitiba
Guaraquecaba
Paranagua
Foz do Iguaçu
Iguaçu River
União da Vitoria
PALMAS
GENERAL CARNEIRO

Figure-3.2 Selected Meteorological Stations

Table-3.10 Annual and Monthly Mean Rainfall with Koeppen Classification(1974 - 1993, 20 years)

No.	Station	Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Total
18	Guaraquecaba	Af(t)	349.0	309.0	326.8	157.1	145.3	107.1	111.2	82.0	149.6	166.1	171.9	235.9	192.6	2311.0
19	Antonina	Af(t)	355.5	343.8	355.3	152.1	150.4	110.0	115.6	87.1	165.0	186.9	204.7	264.5	207.6	2490.9
17	Morretes	Cfa	276.4	242.7	242.8	113.5	118.4	93.5	101.4	82.6	140.2	153.3	147.1	183.2	157.9	1895.1
11	Cerro Azul	Cfa	156.1	135.1	120.0	73.0	116.2	80.8	75.6	66.6	101.0	120.3	105.8	157.1	109.0	1307.6
33	Francisco Beltrao	Cfa	171.6	166.9	127.2	157.8	197.9	154.1	143.1	117.1	153.5	209.7	194.1	163.8	163.1	1956.8
16	Cascavel	Cfa	177.2	173.0	137.1	163.7	218.2	128.9	114.4	109.8	147.8	205.3	197.8	177.9	162.6	1951.1
15	Palotina	Cfa	153.1	141.4	117.1	148.4	177.7	114.2	90.3	81.5	135.8	169.4	165.1	178.3	139.4	1672.3
14	Nova Cantu	Cfa	166.5	178.1	144.2	167.8	195.8	136.1	109.4	99.1	145.1	196.8	185.3	220.0	162.0	1944.2
(13)	Candido de Abreu	Cfa	178.0	149.9	118.6	100.1	157.5	102.1	98.8	77.7	131.8	155.9	129.4	159.1	129.9	1558.9
12	Telemaco Borba	Cfa	181.0	155.3	139.1	102.6	150.8	98.5	87.3	74.1	131.7	150.6	151.4	205.4	135.7	1627.8
2	Joaquim Tavora	Cfa	179.3	141.0	141.2	87.5	128.2	80.2	54.5	52.3	100.2	122.8	123.2	189.6	116.7	1400.0
26	Planalto	Cfa	179.8	143.2	123.3	163.8	181.4	157.4	117.2	124.0	144.4	188.3	182.8	173.1	156.6	1878.7
27	Quedas do Iguacu	Cfa	172.5	174.7	138.0	168.1	181.4	153.0	142.4	117.0	159.3	204.4	202.8	176.8	165.9	1990.4
28	Sao Miguel do Iguacu	Cfa	162.0	152.6	130.5	143.1	166.4	136.0	111.6	112.8	131.5	189.7	178.2	149.9	147.0	1764.3
3	Cambara	Cfa(h)	168.4	174.8	175.8	92.6	94.8	75.8	47.0	43.3	84.3	113.4	154.3	194.9	118.3	1419.4
4	Bandeirantes	Cfa(h)	179.9	160.1	160.2	90.4	110.9	79.7	49.6	46.3	105.3	122.7	166.3	211.4	123.6	1482.8
5	Londrina	Cfa(h)	189.5	165.5	157.7	120.9	117.8	90.5	62.5	53.1	118.9	136.8	179.1	242.4	136.2	1634.7
1	Bela Vista do Paraiso	Cfa(h)	206.5	136.6	143.6	116.4	118.3	86.5	51.1	48.1	112.9	145.1	161.9	217.7	128.7	1544.7
6	Apucarana	Cfa(h)	190.3	154.6	151.5	112.7	151.0	112.2	69.2	66.2	128.6	153.6	159.1	211.3	138.4	1660.3
8	Paranavai	Cfa(h)	184.1	145.0	130.2	110.0	123.7	101.4	54.5	54.8	127.2	163.1	122.0	185.3	125.1	1501.3
9	Cianorte	Cfa(h)	189.1	142.0	139.5	134.4	162.7	110.7	66.6	75.8	134.1	143.7	136.8	211.1	137.2	1646.5
10	Umuarama	Cfa(h)	165.0	126.7	125.0	136.0	157.2	108.0	68.5	76.4	141.3	153.3	168.8	191.2	134.8	1617.4
7	Ibipora	Cfa(h)	199.9	160.7	155.4	111.6	115.3	90.2	55.8	50.8	117.0	131.2	173.6	225.7	132.3	1587.2
20	Piraquara	Cfb	161.3	135.8	125.3	86.4	119.5	88.5	92.8	73.2	109.7	127.2	122.4	146.2	115.7	1388.3
(21)	Lapa	Cfb	159.0	138.0	120.8	86.4	142.5	107.2	109.4	98.3	119.9	146.1	127.7	158.6	126.2	1513.9
22	Ponta Grossa	Cfb	163.2	133.7	140.3	105.0	157.4	98.1	105.1	85.0	128.4	136.3	126.5	151.7	127.6	1530.7
23	Teixeira Soares	Cfb	174.7	126.0	132.0	99.0	168.3	113.7	111.1	89.9	133.6	147.0	152.5	146.9	132.9	1594.7
24	Guarapuava	Cfb	182.0	147.1	146.8	143.7	196.1	141.4	128.6	107.8	156.4	183.9	174.4	184.2	157.7	1892.4
(29)	Uniao da Vitoria	Cfb	184.9	158.6	125.8	110.8	171.0	116.9	144.2	116.3	139.6	162.0	149.6	159.1	144.9	1738.8
30	Palmas	Cfb	187.2	169.5	131.7	161.8	199.3	171.0	161.2	128.3	157.1	208.6	179.5	161.9	168.1	2017.1
31	Clevelandia	Cfb	186.2	152.4	123.1	162.2	213.8	167.6	154.6	126.8	151.1	195.5	199.1	165.6	166.5	1998.0
32	Pato Branco	Cfb	193.7	163.7	123.9	168.8	204.6	166.2	155.7	123.5	163.7	208.5	197.5	175.2	170.4	2045.0
25	Laranjeiras do Sul	Cfb	167.1	175.4	120.0	154.8	188.3	150.6	140.4	115.6	152.7	209.6	180.1	181.7	161.4	1936.3

( ): only rainfall gauging station, Class: Koeppen Classification

Data Source: COPEL

Table-3.11 Annual and Monthly Mean Reference Crop Evapotranspiration with Koeppen Classification (1974 - 1993, 20 years)

No.	Station	Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Total
18	Guaraquecaba	Af(t)	110.3	98.4	88.2	63.2	46.0	33.2	35.9	46.5	55.8	78.2	96.0	104.1	71.3	855.8
19	Antonina	Af(t)	110.0	97.3	88.7	63.7	46.7	34.7	36.9	47.6	56.6	78.9	95.2	102.9	71.6	859.2
17	Morretes	Cfa	114.1	99.8	90.7	63.9	46.6	33.8	36.0	47.1	56.3	80.1	98.4	106.9	72.8	873.7
11	Cerro Azul	Cfa	121.5	103.2	100.2	67.5	44.2	36.6	38.3	54.5	65.4	99.6	119.7	120.2	80.9	970.9
33	Francisco Beltrao	Cfa	136.4	113.1	104.6	69.0	45.2	32.1	39.0	56.3	74.5	106.1	124.3	136.4	86.4	1037.0
16	Cascavel	Cfa	136.9	112.3	108.7	76.5	52.4	38.9	46.0	64.0	79.1	110.1	124.4	137.2	90.5	1086.5
15	Palotina	Cfa	142.7	122.3	117.3	82.6	53.5	38.8	45.9	63.6	82.0	114.5	130.9	143.8	94.8	1137.9
14	Nova Cantu	Cfa	146.7	119.9	115.7	87.0	57.1	42.2	52.3	69.6	86.6	121.6	135.4	146.4	98.4	1180.5
(13)	Candido de Abreu	Cfa	132.9	111.9	107.5	77.3	47.5	31.0	40.3	63.7	80.1	117.1	131.4	129.3	89.2	1070.0
12	Telemaco Borba	Cfa	128.1	109.6	102.0	76.0	50.7	37.4	45.2	63.0	77.3	109.1	122.6	125.2	87.2	1046.2
2	Joaquim Tavora	Cfa	133.3	117.2	110.4	84.9	57.6	42.8	50.4	73.8	84.7	118.9	133.6	129.9	94.8	1137.5
26	Planalto	Cfa	147.4	119.7	116.7	79.5	54.5	39.1	46.2	66.1	82.9	117.8	136.9	152.5	96.6	1159.3
27	Quedas do Iguacu	Cfa	137.5	111.3	107.6	73.9	51.1	36.3	44.2	62.8	79.7	109.1	128.1	140.2	90.2	1081.8
28	Sao Miguel do Iguacu	Cfa	143.0	118.5	113.5	77.4	51.2	35.6	42.4	62.2	79.9	113.7	134.8	146.9	93.3	1119.1
3	Cambara	Cfa(h)	144.7	123.5	122.2	100.0	70.2	55.4	65.6	92.8	108.7	141.8	151.7	139.5	109.7	1316.1
4	Bandeirantes	Cfa(h)	135.4	115.0	111.1	84.4	60.0	44.9	53.0	74.1	85.3	118.1	134.0	131.0	95.5	1146.3
5	Londrina	Cfa(h)	135.2	116.8	112.1	88.4	61.4	46.3	54.9	76.3	91.1	124.2	136.4	132.7	98.0	1175.8
1	Bela Vista do Paraiso	Cfa(h)	133.3	117.0	111.7	88.9	62.9	46.5	56.0	77.7	88.6	120.8	134.1	130.4	97.3	1167.9
6	Apucarana	Cfa(h)	124.3	104.8	103.4	80.7	54.0	37.7	46.9	66.3	79.0	113.4	125.5	126.3	88.5	1062.3
8	Paranavai	Cfa(h)	142.9	120.9	119.6	88.3	61.6	47.9	56.3	76.9	87.7	123.3	138.6	138.9	100.2	1202.9
9	Cianorte	Cfa(h)	139.9	118.7	118.1	85.4	58.3	44.5	52.3	71.5	85.8	120.5	135.5	138.0	97.4	1168.5
10	Umuarama	Cfa(h)	142.6	122.0	120.0	89.2	61.4	46.3	53.9	74.0	86.3	120.8	137.7	143.0	99.8	1197.2
7	Ibipora	Cfa(h)	135.3	118.3	114.5	89.8	62.9	47.3	55.0	76.4	89.4	123.1	135.2	131.9	98.3	1179.1
20	Piraquara	Cfb	112.7	94.8	84.7	63.5	44.9	33.9	40.3	53.8	63.5	89.3	103.5	106.5	74.3	891.4
(21)	Lapa	Cfb	121.6	101.8	95.4	69.8	49.2	38.4	46.4	64.5	74.9	103.1	118.9	119.7	83.6	1003.7
22	Ponta Grossa	Cfb	128.7	108.5	103.2	78.8	58.2	47.2	55.6	73.2	84.5	113.1	127.1	127.9	92.2	1106.0
23	Teixeira Soares	Cfb	113.3	96.1	87.2	60.1	40.6	30.7	34.7	50.6	64.3	90.4	106.4	107.5	73.5	881.9
24	Guarapuava	Cfb	128.3	106.7	102.4	74.6	52.6	41.2	49.7	68.4	82.6	109.9	121.5	126.2	88.7	1064.1
(29)	Porto Uniao	Cfb	115.4	92.3	87.6	58.6	40.1	27.3	33.6	49.7	62.9	89.2	105.5	113.9	73.0	876.1
30	Palmas	Cfb	95.7	82.3	74.2	51.7	35.4	26.1	31.3	45.0	58.0	81.7	96.3	101.7	65.0	779.4
31	Clevelandia	Cfb	126.9	103.0	95.1	65.4	44.3	31.2	38.6	55.2	70.1	98.8	116.9	126.3	81.0	971.8
32	Pato Branco	Cfb	136.9	115.0	105.8	72.9	48.8	35.3	41.5	60.5	77.0	108.4	126.7	137.3	88.8	1066.1
25	Laranjeiras do Sul	Cfb	129.0	107.0	103.1	70.6	49.3	36.1	43.5	61.7	76.0	105.1	117.8	128.1	85.6	1027.3

Note: computed by Penman's Method (Frere, 1979) Class: Koeppen Classification

Data Source: COPEL

In the Cropping Calendar of Paraná state (DERAL/SEAB and CEPA, 1990) mentioned above, the ratio of production and cropping area to the state total in 1989 are available for each primary crop dividing the whole state in 18 regions. Understanding on which Koeppen classification main production regions of each crop extend, one meteorological station nearby a main production region from each Koeppen classification was selected as a representative. For example, since cotton cultivation extends on both Cfa(h) and Cfa, the stations in Bandeirantes and Nova Cantu were selected, respectively. From each meteorological station, mean monthly ET_o and rainfall were obtained in order to estimate ET_{crop} and compare it with precipitation.

The ETcrop estimation of 10 primary crops, except cassava, is shown in Table-3.12. Since cassava is resistant to drought, annual precipitation of Paraná which is more than 1000 mm is sufficient. The estimated value was compared with seasonal ETcrop adopted by FAO for confirmation. The growing stage base calculation was summarized into monthly base and ETcrop was compared with effective rainfall as shown in Table-3.13. In terms of plant, effective rainfall is rainfall stored in the root zone but not lost by surface runoff, deep infiltration and evaporation. In Japan, it is said that 60 - 80 % of rainfall is effective for upland crops and 70 - 90 % for paddy rice. Therefore, 80 % for upland crops and 90 % for paddy rice were adopted as effective. Since rainfall in paddy rice field is reserved like a pond, effectiveness is higher than upland crops.

ETcrop and effective rainfall, ER, for each crop and region were compared in Table-3.13 in order to assess whether irrigation was necessary. As a result, most of crops in different climatic region grow well without irrigation as long as precipitation is favor to agriculture. Some crops such as, cotton in Nova Cantu, potato aguas (rainy season or summer season harvesting) in Lapa show the water deficit of 13 mm/month in January and 22 mm/month in November. 22 mm/month, the largest water deficit, is equivalent to 0.7 mm/day. As mentioned before, ETcrop is crop water requirement under ideal conditions and the growth of crop is at full potential. Practically, ordinal agricultural may have not achieved to this ideal level and 0.7 mm/day is considered as within the tolerance level of water deficit. In conclusion, it can be assumed that irrigation is not commonly practiced and almost all agriculture relies on rainfall in Paraná state. In other words, climate in Paraná state is very favor to agriculture and adequate production can be reached with rain-fed agriculture.

Although there used to be some government irrigation projects such as, PROID (Irrigation and Drainage Program in Paraná), no project seems to exist currently due to the financial problem. There is unauthorized information that sprinkler system has spread gradually in Paraná state for the security during drought but average utilization of the system is approximately 5 - 10 days per one crop season. Even if that information was collect, water consumption would be still small and would be negligible at the strategy or master plan level.

Since no data regarding irrigation such as, location, type of irrigation system, crop, water consumption or frequency of practices, ETcrop was calculated and compared with effective rainfall to estimate water consumption with irrigation system. The result shows that rain-fed agriculture is practically adequate in Paraná state and therefore there is no water consumption in terms of irrigation. This conclusion corresponds well to the actual situation of agriculture in Paraná state. If irrigation was applied, high production would be secured even during the drought but it would depend on cost benefit evaluation.

Table-3.12 (1/4) Computation of Crop Water Requirement (ETcrop) and Effective Rainfall (ER)

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Cotton	Initial	10/1							
Bandeirants**	(20)*	10/20	0.74	3.8	56.2		79.2	63.3	7.1
Cfa(h)***	Crop Development	10/21							
	(40)*	10/31	0.79	3.8	32.9		43.5	34.8	2.0
		11/29	0.94	4.5	122.9		160.8	128.6	5.7
	Mid-season	11/30	1.05	4.5	4.7		5.5	4.4	-0.3
	(45)*	12/31	1.05	4.2	136.7		211.4	169.1	32.4
		1/13	1.05	4.4	60.1		75.4	60.4	0.3
	Late-season	1/14							
	(45)*	1/31	0.97	4.4	76.5		104.5	83.6	7.1
		2/27	0.77	4.1	84.7		154.4	123.5	38.8
				Total	574.7	550 - 950	834.7	667.7	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Cotton	Initial	10/1							0.0
Nova Cantu**	(20)*	10/20	0.73	3.9	57.3		127.0	101.6	44.3
Cfa***	Crop Development	10/21							
	(40)*	10/31	0.78	3.9	33.4		69.8	55.9	22.5
		11/29	0.94	4.5	122.8		179.1	143.3	20.5
	Mid-season	11/30	1.05	4.5	4.7		6.2	4.9	0.2
	(45)*	12/31	1.05	4.7	153.7		220.0	176.0	22.3
		1/13	1.05	4.7	64.6		69.8	55.9	-8.7
	Late-season	1/14							
	(45)*	1/31	0.97	4.7	81.7		96.7	77.3	-4.3
		2/27	0.77	4.3	88.5		171.7	137.4	48.9
				Total	606.7	550 - 950	940.3	752.3	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Rice (paddy)	Initial+Crop devel.	11/1	1.10	4.2	138.1		159.1	143.2	5.1
Apucarana**	(2 months)*	12/31	1.10	4.1	138.9		211.3	190.2	51.2
Cfa(h)***	Mid-season	1/1	1.05	4.0	130.5		190.3	171.3	40.8
	(2 months)*	2/28	1.05	3.7	110.0		154.6	139.1	29.1
	Late-season	3/1						0.0	0.0
	(4 weeks)*	3/31	0.95	3.3	98.5		151.5	136.4	37.9
				Total	616.0	500 - 950	866.8	780.1	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Rice (upland)	Initial+Crop devel.	11/1	0.88	4.2	110.4		159.1	127.3	16.8
Apucarana**	(2 months)*	12/31	1.10	4.1	138.9		211.3	169.0	30.1
Cfa(h)***	Mid-season	1/1	1.05	4.0	130.5		190.3	152.2	21.7
	(2 months)*	2/28	1.05	3.7	110.0		154.6	123.7	13.6
	Late-season	3/1						0.0	0.0
	(4 weeks)*	3/31	0.95	3.3	98.5		151.5	121.2	22.7
				Total	588.4	500 - 950	866.8	693.4	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Rice (paddy)	Initial+Crop devel.	10/1	1.10	3.7	121.9		169.4	152.5	30.6
Palotina**	(2 months)*	11/30	1.10	4.4	148.8		165.1	148.6	-0.2
Cfa***	Mid-season	12/31	1.05	4.6	151.0		178.3	160.5	9.5
	(2 months)*	1/31	1.05	4.6	135.3		153.1	137.8	2.5
	Late-season	2/1						0.0	0.0
	(4 weeks)*	2/28	0.95	4.4	128.9		141.4	127.3	-1.7
				Total	685.9	500 - 950	807.3	726.6	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Rice (upland)	Initial+Crop devel.	10/1	0.88	3.6	96.9		205.3	164.2	67.4
Cascavel**	(2 months)*	11/30	1.10	4.1	136.8		197.8	158.2	21.4
Cfa***	Mid-season	12/31	1.05	4.4	144.1		177.9	142.3	-1.7
	(2 months)*	1/31	1.05	4.4	143.7		177.2	141.8	-2.0
	Late-season	2/1							
	(4 weeks)*	2/28	0.95	4.0	106.9		173.0	138.4	31.5
				Total	628.5	500 - 950	931.2	745.0	

Table-3.12 (2/4) Computation of Crop Water Requirement (ETcrop) and Effective Rainfall (ER)

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Rice (Upland)	Initial+Crop devel.	11/1	0.88	4.1	106.9		174.4	157.0	50.0
Guarapuava**	(2 months)*	12/31	1.10	4.1	138.8		184.2	165.8	27.0
Cfb***	Mid-season	1/1	1.05	4.1	134.7		182.0	163.8	29.1
	(2 months)*	2/28	1.05	3.8	112.0		147.1	132.4	20.4
	Late-season	3/1						0.0	0.0
	(4 weeks)*	3/31	0.95	3.3	97.5		146.8	132.1	34.6
				Total	590.0	500 - 950	834.5	751.1	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Potato (Aguas)	Initial	8/1							0.0
Lapa**	(30)*	8/30	0.65	2.1	40.6		95.1	76.1	35.5
Cfb***	Crop Development	8/31	0.66	2.1	1.4		3.2	2.5	1.2
	(35)*	9/30	0.84	2.5	62.8		119.9	95.9	33.1
		10/4	1.03	3.3	13.7		18.9	15.1	1.3
	Mid-season	10/5						0.0	0.0
	(50)*	10/31	1.05	3.3	93.6		127.2	101.8	8.2
		11/23	1.05	4.0	95.7		97.9	78.3	-17.4
	Late-season	11/24						0.0	0.0
	(30)*	11/30	1.00	4.0	28.1		29.8	23.8	-4.3
		12/23	0.83	3.9	73.6		117.7	94.1	20.6
				Total	409.4	350 - 625	609.7	487.7	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Potato (Seca)	Initial	2/1	0.75	3.6	76.4		138.0	110.4	34.1
Lapa**	(30)*	3/2	0.75	3.1	4.6		7.8	6.2	1.6
Cfb***	Crop Development	3/3							
	(35)*	3/31	0.88	3.1	79.0		113.0	90.4	11.4
		4/6	1.03	2.3	14.4		17.3	13.8	-0.5
	Mid-season	4/7						0.0	0.0
	(50)*	4/30	1.05	2.3	58.0		69.1	55.3	-2.7
		5/26	1.05	1.6	43.3		119.5	95.6	52.3
	Late-season	5/27							
	(30)*	5/31	1.02	1.6	8.1		23.0	18.4	10.3
		6/25	0.84	1.3	26.9		89.3	71.5	44.6
				Total	310.6	350 - 625	577.0	461.6	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Coffee	perennial crop	Jan	0.90	142.6	128.3		165.0	132.0	3.7
Umuarama**		Feb	0.90	122.0	109.8		126.7	101.4	-8.4
Cfa(h)***		Mar	0.90	120.0	108.0		125.0	100.0	-8.0
		Apr	0.90	89.2	80.3		136.0	108.8	28.5
		May	0.90	61.4	55.3		157.2	125.8	70.5
		Jun	0.90	46.3	41.7		108.0	86.4	44.7
		Jul	0.90	53.9	48.5		68.5	54.8	6.3
		Aug	0.90	74.0	66.6		76.4	61.1	-5.5
		Sep	0.90	86.3	77.7		141.3	113.0	35.4
		Oct	0.90	120.8	108.7		153.3	122.6	13.9
		Nov	0.90	137.7	123.9		168.8	135.0	11.1
		Dec	0.90	143.0	128.7		191.2	153.0	24.3
				Total	1077.5	800 - 1200	1617.4	1293.9	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Sugarcane	ratoon crop	Sep	0.55	91.1	50.1		118.9	95.1	45.0
Londrina**		Oct	0.80	124.2	99.4		136.8	109.4	10.1
Cfa(h)***		mid-Nov	0.90	136.4	61.4		89.6	71.6	10.3
		end-Nov	1.00	136.4	68.2		89.6	71.6	3.4
		Dec	1.00	132.7	132.7		242.4	193.9	61.2
		Jan	1.05	135.2	142.0		189.5	151.6	9.6
		Feb	1.05	116.8	122.6		165.5	132.4	9.8
		Mar	1.05	112.1	117.7		157.7	126.2	8.5
		Apr	1.05	88.4	92.8		120.9	96.7	3.9
		May	1.05	61.4	64.5		117.8	94.2	29.8
		Jun	1.05	46.3	48.6		90.5	72.4	23.8
		Jul	0.80	54.9	43.9		62.5	50.0	6.1
		Aug	0.60	76.3	45.8		53.1	42.5	-3.3
				Total	1089.7	1000 - 1500	1634.7	1307.8	

Table-3.12 (3/4) Computation of Crop Water Requirement (ETcrop) and Effective Rainfall (ER)

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Beans (Aguas)	Initial	9/16							
Francisco Beltrao**	(20)*	9/30	0.84	2.5	31.3		76.8	61.4	30.1
Cfa***		10/5	0.84	3.4	14.4		33.8	27.1	12.7
	Crop Development	10/6							
	(30)*	10/31	0.89	3.4	79.2		175.9	140.7	61.5
		11/4	0.94	4.1	15.7		25.9	20.7	5.1
	Mid-season	11/5							
	(30)*	11/30	0.95	4.1	101.3		168.2	134.6	33.3
		12/4	0.95	4.4	16.7		21.1	16.9	0.2
	Late-season	12/5							
	(10)*	12/14	0.90	4.4	39.4		52.8	42.3	2.9
				Total	297.8	250 - 500	554.5	443.6	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Beans (Aguas)	Initial	10/16							
Guarapuava**	(20)*	10/31	0.76	3.5	43.1		89.0	71.2	28.1
Cfb***		11/4	0.76	4.1	12.3		23.3	18.6	6.3
	Crop Development	11/5						0.0	0.0
	(30)*	11/30	0.85	4.1	90.1		151.1	120.9	30.8
		12/4	0.94	4.1	15.3		23.8	19.0	3.7
	Mid-season	12/5						0.0	0.0
	(30)*	12/31	0.95	4.1	105.2		160.4	128.3	23.2
		1/3	0.95	4.1	11.8		17.6	14.1	2.3
	Late-season	1/4						0.0	0.0
	(10)*	1/13	0.90	4.1	36.7		58.7	47.0	10.3
				Total	314.5	250 - 500	523.9	419.1	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Beans (Seca)	Initial	1/1							
Joaquim Tavora**	(20)*	1/20	0.70	4.3	60.2		115.7	92.5	32.3
Cfa***	Crop Development	1/21							
	(30)*	1/31	0.75	4.3	35.5		63.6	50.9	15.4
		2/19	0.88	4.2	69.6		95.7	76.5	7.0
	Mid-season	2/20							
	(30)*	2/28	0.95	4.2	35.9		45.3	36.3	0.3
		3/21	0.95	3.6	71.0		95.7	76.5	5.5
	Late-season	3/22							
	(10)*	3/31	0.90	3.6	32.2		45.5	36.4	4.2
				Total	304.4	250 - 500	461.5	369.2	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Maize	Initial	10/1							0.0
Cascavel**	(30)*	10/30	0.94	3.6	100.2		198.7	158.9	58.8
Cfa***	Crop Development	10/31	0.94	3.6	3.3		6.6	5.3	2.0
	(50)*	11/30	0.98	4.1	121.5		197.8	158.2	36.8
		12/19	1.03	4.4	86.6		109.0	87.2	0.6
	Mid-season	12/20						0.0	0.0
	(60)*	12/31	1.05	4.4	55.8		68.9	55.1	-0.7
		1/31	1.05	4.4	143.7		177.2	141.8	-2.0
		2/17	1.05	4.0	71.6		105.0	84.0	12.4
	Late-season	2/18						0.0	0.0
	(40)*	2/28	0.98	4.0	43.0		68.0	54.4	11.4
		3/29	0.73	3.5	73.7		132.5	106.0	32.3
				Total	699.4	400 - 750	1063.7	851.0	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Maize	Initial	10/1							0.0
Guarapuava**	(30)*	10/30	0.77	3.5	81.9		178.0	142.4	60.5
Cfb***	Crop Development	10/31	0.78	3.5	2.7		5.9	4.7	2.0
	(50)*	11/30	0.86	4.1	104.8		174.4	139.5	34.7
		12/19	1.00	4.1	77.3		112.9	90.3	13.0
	Mid-season	12/20						0.0	0.0
	(60)*	12/31	1.05	4.1	51.3		71.3	57.0	5.7
		1/31	1.05	4.1	134.7		182.0	145.6	10.9
		2/17	1.05	3.8	68.0		89.3	71.4	3.4
	Late-season	2/18						0.0	0.0
	(40)*	2/28	0.98	3.811	40.9		57.8	46.2	5.4
		3/29	0.73	3.3	69.5		137.3	109.9	40.4
				Total	631.1	400 - 750	1008.9	807.1	

Table-3.12 (4/4) Computation of Crop Water Requirement (ETcrop) and Effective Rainfall (ER)

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Soybean	Initial	11/1							0.0
Cascavel**	(15)*	11/15	0.92	4.1	57.2		98.9	79.1	21.9
Cfa***	Crop Development	11/16						0.0	0.0
	(25)*	11/30	0.95	4.1	58.8		98.9	79.1	20.3
		12/10	0.99	4.4	43.6		57.4	45.9	2.3
	Mid-season	12/11						0.0	0.0
	(55)*	12/31	1.00	4.4	92.9		120.5	96.4	3.5
		1/31	1.00	4.4	136.9		177.2	141.8	4.9
		2/3	1.00	4.0	12.0		18.5	14.8	2.8
	Late-season	2/4						0.0	0.0
	(25)*	2/28	0.71	4.0	71.6		154.5	123.6	52.0
				Total	473.1	450 - 825	725.9	580.7	

Crop	Stage	Date	kc	ETo	ETcrop	Seasonal ETcrop	Rain	ER	Difference
Wheat	Initial	5/1							0.0
Cascavel**	(15)*	5/15	1.00	1.7	25.4		105.6	84.5	59.1
Cfa***	Crop Development	5/16						0.0	0.0
	(20)*	5/31	1.02	1.7	27.6		112.6	90.1	62.5
		6/4	1.05	1.3	5.4		17.2	13.7	8.3
	Mid-season	6/5						0.0	0.0
	(50)*	6/30	1.05	1.3	35.4		111.7	89.4	54.0
		7/24	1.05	1.5	37.4		88.6	70.9	33.5
	Late-season	7/25						0.0	0.0
	(30)*	7/31	0.94	1.5	9.8		25.8	20.7	10.9
		8/23	0.54	2.1	25.8		81.5	65.2	39.4
				Total	166.8	no reference	543.0	434.4	

Stage: Stage of growth, kc: Crop coefficient, ETo: Reference crop evapotranspiration (mm/day)

ETcrop: Crop water requirement (mm/stage), Seasonal ETcrop: Source FAO. 1977 Irrigation and Drainage Paper 24. 36p

Rain: (mm/stage), ER: Effective rainfall (mm/stage)

Difference: (mm/stage), Total: (mm/crop season)

*: Stage period assumed (days), **: Meteorological station ***: Koeppen Classification

Aguas: Rainy season cropping (Summer), Seca: Dry season cropping (Winter)

Table-3.13 Comparison between ETcrop and ER for Primary Crops

Crop	Meteorological Station	ET/ Rainfall (mm/month)	Month 1	2	3	4	5	6	7	8	9	10	11	12	Total
Cotton	Bandeirantes	ETcrop	137	85								89	128	137	575
	Cfa(h)*	ER	144	124								98	133	169	668
		Difference	7	39	0	0	0	0	0	0	0	9	5	32	
	Nova Cantu	ETcrop	146	89								91	128	154	607
	Cfa*	ER	133	137								158	148	176	752
		Difference	-13	49	0	0	0	0	0	0	0	67	21	22	
Rice (paddy)	Apucarana	ETcrop	131	110	99								138	139	616
	Cfa(h)*	ER	171	139	136								143	190	780
		Difference	41	29	38	0	0	0	0	0	0	0	5	51	
	Palotina	ETcrop	135	129								122	149	151	686
	Cfa*	ER	138	127								153	149	161	727
		Difference	3	-2	0	0	0	0	0	0	0	31	0	10	
Rice (upland)	Apucarana	ETcrop	131	110	99								110	139	588
	Cfa(h)*	ER	152	124	121								127	169	693
		Difference	22	14	23	0	0	0	0	0	0	0	17	30	
	Cascavel	ETcrop	144	107								97	137	144	628
	Cfa*	ER	142	138								164	158	142	745
		Difference	-2	32	0	0	0	0	0	0	0	67	21	-2	
	Guarapuava	ETcrop	135	112	98								107	139	590
	Cfb*	ER	164	132	132								157	166	751
		Difference	29	20	35	0	0	0	0	0	0	0	50	27	
Potato Aguas (summer)	Lapa	ETcrop								42	63	107	124	74	410
	Cfb*	ER								79	96	117	102	94	488
		Difference	0	0	0	0	0	0	0	37	33	10	-22	21	
Potato Seca (winter)	Lapa	ETcrop		76	84	72	51	27							311
	Cfb*	ER		110	97	69	114	72							462
		Difference	0	34	13	-3	63	45	0	0	0	0	0	0	
Coffee	Umuarama	ETcrop	128	110	108	80	55	42	49	67	78	109	124	129	1078
	Cfa(h)*	ER	132	101	100	109	126	86	55	61	113	123	135	153	1294
		Difference	4	-8	-8	29	71	45	6	-5	35	14	11	24	
Sugarcane	Londrina	ETcrop	142	123	118	93	65	49	44	46	50	99	130	133	1090
	Cfa(h)*	ER	152	132	126	97	94	72	50	43	95	109	143	194	1308
		Difference	10	10	9	4	30	24	6	-3	45	10	14	61	
Beans Aguas (summer)	Francisco Beltrao	ETcrop									31	94	117	56	298
	Cfa*	ER									61	168	155	59	444
		Difference	0	0	0	0	0	0	0	0	30	74	38	3	
	Guarapuava	ETcrop	49									43	102	121	315
	Cfb*	ER	61									71	140	147	419
		Difference	13	0	0	0	0	0	0	0	0	28	37	27	
Beans Seca (winter)	Joaquim Tavora	ETcrop	96	106	103										304
	Cfa*	ER	143	113	113										369
		Difference	48	7	10	0	0	0	0	0	0	0	0	0	
Maize	Cascavel	ETcrop	144	115	74							104	122	142	699
	Cfa*	ER	142	138	106							164	158	142	851
		Difference	-2	24	32	0	0	0	0	0	0	61	37	0	
	Guarapuava	ETcrop	135	109	70							85	105	129	631
	Cfb*	ER	146	118	110							147	140	147	807
		Difference	11	9	40	0	0	0	0	0	0	63	35	19	
Soybean	Cascavel	ETcrop	137	84									116	137	473
	Cfa*	ER	142	138									158	142	581
		Difference	5	55	0	0	0	0	0	0	0	0	42	6	
Wheat	Cascavel	ETcrop					53	41	47	26					167
	Cfa*	ER					175	103	92	65					435
		Difference	0	0	0	0	122	62	44	39	0	0	0	0	

ETcrop: Crop Water Requirement
ER: Effective Rainfall Upland Crops = 0.8 x rainfall, Paddy Rice = 0.9 x rainfall
*: Koeppen Classification

3.5.2 Livestock

Water requirement of livestock depends on many factors such as, food intake, quality of food, and air and water temperature. More intake of dry food is , more consumption of water is. On the other hand, the water requirement of livestock increases with air temperature. At the detailed design level, these factors should be taken account; however, since the object of the Study is a macro level, only water content of food was considered during the estimation of water consumption.

Natural pasture contains as much as 80 % water during the growth period. Therefore, amount of water actually supplied to livestock (actual water intake) corresponds to a part of total water requirement which cannot be provided by moisture content of forage. Pallas Ph. (1986) estimated the total water requirement and actual water intake for cattle under Saharan conditions. Cattle of 0.7 TLU (Tropical Livestock Unit, 1 TLU = 250 kg live weight) consumes 27 liter/day in total during the wet season; however, within 27 liter/day, 10 liter/day (37 %) is consumed as actual water intake.

In Paraná state, it is said that an livestock of 100 kg live weight requires 4 - 12 liter/day. For the calculation sake, the following assumption was made.

- water requirement of 100 kg live weight animal		10 liter/day
- an average live weight	pig	40 kg
	cattle	300 kg
	chicken	2 kg
- total water requirement	pig	4 liter/head/day
	cattle	30 liter/head/day
	chicken	2 liter/10 heads/day

Applying the rate of actual water intake obtained by Pallas Ph. (1986), actual water intake of cattle will be 11 liter/head/day (30 liter/head/day x 0.37). During the estimation of water consumption, 10 liter/head/day was adopted. Since a pig and a chicken are not herbivores, it was assumed that there is no water intake by means of food. Multiplying the livestock population in 1993 (refer to Table-3.5) by these rates, the water consumption of livestock was estimated.

The result is shown in Table-3.14 as the current water consumption assuming that the population does not vary from one in 1993. To raise 2,815 thousand of pig, 9,736 thousand of cattle and 60,744 thousand of chicken, the water of 0.131 m^3/s, 1.127 m^3/s and 0.138 m^3/s is consumed, respectively. The total water consumption of livestock in Paraná is 1.396 m^3/s at present.

Table-3.14 Livestock Population and Water Demand (1993)

NO.	EMATER Region	Pig			Cattle			Chicken			Total
		Herd (1000 head)	Water C. (1000m3/day)	Share of Region (%)	Herd (1000 head)	Water C. (1000m3/day)	Share of Region (%)	Herd (1000 head)	Water C. (1000m3/day)	Share of Region (%)	
EM-1	Paranagua	0.0	0.000	0.0	9.7	0.097	0.1	0.0	0.000	0.0	0.097
EM-2	Curitiba	95.7	0.383	3.4	126.6	1.266	1.3	3037.2	0.607	5.0	2.256
EM-3	Lapa	53.5	0.214	1.9	77.9	0.779	0.8	1700.8	0.340	2.8	1.333
EM-4	Ponta Grossa	168.9	0.676	6.0	506.3	5.063	5.2	6681.9	1.336	11.0	7.075
EM-5	Irati	101.3	0.405	3.6	87.6	0.876	0.9	850.4	0.170	1.4	1.451
EM-6	Uniao da Vitoria	84.5	0.338	3.0	97.4	0.974	1.0	728.9	0.146	1.2	1.458
EM-7	Guarapuava	228.0	0.912	8.1	486.8	4.868	5.0	1700.8	0.340	2.8	6.120
EM-8	Pato Branco	205.5	0.822	7.3	340.8	3.408	3.5	5284.8	1.057	8.7	5.287
EM-9	Francisco Beltrao	349.1	1.396	12.4	379.7	3.797	3.9	10083.6	2.017	16.6	7.210
EM-10	Cascavel	295.6	1.182	10.5	662.1	6.621	6.8	4859.5	0.972	8.0	8.775
EM-11	Toledo	422.3	1.689	15.0	447.9	4.479	4.6	9233.1	1.847	15.2	8.015
EM-12	Umuarama	123.9	0.496	4.4	1625.9	16.259	16.7	1336.4	0.267	2.2	17.022
EM-13	Campo Mourao	118.2	0.473	4.2	788.6	7.886	8.1	1518.6	0.304	2.5	8.663
EM-14	Ivaipora	137.9	0.552	4.9	516.0	5.160	5.3	1093.4	0.219	1.8	5.931
EM-15	Paranavai	39.4	0.158	1.4	1236.5	12.365	12.7	1336.4	0.267	2.2	12.790
EM-16	Maringa	87.3	0.349	3.1	671.8	6.718	6.9	2733.5	0.547	4.5	7.614
EM-17	Apucarana	50.7	0.203	1.8	214.2	2.142	2.2	425.2	0.085	0.7	2.430
EM-18	Londrina	84.5	0.338	3.0	535.5	5.355	5.5	3644.7	0.729	6.0	6.422
EM-19	Cornelio Procopio	56.3	0.225	2.0	321.3	3.213	3.3	1457.9	0.292	2.4	3.730
EM-20	Jacarezinho	112.6	0.450	4.0	603.6	6.036	6.2	3037.2	0.607	5.0	7.093
	Total	2815.0	11.261	100.0	9736.0	97.362	100.0	60744.0	12.149	100.0	120.772

Water C.:Water Consumption

Source: IBGE for the Total Population, Cropping Calendar of Parana (DERAL/SEAB and CEPA) for Share of Region

3.5.3 Fishery

In general, water consumption from fish ponds consists of evaporation from free water surface, seepage and change of water due to contamination. To estimate water consumption, the following assumptions are made; 1) There is no change of water. 2) The bottom of a pond is well coated with clay. Therefore, no seepage occurs or seepage ceases after a long use. 3) 60 % of annual rainfall is stored in a pond and 40 % is overflowed. An average rainfall and evaporation in 33 selected meteorological stations are 1700 mm and 1300 mm, respectively. Applying these average values, annual water loss from a fish pond is approximately 300 mm (= 1300 - 1700 x 0.6). This water loss is compensated by the water intake from either surface water or groundwater. 300 mm/year is equivalent to 1 mm/day. Ignoring the spatial variation, this 1 mm/day was adopted to estimate water consumption. Multiplying the fish pond area (refer to Table-3.7) by this rate, the water consumption in 1993 was estimated as the current one. The result is shown in Table-3.15.

Table-3.15 Fish Pond Area and Water Demand (1993)

NO.	EMATER Region	1993 Area (ha)	W.C. (1000m3/day)	Portion of Region (%)
EM-1	Paranagua	17	0.170	0.5
EM-2	Curitiba	156	1.560	4.2
EM-3	Lapa	87	0.870	2.3
EM-4	Ponta Grossa	320	3.200	8.5
EM-5	Irati	139	1.390	3.7
EM-6	Uniao da Vitoria	103	1.030	2.7
EM-7	Guarapuava	165	1.650	4.4
EM-8	Pato Branco	611	6.110	16.2
EM-9	Francisco Beltrao	736	7.360	19.6
EM-10	Cascavel	405	4.050	10.8
EM-11	Toledo	354	3.540	9.4
EM-12	Umuarama	4	0.040	0.1
EM-13	Campo Mourao	47	0.470	1.3
EM-14	Ivaipora	209	2.090	5.5
EM-15	Paranavai	11	0.110	0.3
EM-16	Maringa	36	0.360	1.0
EM-17	Apucarana	46	0.460	1.2
EM-18	Londrina	75	0.750	2.0
EM-19	Cornelio Procopio	119	1.190	3.2
EM-20	Jacarezinho	116	1.160	3.1
	Total	3,756	37.560	100.0

W. C.:Water Consumption
Source: adapted and enlarged from DEPEC/SEAB for Area

Literature Cited

1. DERAL, SEAB., and CEPA. (1990). Calendário agrícola do Paraná (Cropping calendar in Paraná). Curitiba.

2. Doorenbos, J., and Pruit, W.O. (1977). "guidelines for predicting crop water requirements." Irrigation and Drainage Paper 24, FAO, United Nations, Rome, 144 pp.

3. Godoy, H., and Correa, A.R. (1976). Carta climática do estado do Paraneá. IAPAR, Londrina.

4. Pallas Ph. (1986). "Water for animals." FAO, United Nations, Rome, p. 5-8.

5. SEAB., and ITCF. (1987). Atlas do Estado do Paraná (Atlas of Paraná sate).

CHAPTER 4 AGRICULTURE POTENTIAL

Agriculture potential in Paraná was examined briefly in terms of climate, soil properties and topography. Since Paraná contributes greatly to Brazilian agriculture, its agriculture potential is expected high. Ministry of Agriculture, Brazil, evaluated Paraná's land aptitude for agriculture in 1981 based on soil properties and topography. It was used as one of references during the potential study.

4.1 Climate

Most of the area of Paraná belongs to the humid subtropical climate with no dry season accompanied with either hot summer or mild summer. Therefore, annual precipitation and temperature are adequate to most of crops. Besides, wind velocity is mild throughout the year as a result of the meteorological analysis.

The computation of evapotranspiration by Penman method takes account of all climatic factors necessary to examine the adequacy of climate to agriculture. The factors counted are humidity, wind velocity, solar radiation and air pressure. In the section 3.5, crop water requirements of 10 primary crops were obtained based on the application of Penman method and the result was compared with precipitation. Consequently, it was found that the rain-fed agriculture is enough to achieve the potential productivity. It implies that the climate in Paraná is favorable to agriculture in general.

The brief description of Paraná climate is as follows. The details of climate in Paraná is described in the Sectorial Report B (Meteorology, Hydrology and Surface Water Resources).

1) Annual rainfall ranges between 1,300 and 2,000 mm. There is rain throughout the year; however, it is higher from October to March and May in terms of a long term average.
2) Annual mean temperature ranges between 16 °C and 22 °C. Seasonal variation of monthly mean temperature is not high. In summer, it is around 24 °C and in winter, it is around 15 °C.
3) Annual potential evapotranspiration ranges between 800 and 1,300 mm. The high in the northern part of Paraná and the low in the southern part.
4) Wind speed is stable at range between 2.0 and 5.0 m/s.
5) Mean annual sunshine hours are approximately 7 hours/day.
6) Relative humidity is almost constant at range between 70 and 80 %.

4.2 Soil

There is a soil bulletin to describe Paraná's soils accompanied with a soil map and lots of research works concerning soil have been conducted by IAPAR. Based on those data available, soil properties in Paraná regarding their aptness for crop cultivation is summarized in Table-4.1.

Fertility of soils are generally low, except Latossolo Roxo and Terra Roxa Estruturada. Therefore, to maintain soil fertility by means of chemical fertilizer and green manure is

essential for Paraná agriculture and its application should be combined with soil conservation measures. Otherwise, soil erosion makes the efforts to maintain soil fertility in vain.

This is one of typical characteristics of soil in tropical and sub-tropical zone that most of soils in Paraná are acid, except Cambissolos, as denoted by the presence of Al^{3+}. Acid soils hinder the root growth of most crops. To correct acidity, it requires the lime application and it is a common countermeasure in Paraná.

Physical properties of soils in Paraná, such as effective soil depth, soil texture and presence of low permeability layer, are generally suitable for crop cultivation. Soils, except Cambissolos, Podzolico and Litolico, have the enough effective soil depth and only Podzolico have the low permeability layer, which induces the poor drainage problem.

As long as the adequate measures to maintain and improve soil properties, most of Paraná's soils are suitable for crop cultivation. 30 % of Paraná's area is suitable for mechanization, also.

Table-4.1 Soil Properties in Paraná with Soil Classification

	LE(clay)	LR	LBa	TRe	Ca	LE(sand)	PV	Ra
Fertility	1	4	2	4	1	2	1	2
Presence of Al^{3+}	2	3	3	2	4	3	3	3
Effective Soil Depth	5	4	5	3	2	4	2	1
Soil Texture	4	5	4	5	3	2	2	4
Mechanization	5	4	5	3	2	5	3	1
Low Permeability Layer	2	2	2	2	2	2	1	2
Occurence in Parana (%)	12	15	3	14	10	—	16	21
	12%=LE(clay)+LE(sand)							

Abbreviation:	
LE	Latossolo Vermelho Escuro
LR	Latossolo Roxo
LBa	Latossolo Bruno
TRe	Terra Roxa Estruturada
Ca	Cambissolos
PV	Podzolico Vermelho Escuro and Podzolico Vermelho Amarelo
Ra	Litolico

Class	Fertility	Presence of Al^{3+}	Effective Soil Depth	Soil Texture
1	Phosphorus <1ppm	> 4 me/100g	< 10 cm	< 20 % of clay
2	1 - 6 ppm	3 - 4 me/100g	10 - 20 cm	20 - 30 % of clay
3	6 - 8 ppm	2 - 3 me/100g	20 - 40 cm	30 - 40 % of clay
4	8 - 12 ppm	0 - 2 me/100g	40 - 100 cm	40 - 60 % of clay
5	> 12 ppm	0 me/100g	> 100 cm	> 60 % of clay

Class	Mechanization
1	not applicable
2	suitable only for horse mechanization
3	suitable for horse mechanization but motor mechanization applicable
4	motor mechanization applicable but not suitable for intensive mechanization
5	suitable for intensive mechanization
	note: In class 3, the mechanical harvesting is impossible and not practiced.

Class	Low Permeability Layer
1	Present
2	not present

Source: Biscaia and Osaki (1994)

Moisture contents of soils in Paraná at saturation, field capacity and wilting point are summarized in Table-4.2. Between the soil surface to 130 cm depth, water contents at three conditions do not vary much with depth.

Table-4.2 Water Retention of Soils in Paraná

Soil Classification: Latossolo Roxo
The table may be applicable to Latossolo Bruno (clay) and Terra Roxa.

Soil Depth	SAT	FC	WP
0 - 10 cm	43.0	35.1	24.0
10 - 40 cm	43.0	38.1	29.1
40 - 70 cm	43.0	36.0	27.3
70 - 100 cm	43.0	36.2	27.1
100 - 130 cm	43.0	35.6	27.5

Soil Classification: Latossolo Vermelho Escuro
The table may be applicable to Cambissolo.

Soil Depth	SAT	FC	WP
0 - 10 cm	50.7	40.5	23.2
10 - 40 cm	56.8	35.5	22.0
40 - 70 cm	59.9	34.0	22.1
70 - 100 cm	60.4	33.0	24.4
100 - 130 cm	60.3	39.0	28.0

Soil Classification: Latossolo Vermelho Escuro (sand)
The table may be applicable to Latossolo Bruno(sand) and Podzolico(sand).

Soil Depth	SAT	FC	WP
0 - 10 cm	20.0	13.0	2.9
10 - 40 cm	25.0	19.9	9.7
40 - 70 cm	23.0	15.1	6.9
70 - 100 cm	20.9	10.2	3.1
100 - 130 cm	20.5	10.4	3.0

Unit: cm3 of water / 100 cm3 of soil
SAT: Saturation, FC: Field Capacity, WP: Wilting Point
Source: IAPAR (1993)

4.3 Topography

Since the slope map is not available, the topography was examined by the soil map. Each class of soil is located in specific slope gradient. The slope gradient of each soil class is available in Agricultural Land Aptitude of Paraná (1981) and it is summarized in Table-4.3.

Latossolo Vermelho Escuro, Latossolo Roxo and Latossolo Bruno exist on the level or gentle slope at range between 0 and 8 % gradient. Terra Roxa Estruturada, Podzolico and Cambissolos exist on the rolling or hilly slope at range between 3 and 20 % gradient. Litolico spreads mainly on the steep land at greater than 20 % gradient.

30 % of the state area is level or gentle slope and 40 % of the state area is rolling slope. Roughly speaking, as far as the slope of land is concerned, 70 % of the state area is suitable for crop cultivation with the proper soil management.

Table-4.3 Slope Steepness of Dominant Soil Class

Soil Class	Range of Slope	O(%)	General Description	OP(%)
Latossolo Vermelho Escuro	0 - 8 %	62	flat and gentle	12
	3 - 8 %	36		
	others	2		
Latossolo Roxo	0 - 8 %	29	flat and gentle	15
	3 - 8 %	45		
	8 - 20 %	24		
	others	2		
Latossolo Bruno	3 - 8 %	70	flat and gentle	3
	others	30		
Terra Roxa Estruturada	3 - 20 %	44	rolling	14
	8 - 20 %	45		
	others	11		
Cambissolos	3 - 8 %	39	rolling	10
	8 - 20 %	23		
	> 45 %	9		
	others	29		
Podzolico	3 - 8 %	33	rolling	16
	8 - 20 %	35		
	20 - 45 %	10		
	others	22		
Litolico	20 - 45 %	26	steep	21
	> 20 %	49		
	others	25		

O (%): Occurrence in each soil class, OP (%): Occurrence in Paraná

Source: Agricultural Land Aptitude of Paraná (1981)

4.4 Agriculture Potential

Since the climate of Paraná is favor to agriculture, agriculture potential of Paraná is controlled by soil properties and topography. As mentioned before, Ministry of Agriculture examined the agriculture potential of Paraná and published Agriculture Land Aptitude of Paraná (1981) in terms of soil properties and topography. It is specified the area of each suggested land use. To grasp the agriculture potential, the result of potential evaluation by Ministry of Agriculture is summarized in Table-4.4.

60.3 % (60.3=27.5+32.8) of the state area, 12,020,000 ha, is suggested for crop cultivation with regular handling level, while 13.4 % of the state area, 2,671,000 ha, is possible to crop cultivation but it is difficult. The land not suitable for any agriculture use is shown in the table as no agriculture use. It includes existing towns and urban areas.

Table-4.4 Agriculture Potential of Paraná

Land Use	Aptness	Area (1,000ha)	% to Total State Area
Crop Cultivation	good	5,484	27.5
	regular	6,536	32.8
	restricted	2,671	13.4
Pasture (planted)		2,815	14.1
Pasture (natural)		32	0.2
Forest		886	4.5
no agriculture use		1,482	7.5
Total		19,906	100

Source: Agricultural Land Aptitude of Parana (1981)

Literature Cited

1. Biscaia, R.C.M., and Osaki, F. (1994). Estimation of culture management factor for agriculture of Paraná state based on data from research reports of IAPAR. Curitiba.

2. Ministry of Agriculture. (1981). Aptidão agricola das terras do Paraná (Agricultural land aptitude of Paraná). Brazil.

CHAPTER 5 FUTURE PROJECTION OF AGRICULTURE

Agriculture in Paraná has been influenced largely by internal and external market. For example, the stable price of soybean in the international market has increased its cultivation. Therefore, the market trend is one of the crucial factors to project future agriculture; however, it is difficult to estimate, especially for a long term, due to its complexity. Even if the estimation made, it practically deviates from the real conditions. Since there is no authorized plans with respect to agriculture, future agriculture in Paraná was projected mainly from the technical point of view, such as, area of crop land, productivity, food demand, growth of livestock and fish raising. After the projection, water demand for agriculture was estimated.

5.1 Food Demand in 2005 and 2015

Food demand in the target years, 2005 and 2015, were projected by the same method applied to estimate the current consumption of food (see section 3.3). Table-5.1 shows food demand in 2005 and 2015 compared with one in 1993. Since the available statistic data regarding the consumption rate of food is only IBGE/EMDEF (1976), the same rate was applied throughout the projection neglecting the variation of food consumption with economic development. Therefore, the increase in food demand depends on only the population growth projected by IPARDES (1994).

Table-5.1 Current Consumption and Future Demand of Food

Food	Crop	F. C. R.	C. F.	Annual Consumption (ton)		
				Year 1993	2005	2015
Rice		43.2		371,693	428,069	480,816
	Unhulled Rice		1.4700	546,389	629,261	706,800
Beans		22.5		193,590	222,953	250,425
Potato		25.4		218,542	251,689	282,702
Coffee Powder		4.0		34,416	39,636	44,520
	Coffee Beans		2.3800	81,910	94,334	105,958
Flour		51.0		438,804	505,359	567,630
	Wheat		1.3300	583,609	672,127	754,948
Cassava Powder		3.5		30,114	34,682	38,955
	Cassava		3.7000	111,422	128,323	144,134
	Raw Cassava	15.8		135,943	156,562	175,854
	Cassava Total			247,365	284,885	319,988
Soybean Oil		4.0		34,416	39,636	44,520
	Soybean		5.5600	191,353	220,376	247,531
Sugar		30.5		262,422	302,225	339,465
	Sugarcane		11.1100	2,915,508	3,357,720	3,771,456
Maize		15.0		129,060	148,635	166,950
Beef		18.4		158,314	182,326	204,792
Pork		7.0		60,228	69,363	77,910
Chicken		17.7		152,291	175,389	197,001

F. C. R.: Food Consumption Rate (kg per capita/year)

C. F.: Conversion Factor, Amount of Crop = Food Consumption x C. F.

Population: 8,603,800 in 1993, 9,908,900 in 2005, 11,130,400 in 2015

Data Source: IBGE/EMDEF(1976) for Food Consumption per capita, SEAB/DERAL for C.F., IPARDES(1994) for population

5.2 Cropping Area and Productivity

According to the data from DERAL/SEAB and EMATER, the total cropping area and pasture area in 1993 are 6,450,000 ha and 6,540,000 ha, respectively. IAP conducted mapping for the land use in 1990 using the satellite imagery and SANEPAR (1994) completed the area calculation based on the map. The result shows that 7,350,600 ha for the cropping area and 4,516,000 ha for the pasture. One of the reason why the latter deviates from the former may be that each area is categorized as one of the land use classification even where different land uses are mixed during the satellite imagery analysis. Since the statistic available in IBGE shows 6.5 million ha as the cropping area in 1992, the former was applied during the study. The total area of agriculture occupies approximately 12.99 million ha, which is equivalent to 65 % of the whole area of Paraná state.

The annual data regarding the area, yield and productivity of the major crops in Paraná, except paddy rice, is available in SEAB data base and the data of 10 primary crops was extracted as shown in Appendix-2. Throughout the projection of crop area and productivity for 9 primary crops, cotton, potato, coffee, sugarcane, beans, cassava, maize, soybean and wheat, the data in Appendix-2 was used. For both paddy and upland rice, the data available in EMATER from 1988 was applied.

5.2.1 Productivity

Crop productivity of 11 primary crops was estimated with an assumption that the productivity of each crop will advance in general because of improvement of varieties, cultivation techniques and so on. Linear regression was applied to productivity data from 1970 to 1993 derived from SEAB, except paddy and upland rice, assuming that the past tendency will continue to future. For paddy and upland rice, EMATER data from 1988 was used for the application of linear regression with the same assumption above. During the regression, some productivity considerably deviated from the tendency as either too high or too low was omitted so as to asses fair productivity. The data applied and the result of linear regression are summarized in Appendix-3.

Table-5.2 shows the result of crop productivity projection. By the year of 2015, the productivity of the primary crops will reach at almost full potential level with the above assumption, except coffee and upland rice.

Coffee plantation started to decline since 1973 due to the unfavorable price in the international market and the severe frost in 1975 has accelerated this decline. Therefore, its productivity is expected not to be improved much because large investment and research works will not be input due to less interest of farmers.

Upland rice cultivation in Paraná started as a catch crop of coffee. Since the prices of other crops are favor to farmers, the area of upland rice cultivation has declined in inverse proportion to the expansion of soybean and wheat cultivation as shown in Appendix-2. Without investment and farmer's interest, the productivity of upland rice is expected to tend to decrease.

Table-5.2 Future Projection of Primary Crop Productivity

unit: ton/ha

	Year		
	1993	2005	2015
cotton	1.299	2.255	2.485
paddy rice	4.211	5.997	7.391
upland rice	1.410	1.305	1.251
potato	15.319	18.552	21.255
coffee	0.435	1.343	1.364
sugarcane	71.429	82.460	87.578
beans	0.799	0.825	0.869
cassava	22.000	22.766	23.898
maize	3.018	3.356	3.807
soybean	2.320	2.376	2.528
wheat	1.470	2.185	2.554

5.2.2 Cropping Area

In the past, agriculture in Paraná expanded with deforestation and since the area of natural forest is currently limited to only 9 % of the state area according to the satellite imagery analysis, the total agricultural area will no more expand. While a part of the pasture shifts to the perennial crops or cassava, the cropping area also shifts to the pasture. Therefore, it is assumed that the total area (12,990,000 ha) of the pasture (6,540,000 ha) and the cropping land (6,450,000 ha) will be constant; however, the area of pasture and crop may alternate with time. Based on the assumption made, DERAL/SEAB (1994) reviewed the past data and projected the area of 18 major crops, inclusive of the primary crops, with the following assumptions.

Regarding the second cropping in summer and winter cropping, DERAL/SEAB (1994) assumed their total area as 8 % of the total crop area based on the data in 1993 and did not specify the area of each crop. Therefore, another assumption was made to determine the area of each crop concerned and described below.

1) Cotton

The production is expected to be double in the next twenty years because of the demand increase in the internal and external market. 448 thousand tons of yield in 1993 will be approximately 895 thousand tons in 2015. To achieve this figure, the area required in 2015 is 360 thousand ha with the productivity projected, 2.485 ton /ha.

2) Paddy rice

Its current cultivation is limited to 19 thousand ha, as of 1993. Since the demand of rice is high as staple food and the productivity of paddy rice is much greater than one of upland rice in general, paddy rice cultivation has high potential to extend. However, its area is expected to expand gradually as long as no irrigation is applied. Its area will be probably double by 2015.

3) Upland rice

Considering the current tendency, its area will continue to decrease and it will be half by 2015.

4) Potato

The average areas of its summer cultivation and winter cultivation in the last 25 years are approximately 27,000 ha and 18,000 ha, respectively. Since potato is one of Brazilian staple food, it can be assumed that its area of summer cultivation will remain at the average, around 30,000 ha by 2015. The winter cultivation depends on the demand. The larger the demand is, the grater the yield is. Since the area of winter cultivation is 70 % of one of summer in 1993, it was assumed that this rate will stay constant for the calculation sake.

5) Coffee

Coffee plantation has declined due to the unfavorable international market price and severe frost in 1975. Even if the plantation is supported by new technology, new variety, credit and so on, its area will be reduced to more than half of the current area.

6) Sugarcane

Its area for 2015 was projected based on the quantity required for the sugar and alcohol industries in Paraná. The current demands of both industries are 6 million tons/year and 12 million tons/year, respectively. Considering the growth of these industries, the total demand in 2015 will be at least 20 million tons/year. To achieve this figure, 230 thousand ha is necessary with the productivity projected, 87.578 ton/ha.

7) Beans

In the last 25 years, the area of beans cultivation has fluctuated and there is a tendency to decrease, especially since 1989. In 1993, the area was limited to 574 thousand ha. However, as beans are one of staple food in Brazil, the area is expected to recover to around 700 thousand ha by 2015. Beans are cultivated mostly in summer and the winter cultivation is almost 15 % of summer as of 1993. It is assumed that the rate of winter cultivation will be constant by 2015.

8) Cassava

Since there is a large market in the northern part of Brazil, cassava is one of promising crops in Paraná. Therefore, by 2015 its cultivation area will be at least 250 thousand ha, almost double of the current area.

9) Maize and Soybean

The total area of two cultures, exclusive of second cropping in summer (safrinha), is 4,173 thousand ha as of 1993, which is almost 70 % of the total crop area in Paraná. Considering this large occupation, it will not expand any more. Since the area of two cultures has been replaced by each other, the total area will remain constant but the

alternation of two cultures will happen. For the future projection, it was assumed that the total area of two cultures is 70 % of the total crop area, 4,410 thousand ha, and the area of each culture is constant at 2,205 thousand ha because the alternation depends on the market. According to the data in 1993, the area of second cropping in summer is 25 % of first cropping for maize and 4 % for soybean. Since the second cropping in summer depends on the conditions of first one, its area varies annually and consequently it is unpredictable. Therefore, the rate in 1993 was applied to both cultures.

10) Wheat

Wheat is cultivated in winter as a second crop of soybean. Therefore, its area does not exceed the area of soybean cultivation. The average area in the last 9 years, except 1993, is approximately 1,500 thousand ha, while in 1993 the area declined rapidly to 696 thousand ha due to the market. Taking account of the market trend, it was assumed that the area of wheat cultivation will be constant at 696 thousand ha same as one in 1993.

The result of the area projection of 11 primary crops is shown in Table-5.3. By the year of 2015, the cropping area will increase slightly at the rate of 0.3 %/year for summer crop and 0.2 %/year for winter crop. This expansion is considered as almost constant.

Table-5.3 Current and Projected Area of Primary Crops

unit: 1000 ha

	Year		
	1993	2005	2015
Summer Crop			
cotton	345	306	360
paddy rice	19	28	38
upland rice	109	75	50
potato	24	28	30
coffee	230	128	96
sugarcane	196	213	230
beans	504	640	700
cassava	137	210	250
maize	2173	2205	2205
maize (safrinha)	530	551	551
soybean	2000	2205	2205
soybean (safrinha)	76	88	88
Total	6343	6677	6803
Winter Crop			
potato (seca)	17	20	21
beans (seca)	71	96	105
wheat	696	696	696
Total	784	812	822

1) potato (seca) = potato (summer) x 0.7
2) beans (seca) = beans (summer) x 0.15
3) maize (safrinha) = maize (normal) x 0.25
4) soybean (safrinha) = soybean (normal) x 0.04
safrinha: second cropping in summer
seca: dry season (winter) cropping
Source: adapted and enlarged from DERAL/SEAB (1994)

5.2.3 Livestock Population

Livestock population in future, except pig raising, was estimated by means of linear regression in the last 20 years, 1973 to 1993, using the data available from IBGE. Regarding pig raising, this method cannot apply due to the sharp decline in its population. In 1973, its population was 7 million heads compared to 2.8 million heads in 1993. The reason for this decline is mainly due to the low price in the market. The average population of pig in the last 20 years is approximately 5 million head/year. According to the estimation of DERAL/SEAB (1994), its population will be stabilized at around 4 million heads by the year of 2000. Adopting this estimation, it was assumed that 4 million heads in 2005 and 2015.

Annual livestock population from 1973 to 1993, population ratio of each region and figure of linear regression are summarized in Appendix-4. Regarding the population ratio, the original (Cropping Calendar of Paraná, 1990) divides the state in 18 regions. Assuming the livestock population is uniformly spread within the region, the ratio was converted into EMATER division, 20 regions.

The result of livestock population projection for the year of 2005 and 2015 by sate wide was converted to EMATER regional wide applying the conversion ratio of each region as shown in Table-5.4.

Table-5.4 Livestock Population in 2005 and 2015

Unit: Herd (1,000 head)

NO.	EMATER Region	Pig				Cattle				Chicken			
		1993 Herd	2005 Herd	2015 Herd	Ratio (%)	1993 Herd	2005 Herd	2015 Herd	Ratio (%)	1993 Herd	2005 Herd	2015 Herd	Ratio (%)
EM-1	Paranagua	0.0	0.0	0.0	0.0	9.7	11.5	13.3	0.1	0.0	0.0	0.0	0.0
EM-2	Curitiba	95.7	136.0	136.0	3.4	126.6	150.1	172.7	1.3	3,037.2	4,572.2	5,490.7	5.0
EM-3	Lapa	53.5	76.0	76.0	1.9	77.9	92.4	106.3	0.8	1,700.8	2,560.4	3,074.8	2.8
EM-4	Ponta Grossa	168.9	240.0	240.0	6.0	506.3	600.3	690.9	5.2	6,681.9	10,058.7	12,079.4	11.0
EM-5	Irati	101.3	144.0	144.0	3.6	87.6	103.9	119.6	0.9	850.4	1,280.2	1,537.4	1.4
EM-6	Uniao da Vitoria	84.5	120.0	120.0	3.0	97.4	115.5	132.9	1.0	728.9	1,097.3	1,317.8	1.2
EM-7	Guarapuava	228.0	324.0	324.0	8.1	486.8	577.3	664.4	5.0	1,700.8	2,560.4	3,074.8	2.8
EM-8	Pato Branco	205.5	292.0	292.0	7.3	340.8	404.1	465.0	3.5	5,284.8	7,955.5	9,553.7	8.7
EM-9	Francisco Beltrao	349.1	496.0	496.0	12.4	379.7	450.3	518.2	3.9	10,083.6	15,179.5	18,229.0	16.6
EM-10	Cascavel	295.6	420.0	420.0	10.5	662.1	785.1	903.5	6.8	4,859.5	7,315.4	8,785.0	8.0
EM-11	Toledo	422.3	600.0	600.0	15.0	447.9	531.1	611.2	4.6	9,233.1	13,899.3	16,691.6	15.2
EM-12	Umuarama	123.9	176.0	176.0	4.4	1,625.9	1,928.0	2,218.9	16.7	1,336.4	2,011.7	2,415.9	2.2
EM-13	Campo Mourao	118.2	168.0	168.0	4.2	788.6	935.1	1,076.2	8.1	1,518.6	2,286.1	2,745.3	2.5
EM-14	Ivaipora	137.9	196.0	196.0	4.9	516.0	611.9	704.2	5.3	1,093.4	1,646.0	1,976.6	1.8
EM-15	Paranavai	39.4	56.0	56.0	1.4	1,236.5	1,466.2	1,687.4	12.7	1,336.4	2,011.7	2,415.9	2.2
EM-16	Maringa	87.3	124.0	124.0	3.1	671.8	796.6	916.8	6.9	2,733.5	4,114.9	4,941.6	4.5
EM-17	Apucarana	50.7	72.0	72.0	1.8	214.2	254.0	292.3	2.2	425.2	640.1	768.7	0.7
EM-18	Londrina	84.5	120.0	120.0	3.0	535.5	635.0	730.8	5.5	3,644.7	5,486.6	6,588.8	6.0
EM-19	Comelio Procopio	56.3	80.0	80.0	2.0	321.3	381.0	438.5	3.3	1,457.9	2,194.6	2,635.5	2.4
EM-20	Jacarezinho	112.6	160.0	160.0	4.0	603.6	715.8	823.8	6.2	3,037.2	4,572.2	5,490.7	5.0
	Total	2,815.0	4,000.0	4,000.0	100.0	9,736.0	11,545.0	13,287.0	100.0	60,744.0	91,443.0	109,813.0	100.0

Source: IBGE for livestock population in 1993, Cropping Calendar of Parana (1990) for the ratio of each region
Livestock population in 2005 and 2015 was based on projection.

5.2.4 Fish Pond Area

Regarding inland fishery, there is unauthorized information that annual target of fish pond expansion is 300 ha, approximately 8 % increase per year; however, this figure seems to be too high considering customers' taste and market. Therefore, it is assumed that fish raising will expand proportional to the increase of agricultural gross income, 2 % per year. The total area of fish pond, excluding reservoirs and natural ponds, was projected for the year of 2005 and 2015, and converted to EMATER region wise as shown in Table-5.5. The area ratio of each EMATER region was determined based on 1993 data from DEPEC/SEAB.

Table-5.5 Projection of Fish Pond Area

NO.	EMATER Region	Year Ratio (%)	1993 Area (ha)	2005 Area (ha)	2015 Area (ha)
EM-1	Paranagua	0.5	17	24	29
EM-2	Curitiba	4.2	156	202	244
EM-3	Lapa	2.3	87	110	133
EM-4	Ponta Grossa	8.5	320	408	493
EM-5	Irati	3.7	139	178	215
EM-6	Uniao da Vitoria	2.7	103	130	157
EM-7	Guarapuava	4.4	165	211	255
EM-8	Pato Branco	16.2	611	778	940
EM-9	Francisco Beltrao	19.6	736	940	1,136
EM-10	Cascavel	10.8	405	518	626
EM-11	Toledo	9.4	354	451	545
EM-12	Umuarama	0.1	4	5	6
EM-13	Campo Mourao	1.3	47	62	75
EM-14	Ivaipora	5.5	209	264	319
EM-15	Paranavai	0.3	11	14	17
EM-16	Maringa	1.0	36	48	58
EM-17	Apucarana	1.2	46	58	70
EM-18	Londrina	2.0	75	96	116
EM-19	Cornelio Procopio	3.2	119	154	186
EM-20	Jacarezinho	3.1	116	149	180
	Total	100.0	3,756	4,800	5,800

5.3 Future Agriculture

Based on area, crop productivity and livestock population projected, the growth of farmers income was evaluated. Since the producer's value or price fluctuates monthly depending on the market, it is unpredictable for a long time. Therefore, the producer's value of each crop in 1993 available from DERAL/SEAB (refer to Appendix-5) was applied to the year of 2005 and 2015, too. The result in Table-5.6 is very rough approximation; however, it shows at least future tendency. Farmers gross income will increase 1.6 % per year by 2015. The growth of Agriculture from economical point of view examined (see Sectorial Report-A, Socio-economy) shows 2 % annual increase. The both result well correlate to each other.

Table-5.6 Future Production and Farmers' Gross Income

Crop	Area (1,000ha)			Productivity (ton/ha)			Production (1000 ton)			Producer's Value	Value (million US$)		
	1993	2005	2015	1993	2005	2015	1993	2005	2015		1993	2005	2015
Cotton	345	306	360	1.299	2.255	2.485	448	690	895	5.54 US$/15 kg	165	255	331
Paddy Rice	19	28	38	4.126	5.997	7.391	78	168	281	10.39 US$/50 kg	16	35	58
Upland Rice	109	75	50	1.427	1.305	1.251	156	98	63	9.57 US$/60 kg	25	16	10
Potato 1)	41	48	51	15.315	18.552	21.255	625	890	1,084	7.6 US$/50 kg	95	135	165
Coffee	230	128	96	0.435	1.343	1.364	100	172	131	.9 US$/kg	90	155	118
Sugarcane	196	213	230	71.429	82.460	87.578	14,000	17,564	20,143	9.66 US$/ton	135	170	195
Beans 2)	575	736	805	0.799	0.825	0.869	459	607	700	25.57 US$/60 kg	196	259	298
Cassava	137	210	250	22.000	22.766	23.898	3,014	4,781	5,975	36.01 US$/ton	109	172	215
Maize 3)	2,703	2,756	2,756	3.018	3.356	3.807	8,158	9,249	10,492	6.27 US$/60 kg	853	967	1,096
Soybean 4)	2,076	2,293	2,293	2.320	2.376	2.528	4,817	5,448	5,797	11.16 US$/60 kg	896	1,013	1,078
Wheat	696	696	696	1.470	2.185	2.554	1,023	1,521	1,778	7.72 US$/60 kg	132	196	229
Livestock	Herd (1000 head)			Productivity 5)			Production 6)			Producer's Value	Value (million US$)		
	1993	2005	2015	1993	2005	2015	1993	2005	2015		1993	2005	2015
Cattle (meat)	8,470	10,044	11,560	0.048	0.048	0.048	407	482	555	23.14 US$/15 kg	628	744	856
Cattle (milk) 7)	1,266	1,501	1,727	460	460	460	582	690	794	.21 US$/l	122	145	167
Pig	2,815	4,000	4,000	0.070	0.070	0.070	197	280	280	.65 US$/kg	128	182	182
Chicken (meat)	60,744	91,443	109,813	0.008	0.008	0.008	486	732	879	.6 US$/kg	292	439	527
Chicken (egg)				3	3	3	182	274	329	12.17 US$/30 dz.	74	111	133
										Total	3,955	4,993	5,659

1): inclusive of dry season (seca) cropping, 70% of rainy season cropping

2): inclusive of dry season (seca) and winter season (inverno) cropping, 15% of rainy season cropping

3): inclusive of second summer season (safrinha) cropping, 25 % of normal cropping

4): inclusive of second summer season (safrinha) cropping, 4 % to normal season cropping

5): Meat, productivity = number of heads slaugghtered/total number of heads x meat productivity (ton/head)
Milk, liter/head
Egg, dz./head

6): Meat (1000 ton), Milk (million liter), Egg (million dz.)

7): Number of milch cows is 13 % of the total number of cattle.

The future food demand was compared with the future production. As shown in Table-5.7, future production of primary crops, except rice, and meat will be much more than the demand. For example, soybean production in 2015 will be 23 times more and potato 4 times more. The large excessive production will be exported not only to other states in Brazil to achieve self sufficiency but also abroad to stabilize food supply in the world. As long as the reality follows the projection somehow, future agriculture in Paraná will be promising and Paraná state will keep a current position as one of leading states of Brazilian agriculture.

Table-5.7 Future Production and Demand of Food

Crop	Production (1000 ton)			Consumption (1000 ton)		
	1993	2005	2015	1993	2005	2015
Rice	234	266	344	546	629	707
Potato	625	890	1,084	219	252	283
Coffee	100	172	131	82	94	106
Sugarcane	14,000	17,564	20,143	2,916	3,358	3,771
Beans	459	607	700	194	223	250
Cassava	3,014	4,781	5,975	247	285	320
Maize	8,158	9,249	10,492	129	149	167
Soybean	4,817	5,448	5,797	191	220	248
Wheat	1,023	1,521	1,778	584	672	755
Beef	407	482	555	158	182	205
Pork	197	280	280	60	69	78
Chicken	486	732	879	152	175	197

Sugarcane consumption does not include the alcohol production.

5.4 Water Demand Projection

Water demand in the agricultural sector for the year of 2005 and 2015 was projected. Since the rain-fed agriculture is practically adequate in Paraná state, the future water demand consists of ones for livestock and inland fish culture only, assuming that irrigation is negligible. Future water demand for livestock and inland fishery are shown in Table-5.8 and Table-5.9, respectively.

As shown in Table-5.10, current water consumption in 1993, future water demand in 2005 and 2015 were 158,000 m^3/day, 198,000 m^3/day and 229,000 m^3/day, respectively. This increase is due to livestock population growth and expansion of fish pond area.

Literature Cited

1. DERAL, SEAB. (1994). "Estimativa do Setor Agropecuário Paranáense - Horizonte - 2015" (Estimation for agriculture and livestock raising in Paraná - Year 2015). Curitiba.

2. DERAL, SEAB., and CEPA. (1990). Calendário agrícola do Paraná (Cropping calendar of Paraná). Curitiba.

Table-5.8 Water Demand Projection for Livestock (2005 & 2015)

NO.	EMATER	Population (1,000 head) Pig		Water Demand (1,000 m^3/day) Pig		Population (1,000 head) Cattle		Water Demand (1,000 m^3/day) Cattle		Population (1,000 head) Chicken		Water Demand (1,000 m^3/day) Chicken	
	Region	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015
EM-1	Paranagua	0.0	0.0	0.000	0.000	11.5	13.3	0.115	0.133	0.0	0.0	0.000	0.000
EM-2	Curitiba	136.0	136.0	0.544	0.544	150.1	172.7	1.501	1.727	4,572.2	5,490.7	0.914	1.098
EM-3	Lapa	76.0	76.0	0.304	0.304	92.4	106.3	0.924	1.063	2,560.4	3,074.8	0.512	0.615
EM-4	Ponta Grossa	240.0	240.0	0.960	0.960	600.3	690.9	6.003	6.909	10,058.7	12,079.4	2.012	2.416
EM-5	Irati	144.0	144.0	0.576	0.576	103.9	119.6	1.039	1.196	1,280.2	1,537.4	0.256	0.307
EM-6	Uniao da Vitoria	120.0	120.0	0.480	0.480	115.5	132.9	1.155	1.329	1,097.3	1,317.8	0.219	0.264
EM-7	Guarapuava	324.0	324.0	1.296	1.296	577.3	664.4	5.773	6.644	2,560.4	3,074.8	0.512	0.615
EM-8	Pato Branco	292.0	292.0	1.168	1.168	404.1	465.0	4.041	4.650	7,955.5	9,553.7	1.591	1.911
EM-9	Francisco Beltrao	496.0	496.0	1.984	1.984	450.3	518.2	4.503	5.182	15,179.5	18,229.0	3.036	3.646
EM-10	Cascavel	420.0	420.0	1.680	1.680	785.1	903.5	7.851	9.035	7,315.4	8,785.0	1.463	1.757
EM-11	Toledo	600.0	600.0	2.400	2.400	531.1	611.2	5.311	6.112	13,899.3	16,691.6	2.780	3.338
EM-12	Umuarama	176.0	176.0	0.704	0.704	1,928.0	2,218.9	19.280	22.189	2,011.7	2,415.9	0.402	0.483
EM-13	Campo Mourao	168.0	168.0	0.672	0.672	935.1	1,076.2	9.351	10.762	2,286.1	2,745.3	0.457	0.549
EM-14	Ivaipora	196.0	196.0	0.784	0.784	611.9	704.2	6.119	7.042	1,646.0	1,976.6	0.329	0.395
EM-15	Paranavai	56.0	56.0	0.224	0.224	1,466.2	1,687.4	14.662	16.874	2,011.7	2,415.9	0.402	0.483
EM-16	Maringa	124.0	124.0	0.496	0.496	796.6	916.8	7.966	9.168	4,114.9	4,941.6	0.823	0.988
EM-17	Apucarana	72.0	72.0	0.288	0.288	254.0	292.3	2.540	2.923	640.1	768.7	0.128	0.154
EM-18	Londrina	120.0	120.0	0.480	0.480	635.0	730.8	6.350	7.308	5,486.6	6,588.8	1.097	1.318
EM-19	Cornelio Procopio	80.0	80.0	0.320	0.320	381.0	438.5	3.810	4.385	2,194.6	2,635.5	0.439	0.527
EM-20	Jacarezinho	160.0	160.0	0.640	0.640	715.8	823.8	7.158	8.238	4,572.2	5,490.7	0.914	1.098
	Total	4,000.0	4,000.0	16.000	16.000	11,545.0	13,287.0	115.452	132.869	91,443.0	109,813.0	18.286	21.962

Table-5.9 Water Demand for Fish Culture (2005 & 2015)

NO.	EMATER Region	Area (ha)		Water Demand (1,000 m³/day)	
		2005	2015	2005	2015
EM-1	Paranagua	24	29	0.240	0.290
EM-2	Curitiba	202	244	2.020	2.440
EM-3	Lapa	110	133	1.100	1.330
EM-4	Ponta Grossa	408	493	4.080	4.930
EM-5	Irati	178	215	1.780	2.150
EM-6	Uniao da Vitoria	130	157	1.300	1.570
EM-7	Guarapuava	211	255	2.110	2.550
EM-8	Pato Branco	778	940	7.780	9.400
EM-9	Francisco Beltrao	940	1,136	9.400	11.360
EM-10	Cascavel	518	626	5.180	6.260
EM-11	Toledo	451	545	4.510	5.450
EM-12	Umuarama	5	6	0.050	0.060
EM-13	Campo Mourao	62	75	0.620	0.750
EM-14	Ivaipora	264	319	2.640	3.190
EM-15	Paranavai	14	17	0.140	0.170
EM-16	Maringa	48	58	0.480	0.580
EM-17	Apucarana	58	70	0.580	0.700
EM-18	Londrina	96	116	0.960	1.160
EM-19	Cornelio Procopio	154	186	1.540	1.860
EM-20	Jacarezinho	149	180	1.490	1.800
	Total	4,800	5,800	48.000	58.000

Table-5.10 Water Demand for Agricultural Sector

Unit: 1,000 m³/day

NO.	EMATER Region	1993 Pig	Cattle	Chicken	Fish	Total
EM-1	Paranagua	0.000	0.097	0.000	0.170	0.267
EM-2	Curitiba	0.383	1.266	0.607	1.560	3.816
EM-3	Lapa	0.214	0.779	0.340	0.870	2.203
EM-4	Ponta Grossa	0.676	5.063	1.336	3.200	10.275
EM-5	Irati	0.405	0.876	0.170	1.390	2.841
EM-6	Uniao da Vitoria	0.338	0.974	0.146	1.030	2.488
EM-7	Guarapuava	0.912	4.868	0.340	1.650	7.770
EM-8	Pato Branco	0.822	3.408	1.057	6.110	11.397
EM-9	Francisco Beltrao	1.396	3.797	2.017	7.360	14.570
EM-10	Cascavel	1.182	6.621	0.972	4.050	12.825
EM-11	Toledo	1.689	4.479	1.847	3.540	11.555
EM-12	Umuarama	0.496	16.259	0.267	0.040	17.062
EM-13	Campo Mourao	0.473	7.886	0.304	0.470	9.133
EM-14	Ivaipora	0.552	5.160	0.219	2.090	8.021
EM-15	Paranavai	0.158	12.365	0.267	0.110	12.900
EM-16	Maringa	0.349	6.718	0.547	0.360	7.974
EM-17	Apucarana	0.203	2.142	0.085	0.460	2.890
EM-18	Londrina	0.338	5.355	0.729	0.750	7.172
EM-19	Cornelio Procopio	0.225	3.213	0.292	1.190	4.920
EM-20	Jacarezinho	0.450	6.036	0.607	1.160	8.253
	Total	11.261	97.362	12.149	37.560	158.332
NO.	EMATER Region	2005 Pig	Cattle	Chicken	Fish	Total
EM-1	Paranagua	0.000	0.115	0.000	0.240	0.355
EM-2	Curitiba	0.544	1.501	0.914	2.020	4.979
EM-3	Lapa	0.304	0.924	0.512	1.100	2.840
EM-4	Ponta Grossa	0.960	6.003	2.012	4.080	13.055
EM-5	Irati	0.576	1.039	0.256	1.780	3.651
EM-6	Uniao da Vitoria	0.480	1.155	0.219	1.300	3.154
EM-7	Guarapuava	1.296	5.773	0.512	2.110	9.691
EM-8	Pato Branco	1.168	4.041	1.591	7.780	14.580
EM-9	Francisco Beltrao	1.984	4.503	3.036	9.400	18.923
EM-10	Cascavel	1.680	7.851	1.463	5.180	16.174
EM-11	Toledo	2.400	5.311	2.780	4.510	15.001
EM-12	Umuarama	0.704	19.280	0.402	0.050	20.436
EM-13	Campo Mourao	0.672	9.351	0.457	0.620	11.100
EM-14	Ivaipora	0.784	6.119	0.329	2.640	9.872
EM-15	Paranavai	0.224	14.662	0.402	0.140	15.428
EM-16	Maringa	0.496	7.966	0.823	0.480	9.765
EM-17	Apucarana	0.288	2.540	0.128	0.580	3.536
EM-18	Londrina	0.480	6.350	1.097	0.960	8.887
EM-19	Cornelio Procopio	0.320	3.810	0.439	1.540	6.109
EM-20	Jacarezinho	0.640	7.158	0.914	1.490	10.202
	Total	16.000	115.452	18.286	48.000	197.738
NO.	EMATER Region	2015 Pig	Cattle	Chicken	Fish	Total
EM-1	Paranagua	0.000	0.133	0.000	0.290	0.423
EM-2	Curitiba	0.544	1.727	1.098	2.440	5.809
EM-3	Lapa	0.304	1.063	0.615	1.330	3.312
EM-4	Ponta Grossa	0.960	6.909	2.416	4.930	15.215
EM-5	Irati	0.576	1.196	0.307	2.150	4.229
EM-6	Uniao da Vitoria	0.480	1.329	0.264	1.570	3.643
EM-7	Guarapuava	1.296	6.644	0.615	2.550	11.105
EM-8	Pato Branco	1.168	4.650	1.911	9.400	17.129
EM-9	Francisco Beltrao	1.984	5.182	3.646	11.360	22.172
EM-10	Cascavel	1.680	9.035	1.757	6.260	18.732
EM-11	Toledo	2.400	6.112	3.338	5.450	17.300
EM-12	Umuarama	0.704	22.189	0.483	0.060	23.436
EM-13	Campo Mourao	0.672	10.762	0.549	0.750	12.733
EM-14	Ivaipora	0.784	7.042	0.395	3.190	11.411
EM-15	Paranavai	0.224	16.874	0.483	0.170	17.751
EM-16	Maringa	0.496	9.168	0.988	0.580	11.232
EM-17	Apucarana	0.288	2.923	0.154	0.700	4.065
EM-18	Londrina	0.480	7.308	1.318	1.160	10.266
EM-19	Cornelio Procopio	0.320	4.385	0.527	1.860	7.092
EM-20	Jacarezinho	0.640	8.238	1.098	1.800	11.776
	Total	16.000	132.869	21.962	58.000	228.831

CHAPTER 6 CURRENT AGRICULTURE IN PILOT RIVER BASINS

Since Iguaçu and Tibagi were selected as pilot river basins, the following study was conducted just for Iguaçu and Tibagi river basin.

The data concerning agriculture was collected from EMATER database with municipality wise and is attached as Appendix-6. The data was extracted from the database for crops whose area in a municipality is more than 100 ha to identify dominant crops. 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.

The landuse of each municipality was computed by SANEPAR based on IAP satellite imagery analysis. The result is also in Appendix-6.

6.1 Characteristics of Crop Cultivation

6.1.1 Iguaçu River Basin

According to SANEPAR GIS computation (1994) based on IAP satellite imagery analysis (1990 and 1994), 37.9 % (21,000 km^2) and 17.6 % (9,700 km^2) of Iguaçu 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 three as shown in Figure-6.1, characteristics of agriculture was identified and the result is summarized in Table-6.1. The detailed information regarding agriculture is shown in Appendix-6.

Crop land and pasture spread over the river basin; however, in the downstream of Iguaçu river basin, Region III in Figure-6.1, crop land and pasture are slightly more dense than other regions. In Region II, the area of forest is larger than other regions resulting in the lower occupation of crop land.

The most distinct characteristic of agriculture in Iguaçu river basin is potato culture. Almost all potato of Paraná state is produced in the upstream of Iguaçu (Region I) around Curitiba and Lapa despite the fact that its cropping area is limited. As shown in Appendix-6, approximately 33,300 ha is currently cultivated for potato. The rate of mechanization is very high, almost 100 % in spite of the very low practices of soil conservation.

Maize culture extend over the whole river basin with the high rate of cultivated area. More than 50 % of crop land is cultivated for maize. Productivity varies with location but the average in the river basin is 3.1 ton/ha.

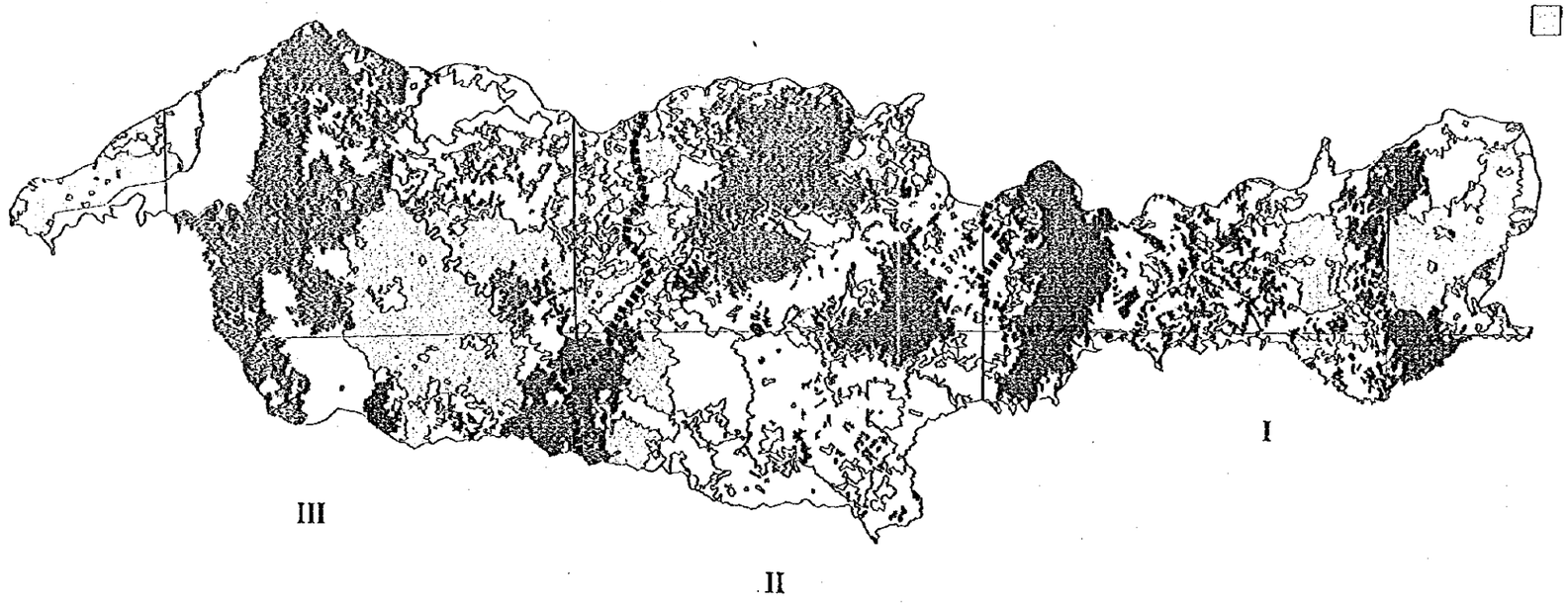
Soybean is the second dominant crop in Iguaçu river basin after maize. Approximately 30 % of crop land in Region II and III is cultivated for soybean, however in Region I soybean area is only 6.9 % of its crop land. Both application rates of mechanization and soil conservation are very high, 94.7 % and 81.5 % respectively in river basin average.

Beans culture spreads all over the river basin; however, it is more cultivated in Region I, 31.1 % of its crop area, while the river basin average is 17.0 %. The average rate of mechanization is not as high as ones of potato and soybean, however, in Region I, it is almost 80 %. In contrast to mechanization, the application rate of soil conservation is much higher in Region III, 51.7 %, while ones of other regions are around 20 %.

IGUACU RIVER BASIN

Region	Total Area (km2)	Forest (%)	2nd Vegetation (%)	Reforestation (%)	Pasture (%)	Crop (%)	Others (%)
I	13,270	7.5	34.7	5.1	10.3	39.0	2.1
II	19,770	21.1	27.2	0.4	16.6	34.3	1.1
III	22,280	12.3	22.2	0.8	22.8	40.5	1.5
Whole Basin	55,320	14.3	27.0	1.7	17.6	37.9	1.5

Source: SANEPAR GIS computation (1994)



LEGEND

- Crop-Land
- Crop-Land (65%) + Secondary Vegetation (35%)
- Crop-Land (65%) + Pasture (35%)
- Crop-Land (55%) + Secondary Vegetation (30%) + Pasture (15%)
- Crop-Land (55%) + Pasture (30%) + Secondary Vegetation (15%)

Scale ; 1 / 2,150,000

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

Figure-6.1 Sub-division and Landuse in Iguaçu River Basin

Table-6.1 Agricultural Characteristics of Iguaçu River Basin (1994)

Region	Total Crop Area (km²)	Item	Cotton	Sugarcane	Beans	Maize	Soybean	Cassava	Potato	Wheat
I	5,180	Area Ratio to Total (%)	0.0	0.0	31.1	55.2	6.9	0.2	6.6	0.6
		Productivity (ton/ha)	-	-	1.0	2.8	2.4	13.9	14.5	1.5
		Mechanization (%)	-	-	78.0	76.0	96.9	45.8	99.0	91.0
		Implementation of Conservation (%)	-	-	24.4	25.8	65.0	4.2	10.0	55.6
		Implementation of Non-tillage (%)	-	-	0.3	2.1	23.2	-	-	12.4
II	6,780	Area Ratio to Total (%)	0.0	0.0	14.2	54.1	30.3	1.3	0.1	2.5
		Productivity (ton/ha)	-	-	0.9	3.1	2.5	16.5	18.1	2.1
		Mechanization (%)	-	-	51.2	59.4	99.6	23.6	99.0	97.9
		Implementation of Conservation (%)	-	-	21.4	35.8	87.3	5.8	10.0	86.0
		Implementation of Non-tillage (%)	-	-	0.0	26.3	64.6	-	-	68.1
III	9,020	Area Ratio to Total (%)	1.1	0.6	11.1	53.9	30.5	2.8	0.0	9.7
		Productivity (ton/ha)	1.6	37.9	1.0	3.3	2.3	25.4	-	1.5
		Mechanization (%)	71.3	33.3	56.3	62.3	90.7	53.8	-	84.7
		Implementation of Conservation (%)	64.6	50.5	51.7	51.8	79.2	38.2	-	72.5
		Implementation of Non-tillage (%)	-	-	0.9	6.5	19.6	-	-	13.7
River Basin Average	20,980	Area Ratio to Total (%)	0.5	0.3	17.0	54.3	24.7	1.6	1.6	5.1
		Productivity (ton/ha)	1.6	37.4	1.0	3.1	2.4	22.7	14.6	1.6
		Mechanization (%)	71.3	32.1	64.7	64.8	94.7	45.8	99.0	86.9
		Implementation of Conservation (%)	64.6	48.4	31.2	40.1	81.5	28.7	10.0	74.1
		Implementation of Non-tillage (%)	-	-	0.4	11.8	37.9	-	-	22.1
		Scale of Farmers	Small	Medium	Large	Total (household)				
I		Number of Household (%)	89.0	9.0	2.0	37,200				
		Scale of Farmers	Small	Medium	Large	Total (household)				
II		Number of Household (%)	76.0	16.9	7.1	25,200				
		Scale of Farmers	Small	Medium	Large	Total (household)				
III		Number of Household (%)	89.0	9.3	1.7	76,900				
		Scale of Farmers	Small	Medium	Large	Total (household)				
River Basin		Number of Household (%)	86.7	10.6	2.7	139,300				

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

Other dominant crops are cassava, sugarcane , cotton and wheat (winter crop). Cotton and sugarcane are only cultivated in Region III, while cassava cultivation spreads all river basin but more in Region III. Wheat in Paraná is usually cultivated as a second crop after either soybean or maize. Its area is not as much as ones of soybean and maize. The river basin average of its cultivation is 5.1 %, while in Region III its area is almost 10 % of the total crop area of Region III.

The recent trends show the extension of non tillage. As studied at the Strategy for the state, it is expected to be more popular in future. Non tillage is practiced for soybean, maize, beans and wheat culture in Iguaçu river basin. Among them, the current application rate of non tillage is the highest in soybean cultivation, while the lowest in beans cultivation. Their rates in basin average are 37.9 % and 0.4 %, respectively. Comparing the rates in three regions, the application rates for soybean, maize and wheat are the highest in Region II.

The total number of farmers in Iguaçu river basin is 139,300 households in 1994. Among them, 86.7 % 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 10.6 and 2.7 %, respectively. In contrast with the state tendency, which shows the expansion of medium size farmers, small size farmers are dominant in Iguaçu river basin. In Region II, medium and large size farmers are more, 16.9 % and 7.1 % respectively, compared to other regions.

6.1.2 Tibagi River Basin

As shown in Figure-6.2, 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, characteristics of agriculture was identified and the result is shown in Table-6.2.

The most distinct characteristic of agriculture in Tibagi river basin is maize and soybean culture. Their area extends 44.4 % (4,400 km^2) and 39.3 % (3,900 km^2) of the total crop area of Tibagi river basin. More than 80 % of the crop land is cultivated for soybean and maize. The rate of mechanization for both crop is very high, 98.8 % for soybean and 76.7 % for maize, while the application rate of soil conservation is high in soybean culture (86.9 %) but medium in maize culture (57.4 %).

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.

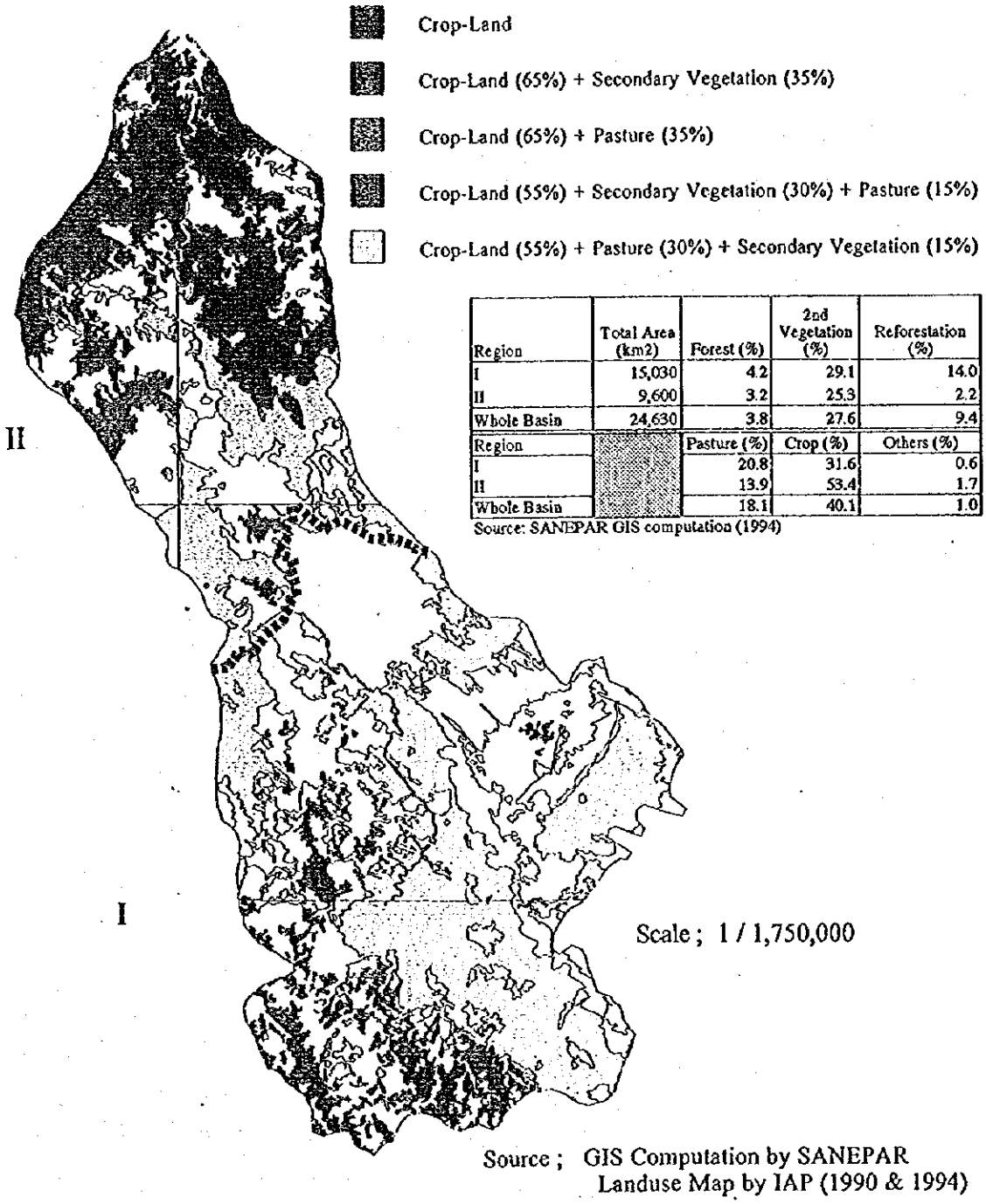
Wheat cultivation is more popular in Tibagi river basin compared to Iguaçu river basin. Since wheat is a second crop after either soybean or maize, the rates of mechanization and application of soil conservation are high, 99.6 % and 87.9 % of its area respectively.

Other dominant crops are beans, cotton and sugarcane. Beans cultivation spreads over the river basin occupying 8.3 % of the total crop area in Tibagi river basin, while cotton and sugarcane are only cultivated in Region II. In contrast to other two crops, the rates of mechanization and application of soil conservation in sugarcane cultivation are very high, 99.5 % and 91.1 % respectively.

Area of potato and cassava culture are limited to only 0.2 % (21 km^2) and 0.5 % (48 km^2) of the total crop area in the river basin. Potato is only cultivated in Region I near the border with Iguaçu river basin, while cassava is cultivated in Region I and II but producing municipalities in Region II are Ortigueira and Curiuva which are close to the boundary with Region I. As shown in Appendix-6, producing municipalities for potato are Porto Amazonas, Palmeira, Teixeira Soares, Imbituva and Pirai do Sul.

Non-tillage is well practiced in Region I in contrast to Region II. 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.

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-6.2 Sub-division and Landuse in Tibagi River Basin

Table-6.2 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	-	-	-	13.8
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
		Scale of Farmers	Small	Medium	Large	Total (household)					
I		Number of Household (%)	77.2	16.5	6.3	20,900					
		Scale of Farmers	Small	Medium	Large	Total (household)					
II		Number of Household (%)	80.4	14.1	5.5	20,400					
		Scale of Farmers	Small	Medium	Large	Total (household)					
River Basin		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 total number of farmers in Tibagi river basin is 41,300 households 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.

6.2 Livestock and Inland Fishery

6.2.1 Iguaçu River Basin

Table-6.3 shows population of livestock and fish pond area as of 1994 in Iguaçu river basin. The data was extracted from EMATER database with municipality wise.

Cattle raising is popular in the middle and downstream of Iguaçu river basin, Region II and Region III. Pinhao, Palmas, Candoi and Guarapuava raise more than 50 thousand heads of cattle. One of the reasons is their large municipality area so that pasture can extend more than other municipalities. According to the landuse (Appendix-6), more pasture is allocated with going to the downstream.

Pig raising is also popular in Region II and III. Among the municipalities in Region II and III, Cruz Machado, Nova Prata do Iguaçu, Dois Vizinhos and Guarapuava raise more than 40 thousand heads of pig.

Table-6.3 Current Livestock Population and Fish Pond Area in Iguaçu River Basin (1/2)

Div.	No.	Municipality	Area (km²)	1994 Cattle (1,000 head)	1994 Pig (1,000 head)	1994 Chicken (1,000 head)	1994 Fish Pond Area (ha)
	I-001	Campina Grande do Sul	79.2	0	0	0	8
	I-002	Quatro Barras	99.5	1	1	0	8
	I-003	Piraquara	171.9	3	1	0	1
	I-004	Sao Jose dos Pinhais	674.2	9	17	468	12
	I-005	Colombo	127.6	1	3	14	7
	I-006	Pinhais	98.2	2	1	0	0
	I-007	Almirante Tamandare	189.3	2	5	238	2
	I-008	Curitiba	431.7	1	1	100	0
	I-009	Campo Largo	297.2	2	7	14	10
	I-010	Araucaria	503.7	3	2	600	25
	I-011	Fazenda Rio Grande	110.9	2	2	467	10
	I-012	Mandirituba	392.3	2	8	3,112	22
	I-013	Tijucas do Sul	422.6	3	5	560	2
	I-014	Balsa Nova	319.7	1	1	0	15
I	I-015	Contenda	222.2	7	9	0	6
	I-016	Quitandinha	419.4	3	11	330	41
	I-017	Agudos do Sul	259.6	3	5	64	30
	I-018	Pien	261.7	3	5	525	16
	I-019	Rio Negro	603.2	9	8	990	3
	I-020	Campo do Tenente	314.0	7	1	96	7
	I-021	Lapa	2,203.9	32	20	700	14
	I-022	Porto Amazonas	153.0	2	3	174	1
	I-023	Palmeira	273.4	7	5	91	3
	I-024	Sao Joao do Triunfo	708.1	6	6	0	2
	I-025	Antonio Olinto	482.5	4	14	0	6
	I-026	Sao Mateus do Sul	1,332.8	15	18	250	10
	I-027	Reboucas	498.9	6	3	227	10
	I-028	Irati	408.1	5	8	0	12
	I-029	Rio Azul	642.6	8	6	50	42
	I-030	Mallet	672.8	6	20	864	20
		Sub-total	13,374.2	154	196	9,934	345
	I-031	Paulo Frontin	377.5	5	12	870	27
	I-032	Paula Freitas	417.0	5	4	650	1
	I-033	Uniao da Vitoria	773.9	28	5	120	15
	I-034	Porto Vitoria	220.2	3	3	0	4
	I-035	General Carneiro	1,063.7	20	4	0	10
	I-036	Bituruna	1,209.7	20	25	50	350
	I-037	Cruz Machado	1,500.5	16	57	139	56
II	I-038	Inacio Martins	879.9	9	10	0	59
	I-039	Guarapuava	3,402.7	56	42	0	180
	I-040	Pinhao	2,875.2	67	28	0	0
	I-041	Palmas	3,125.5	65	7	0	190
	I-042	Clevelandia	708.4	31	8	288	125
	I-043	Honorio-Serpa	806.6	9	5	0	1
	I-044	Mangueirinha	801.3	22	10	0	10
	I-045	Candoi	999.8	62	19	0	0
	I-046	Cantagalo	774.1	14	17	0	0
		Sub-total	19,936.0	428	251	2,117	1,028
	I-047	Virmound	198.4	4	12	0	0
	I-048	Laranjeiras do Sul	1,052.7	21	15	0	20
	I-049	Chopinzinho	992.5	44	19	1,824	60
	I-050	Coronel Vivida	681.5	34	22	170	36
	I-051	Pato Branco	570.2	26	13	3,658	15
	I-052	Mariopolis	232.1	10	5	480	6
	I-053	Vitorino	326.1	11	17	1,360	17
III	I-054	Renascenca	434.7	17	12	500	40
	I-055	Bom Sucesso do Sul	135.3	13	10	600	30
	I-056	Itapejara D'Oeste	246.0	12	23	2,700	10
	I-057	Vere	345.6	16	13	900	32
	I-058	Sao Joao	408.9	26	16	3,966	11
	I-059	Sulina	158.5	13	8	132	16
	I-060	Saudade do Iguacu	147.8	11	3	1,000	4
	I-061	Rio Bonito do Iguacu	452.3	6	7	0	0
	I-062	Nova Laranjeiras	578.8	17	7	41	0
	I-063	Guaraniacu	495.0	40	11	626	6
	I-064	Quedas do Iguacu	1,192.9	36	12	318	7
	I-065	Sao Jorge do Oeste	385.1	16	8	900	21
	I-066	Cruzeiro do Iguacu	96.6	7	5	3,498	1
	I-067	Boa Esperanca do Iguacu	249.4	11	11	312	10

Table-6.3 Current Livestock Population and Fish Pond Area in Iguaçu River Basin (2/2)

Div.	No.	Municipality	Area (km²)	1994 Cattle (1,000 head)	1994 Pig (1,000 head)	1994 Chicken (1,000 head)	1994 Fish Pond Area (ha)
	I-068	Dois Vizinhos	372.7	22	46	5,000	7
	I-069	Eneas Marques	234.7	15	26	372	4
	I-070	Francisco Beltrao	696.7	34	38	2,270	104
	I-071	Marmeleiro	449.9	15	30	650	15
	I-072	Flor da Serra do Sul	94.7	10	14	205	92
	I-073	Barracao	386.3	21	7	150	5
	I-074	Salgado Filho	506.4	35	20	800	4
	I-075	Santo Antonio do Sudoeste	313.8	19	1	380	66
	I-076	Pranchita	297.1	10	15	150	30
	I-077	Pinhal de Sao Bento	107.6	4	8	120	7
	I-078	Ampere	307.9	15	17	4,600	4
	I-079	Nova Esperanca do Sudoeste	176.9	18	19	1,000	3
III	I-080	Salto do Lontra	336.9	18	16	3,950	55
	I-081	Santa Izabel do Oeste	330.5	16	17	1,200	4
	I-082	Nova Prata do Iguacu	333.0	32	54	198	9
	I-083	Perola do Oeste	330.1	13	22	60	9
	I-084	Planalto	337.1	34	20	0	5
	I-085	Realeza	351.9	25	20	160	3
	I-086	Capanema	403.9	30	10	800	25
	I-087	Tres Barras do Parana	521.7	34	21	420	5
	I-088	Catanduvas	593.9	19	10	346	12
	I-089	Ibema	148.3	9	2	352	11
	I-090	Cascavel	1,198.9	39	25	1,265	27
	I-091	Boa Vista da Aparecida	232.2	17	2	240	2
	I-092	Capitao Leonidas Marques	279.8	17	9	1,100	15
	I-093	Santa Lucia	137.1	21	4	192	0
	I-094	Lindoeste	273.2	34	8	125	8
	I-095	Santa Tereza do Oeste	235.5	10	6	70	7
	I-096	Ceu Azul	937.2	21	28	403	6
	I-097	Matelandia	601.4	27	27	346	25
	I-098	Medianeira	621.1	32	38	598	32
	I-099	Sao Miguel do Iguacu	455.7	23	17	159	15
	I-100	Santa Terezinha de Itaipu	162.1	10	3	47	2
	I-101	Foz do Iguacu	312.2	10	3	33	8
		Sub-total	22,465.8	1,098	851	50,747	968
		Total	55,776.0	1,681	1,301	62,798	2,341

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 the different data source.

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

In contrast to cattle and pig raising, poultry farming is popular in Region I and III. Dois Vizinhos, Ampere, Sao Joao, Salto do Lontra, Pato Branco, Cruzeiro do Iguaçu and Mandirituba raise more than 3 million heads. The total number of chicken in Iguaçu river basin is approximately 63 million heads. Because of these large figures, Paraná state is ranked as a second producer for chicken meat and third for eggs in Brazi.

The total fish pond area in Iguaçu river basin is 2,341 ha as of 1994. Fish pons are mainly located in Bituruna, Palmas, Guarapuava, Clevelandia and Francisco Beltrao.

6.2.2 Tibagi River Basin

Table-6.4 shows population of livestock and fish pond area as of 1994 in Tibagi river basin. The data was extracted from EMATER database with municipality wise. In Tibagi river basin, livestock raising is mostly concentrated in several municipalities, such as Ponta Grossa, Castro and Londrina regardless of kind of livestock.

Main producing municipalities for cattle are Londrina, Tibagi, Ortigueira and Castro where the large pasture extends. These municipalities raise more than 50 thousand heads of cattle as of 1994.

Pig raising in Tibagi river basin is practiced mainly in 10 municipalities out of 43 municipalities. These municipalities, such as Tibagi, Londrina, Arapongas, Palmeira, Ortigueira and so on, raise more than 10 thousand heads and contribute to 73 % of the total pig raising in the river basin.

Poultry farming is the mostly practiced in Londrina, Castro, Sertanopolis, Ponta Grossa and Pirai do Sul. These municipalities contribute 84 % of poultry farming in the river basin.

The total fish pond area in Tibagi river basin is 418 ha as of 1994. Fish pons are mainly located in Region I, the upstream, while in Region II, downstream, only 5 municipalities have more than 10 ha. The area of fish pond in Tibagi river basin is limited.

Table-6.4 Current Livestock Population and Fish Pond Area in Tibagi River Basin

Div.	Code	Municipality	Area (km²)	1994 Cattle (1,000 head)	1994 Pig (1,000 head)	1994 Chicken (1,000 head)	1994 Fish Pond Area (ha)
	T-001	Porto Amazonas	53.8	0.8	0.9	61.1	0
	T-002	Palmeira	1,227.4	29.8	21.3	408.9	17
	T-003	Teixeira Soares	1,303.5	20.3	19.4	0.0	24
	T-004	Irati	139.6	1.6	2.8	0.0	4
	T-005	Imbituva	811.3	14.1	13.6	0.0	2
	T-006	Ipiranga	932.0	18.3	7.5	0.0	34
I	T-007	Ponta Grossa	1,870.8	42.6	11.1	1,205.1	10
	T-008	Castro	2,278.4	65.7	11.2	1,443.1	26
	T-009	Ivai	212.2	2.8	2.1	0.0	35
	T-010	Reserva	555.9	15.2	3.1	0.0	25
	T-011	Tibagi	2,926.6	110.7	27.9	0.0	34
	T-012	Pirai do Sul	965.2	31.3	12.0	988.3	5
	T-013	Ventania	380.1	9.6	0.4	0.0	2
	T-014	Telemaco Borba	1,625.3	8.3	2.4	0.0	50
		Sub-total	15,282.1	371.1	135.7	4106.5	268.0
	T-015	Ortigueira	1,588.5	69.4	19.3	0.0	48
	T-016	Curiuva	361.8	1.4	0.0	37.3	1
	T-017	Sapopema	531.9	27.8	1.5	0.0	0
	T-018	Sao Jeronimo da Serra	851.3	47.2	7.5	0.0	3
	T-019	Maua da Serra	48.0	1.5	0.5	25.0	0
	T-020	Marilandia do Sul	152.2	10.2	0.8	56.9	3
	T-021	California	97.2	9.2	0.1	0.0	0
	T-022	Apucarana	182.2	9.6	2.5	61.7	2
	T-023	Arapongas	191.9	7.1	22.9	236.1	7
	T-024	Londrina	2,095.6	162.4	25.0	2,343.0	18
	T-025	Nova Santa Barbara	112.2	0.5	0.1	0.0	1
	T-026	Santa Cecilia do Pavao	68.5	0.5	0.1	0.0	2
	T-027	Santo Antonio do Paraiso	151.9	8.3	1.0	0.0	2
	T-028	Congonhinhas	101.6	5.2	0.3	13.3	0
	T-029	Nova Fatima	83.5	7.9	0.0	0.0	0
	T-030	Sao Sebastiao da Amoreira	217.4	9.5	0.6	0.0	1
II	T-031	Assai	450.5	10.6	3.0	131.0	4
	T-032	Nova America da Colina	133.3	7.6	1.7	0.0	2
	T-033	Cornelio Procopio	336.7	23.6	0.2	0.0	2
	T-034	Urai	209.6	9.3	6.0	0.0	15
	T-035	Jataizinho	199.1	11.5	0.4	0.0	0
	T-036	Ibipora	295.4	10.5	6.7	72.0	16
	T-037	Rolandia	57.4	1.9	2.5	107.9	1
	T-038	Cambe	143.5	4.4	2.5	65.0	0
	T-039	Sertanopolis	478.9	17.7	7.2	1,328.7	19
	T-040	Rancho Alegre	187.4	0.1	0.0	0.0	3
	T-041	Leopolis	68.9	2.8	1.3	0.0	0
	T-042	Sertaneja	226.7	3.4	0.9	0.0	0
	T-043	Primeiro de Maio	142.8	3.5	1.3	112.9	0
		Sub-total	9,768.9	484.6	115.9	4590.8	150.0
		Total	25,051.0	856.0	252.0	8,697.0	418.0

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 the different data source.

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

6.3 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. Although there are a few cases of irrigation in pilot river basins, especially the suburb of Curitiba for horticulture, its area and water consumption are considered as negligibly small. Therefore, the agricultural water in pilot river basins consists of water for livestock and fish pond.

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 (refer to Section 3.5) 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.
4) Actual Water Supply to licestock is;

Pig	4 liter/head/day
Cattle	10 liter/head/day
Chicken	2 liter/10 heads/day

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 is just multiplication of livestock population or fish pond area by the above rates. It was computed for Iguaçu and Tibagi river basins based on Table-6.3 and Table-6.4.

6.3.1 Current Water Consumption in Iguaçu River Basin

The current water consumption of agriculture in Iguaçu river basin was estimated and the result is shown in Table-6.5.

Bituruna, Palmas, Guarapuava, Francisco Beltrao, Clevelandia, Chopinzinho and Flor da Serra do Sul consume water more than one thousand m^3/day due to the large area of fish ponds. On the other hand, the consumption of water in Salto do Lontra, Dois Vizinhos, Sao Joao, Pato Branco and Ampere is high due to the thriving polutry farming.

Table-6.5 Current Water Consumption of Agriculture in Iguaçu River Basin (1/2)

Unit: 1,000 m^3/day

Div.	No.	Municipality	1994 Cattle	Pig	Chicken	Fish	Total
	I-001	Campina Grande do Sul	0.00	0.00	0.00	0.08	0.08
	I-002	Quatro Barras	0.01	0.00	0.00	0.08	0.09
	I-003	Piraquara	0.03	0.00	0.00	0.01	0.04
	I-004	Sao Jose dos Pinhais	0.09	0.07	0.09	0.12	0.37
	I-005	Colombo	0.01	0.01	0.00	0.07	0.09
	I-006	Pinhais	0.02	0.00	0.00	0.00	0.02
	I-007	Almirante Tamandare	0.02	0.02	0.05	0.02	0.11
	I-008	Curitiba	0.01	0.00	0.02	0.00	0.03
	I-009	Campo Largo	0.02	0.03	0.00	0.10	0.15
	I-010	Araucaria	0.03	0.01	0.12	0.25	0.41
	I-011	Fazenda Rio Grande	0.02	0.01	0.09	0.10	0.22
	I-012	Mandirituba	0.02	0.03	0.62	0.22	0.89
	I-013	Tijucas do Sul	0.03	0.02	0.11	0.02	0.18
	I-014	Balsa Nova	0.01	0.00	0.00	0.15	0.16
I	I-015	Contenda	0.07	0.04	0.00	0.06	0.17
	I-016	Quitandinha	0.03	0.04	0.07	0.41	0.55
	I-017	Agudos do Sul	0.03	0.02	0.01	0.30	0.36
	I-018	Pien	0.03	0.02	0.11	0.16	0.32
	I-019	Rio Negro	0.09	0.03	0.20	0.03	0.35
	I-020	Campo do Tenente	0.07	0.01	0.02	0.07	0.17
	I-021	Lapa	0.32	0.08	0.14	0.14	0.68
	I-022	Porto Amazonas	0.02	0.01	0.03	0.01	0.07
	I-023	Palmeira	0.07	0.02	0.02	0.03	0.14
	I-024	Sao Joao do Triunfo	0.06	0.02	0.00	0.02	0.10
	I-025	Antonio Olinto	0.04	0.05	0.00	0.06	0.15
	I-026	Sao Mateus do Sul	0.15	0.07	0.05	0.10	0.37
	I-027	Rebouças	0.06	0.01	0.05	0.10	0.22
	I-028	Irati	0.05	0.03	0.00	0.12	0.20
	I-029	Rio Azul	0.08	0.03	0.01	0.42	0.54
	I-030	Mallet	0.06	0.08	0.17	0.20	0.51
	I-031	Paulo Frontin	0.05	0.05	0.17	0.27	0.54
	I-032	Paula Freitas	0.05	0.01	0.13	0.01	0.20
	I-033	Uniao da Vitoria	0.28	0.02	0.02	0.15	0.47
	I-034	Porto Vitoria	0.03	0.01	0.00	0.04	0.08
	I-035	General Carneiro	0.20	0.02	0.00	0.10	0.32
	I-036	Bituruna	0.20	0.10	0.01	3.50	3.81
II	I-037	Cruz Machado	0.16	0.23	0.03	0.56	0.98
	I-038	Inacio Martins	0.09	0.04	0.00	0.59	0.72
	I-039	Guarapuava	0.56	0.17	0.00	1.80	2.53
	I-040	Pinhao	0.67	0.11	0.00	0.00	0.78
	I-041	Palmas	0.65	0.03	0.00	1.90	2.58
	I-042	Clevelandia	0.31	0.03	0.06	1.25	1.65
	I-043	Honorio Serpa	0.09	0.02	0.00	0.01	0.12
	I-044	Mangueirinha	0.22	0.04	0.00	0.10	0.36
	I-045	Candoi	0.62	0.08	0.00	0.00	0.70
	I-046	Cantagalo	0.14	0.07	0.00	0.00	0.21

Table-6.5 Current Water Consumption of Agriculture in Iguaçu River Basin (2/2)

Unit: 1,000 m³/day

Div.	No.	Municipality	1994 Cattle	Pig	Chicken	Fish	Total
	I-047	Virmound	0.04	0.05	0.00	0.00	0.09
	I-048	Laranjeiras do Sul	0.21	0.06	0.00	0.20	0.47
	I-049	Chopinzinho	0.44	0.08	0.36	0.60	1.48
	I-050	Coronel Vivida	0.34	0.09	0.03	0.36	0.82
	I-051	Pato Branco	0.26	0.05	0.73	0.15	1.19
	I-052	Mariopolis	0.10	0.02	0.10	0.06	0.28
	I-053	Vitorino	0.11	0.07	0.27	0.17	0.62
	I-054	Renascenca	0.17	0.05	0.10	0.40	0.72
	I-055	Bom Sucesso do Sul	0.13	0.04	0.12	0.30	0.59
	I-056	Itapejara D'Oeste	0.12	0.09	0.54	0.10	0.85
	I-057	Vere	0.16	0.05	0.18	0.32	0.71
	I-058	Sao Joao	0.26	0.07	0.79	0.11	1.23
III	I-059	Sulina	0.13	0.03	0.03	0.16	0.35
	I-060	Saudade do Iguacu	0.11	0.01	0.20	0.04	0.36
	I-061	Rio Bonito do Iguacu	0.06	0.03	0.00	0.00	0.09
	I-062	Nova Laranjeiras	0.17	0.03	0.01	0.00	0.21
	I-063	Guaraniacu	0.40	0.04	0.13	0.06	0.63
	I-064	Quedas do Iguacu	0.36	0.05	0.06	0.07	0.54
	I-065	Sao Jorge do Oeste	0.16	0.03	0.18	0.21	0.58
	I-066	Cruzeiro do Iguacu	0.07	0.02	0.70	0.01	0.80
	I-067	Boa Esperanca do Iguacu	0.11	0.04	0.06	0.10	0.31
	I-068	Dois Vizinhos	0.22	0.18	1.00	0.07	1.47
	I-069	Eneas Marques	0.15	0.10	0.07	0.04	0.36
	I-070	Francisco Beltrao	0.34	0.15	0.45	1.04	1.98
	I-071	Marmeleiro	0.15	0.12	0.13	0.15	0.55
	I-072	Flor da Serra do Sul	0.10	0.06	0.04	0.92	1.12
	I-073	Barracao	0.21	0.03	0.03	0.05	0.32
	I-074	Salgado Filho	0.35	0.08	0.16	0.04	0.63
	I-075	Santo Antonio do Sudoeste	0.19	0.01	0.08	0.66	0.94
	I-076	Pranchita	0.10	0.06	0.03	0.30	0.49
	I-077	Pinhal de Sao Bento	0.04	0.03	0.02	0.07	0.16
	I-078	Ampere	0.15	0.07	0.92	0.04	1.18
	I-079	Nova Esperanca do Sudoeste	0.18	0.08	0.20	0.03	0.49
	I-080	Salto do Lontra	0.18	0.06	0.79	0.55	1.58
	I-081	Santa Izabel do Oeste	0.16	0.07	0.24	0.04	0.51
	I-082	Nova Prata do Iguacu	0.32	0.22	0.04	0.09	0.67
	I-083	Perola do Oeste	0.13	0.09	0.01	0.09	0.32
	I-084	Planalto	0.34	0.08	0.00	0.05	0.47
	I-085	Realeza	0.25	0.08	0.03	0.03	0.39
	I-086	Capanema	0.30	0.04	0.16	0.25	0.75
	I-087	Tres Barras do Parana	0.34	0.08	0.08	0.05	0.55
	I-088	Catanduvas	0.19	0.04	0.07	0.12	0.42
	I-089	Ibema	0.09	0.01	0.07	0.11	0.28
	I-090	Cascavel	0.39	0.10	0.25	0.27	1.01
	I-091	Boa Vista da Aparecida	0.17	0.01	0.05	0.02	0.25
	I-092	Capitao Leonidas Marques	0.17	0.03	0.22	0.15	0.57
	I-093	Santa Lucia	0.21	0.01	0.04	0.00	0.26
	I-094	Lindoeste	0.34	0.03	0.03	0.08	0.48
	I-095	Santa Tereza do Oeste	0.10	0.03	0.01	0.07	0.21
	I-096	Ceu Azul	0.21	0.11	0.08	0.06	0.46
	I-097	Matelandia	0.27	0.11	0.07	0.25	0.70
	I-098	Medianeira	0.32	0.15	0.12	0.32	0.91
	I-099	Sao Miguel do Iguacu	0.23	0.07	0.03	0.15	0.48
	I-100	Santa Terezinha de Itaipu	0.10	0.01	0.01	0.02	0.14
	I-101	Foz do Iguacu	0.10	0.01	0.01	0.08	0.20
		Total	16.87	5.20	12.53	23.41	58.01

6.3.2 Current Water Consumption in Tibagi River Basin

The current water consumption of agriculture in Tibagi river basin was estimated and the result is shown in Table-6.6. In contrast to Iguaçu river basin, cattle raising consumes more water than fish ponds. Water consumption in Londrina, Tibagi, Castro and Ortigueira exceeds one thousand m^3/day due to the high population of cattle.

Table-6.6 Current Water Consumption of Agriculture in Tibagi River Basin

Unit: 1,000 m^3/day

Div.	No.	Municipality	1994 Cattle	Pig	Chicken	Fish	Total
	T-001	Porto Amazonas	0.01	0.00	0.01	0.00	0.02
	T-002	Palmeira	0.30	0.09	0.08	0.17	0.64
	T-003	Tebeira Soares	0.20	0.08	0.00	0.24	0.52
	T-004	Irati	0.02	0.01	0.00	0.04	0.07
	T-005	Imbituva	0.14	0.05	0.00	0.02	0.21
I	T-006	Ipiranga	0.18	0.03	0.00	0.34	0.55
	T-007	Ponta Grossa	0.43	0.04	0.24	0.10	0.81
	T-008	Castro	0.66	0.04	0.29	0.26	1.25
	T-009	Ivai	0.03	0.01	0.00	0.35	0.39
	T-010	Reserva	0.15	0.01	0.00	0.25	0.41
	T-011	Tibagi	1.11	0.11	0.00	0.34	1.56
	T-012	Pirai do Sul	0.31	0.05	0.20	0.05	0.61
	T-013	Ventania	0.10	0.00	0.00	0.02	0.12
	T-014	Telemaco Borba	0.08	0.01	0.00	0.50	0.59
	T-015	Ortigueira	0.69	0.08	0.00	0.48	1.25
	T-016	Curiuva	0.01	0.00	0.01	0.01	0.03
	T-017	Sapopema	0.28	0.01	0.00	0.00	0.29
	T-018	Sao Jeronimo da Serra	0.47	0.03	0.00	0.03	0.53
	T-019	Mata da Serra	0.02	0.00	0.01	0.00	0.03
	T-020	Marilandia do Sul	0.10	0.00	0.01	0.03	0.14
	T-021	California	0.09	0.00	0.00	0.00	0.09
	T-022	Apucarana	0.10	0.01	0.01	0.02	0.14
	T-023	Arapongas	0.07	0.09	0.05	0.07	0.28
	T-024	Londrina	1.62	0.10	0.47	0.18	2.37
	T-025	Nova Santa Barbara	0.01	0.00	0.00	0.01	0.02
	T-026	Santa Cecilia do Pavao	0.01	0.00	0.00	0.02	0.03
	T-027	Santo Antonio do Paraiso	0.08	0.00	0.00	0.02	0.10
	T-028	Congonhinhas	0.05	0.00	0.00	0.00	0.05
II	T-029	Nova Fatima	0.08	0.00	0.00	0.00	0.08
	T-030	Sao Sebastiao da Amoreira	0.10	0.00	0.00	0.01	0.11
	T-031	Assai	0.11	0.01	0.03	0.04	0.19
	T-032	Nova America da Colina	0.08	0.01	0.00	0.02	0.11
	T-033	Cornelio Procopio	0.24	0.00	0.00	0.02	0.26
	T-034	Urai	0.09	0.02	0.00	0.15	0.26
	T-035	Jataizinho	0.12	0.00	0.00	0.00	0.12
	T-036	Ibipora	0.11	0.03	0.01	0.16	0.31
	T-037	Rolandia	0.02	0.01	0.02	0.01	0.06
	T-038	Cambe	0.04	0.01	0.01	0.00	0.06
	T-039	Sertanopolis	0.18	0.03	0.27	0.19	0.67
	T-040	Rancho Alegre	0.00	0.00	0.00	0.03	0.03
	T-041	Leopolis	0.03	0.01	0.00	0.00	0.04
	T-042	Sertaneja	0.03	0.00	0.00	0.00	0.03
	T-043	Primeiro de Maio	0.04	0.01	0.02	0.00	0.07
		Total	8.59	0.99	1.74	4.18	15.50

CHAPTER 7 WATER DEMAND PROJECTION FOR PILOT RIVER BASINS

7.1 Future Agriculture in Iguaçu and Tibagi River Basins

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 at this study level. 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 as shown in the following equations.

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

Chicken (million head) = 1.83697 x Year - 3591.68

Pig population in the state was assumed to be stabilized at around 4 million heads by the year of 2000. According to EMATER, pig population of the whole state in 1994 is approximately 3.58 million heads. Thus, pig population in 2000 is 1.117 times more than the current one.

Applying the above rate, the future population of livestock in pilot river basins in comparison with ones in 1994 will be as follows.

	2005	2015
Cattle	1.199 times	1.380 times
Chicken	1.284 times	1.542 times
Pig	1.117 times	1.117 times

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-7.1 for Iguaçu river basin and Table-7.2 for Tibagi river basin with the livestock population and fish pond area as of 1994.

Table7.1 Projection of Future Livestock and Fish Pond Area in Iguaçu River Basin (1/2)

Div	Code	Municipality	Area (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)
	I-001	Campina Grande do Sul	79.2	0.2	0.2	0.3	0.1	0.1	0.1	0.0	0.0	0.0	8	10	13
	I-002	Quatro Barras	99.5	1.0	1.2	1.3	1.0	1.1	1.1	0.0	0.0	0.0	8	10	12
	I-003	Piraquara	171.9	2.7	3.2	3.7	1.1	1.2	1.2	0.0	0.0	0.0	1	1	1
	I-004	Sao Jose dos Pinhais	674.2	8.5	10.1	11.7	16.6	18.5	18.5	468.1	600.6	721.3	12	15	18
	I-005	Colombo	127.6	1.0	1.3	1.4	2.9	3.2	3.2	13.5	17.5	20.9	7	8	10
	I-006	Pinhais	98.2	1.5	1.8	2.1	0.6	0.7	0.7	0.0	0.0	0.0	0	0	1
	I-007	Almirante Tamandare	189.3	1.7	2.0	2.3	5.3	5.9	5.9	237.5	305.0	366.0	2	2	3
	I-008	Curitiba	431.7	1.1	1.3	1.5	0.6	0.7	0.7	100.0	128.0	154.0	0	0	0
	I-009	Campo Largo	297.2	2.4	2.9	3.3	7.1	7.9	7.9	14.1	18.1	21.6	10	12	15
	I-010	Araucaria	503.7	2.6	3.1	3.6	2.4	2.7	2.7	600.0	770.0	925.0	25	31	38
	I-011	Fazenda Rio Grande	110.9	1.8	2.2	2.5	2.3	2.6	2.6	467.0	599.0	720.0	10	12	15
	I-012	Mandirituba	392.3	2.3	2.7	3.1	8.0	8.9	8.9	3,112.0	3,995.0	4,797.0	22	27	33
	I-013	Tijucas do Sul	422.6	2.7	3.2	3.7	4.7	5.3	5.3	560.3	719.0	863.4	2	3	4
	I-014	Balsa Nova	319.7	1.4	1.6	1.9	0.9	1.1	1.1	0.0	0.0	0.0	15	19	23
I	I-015	Contenda	222.2	7.4	8.8	10.1	9.2	10.3	10.3	0.0	0.0	0.0	6	7	9
	I-016	Quitandinha	419.4	2.8	3.3	3.8	11.0	12.3	12.3	330.0	424.0	509.0	41	51	62
	I-017	Agudos do Sul	259.6	2.8	3.3	3.8	5.0	5.6	5.6	64.0	82.0	99.0	30	37	45
	I-018	Pien	261.7	3.0	3.5	4.1	5.0	5.6	5.6	525.0	674.0	809.0	16	20	24
	I-019	Rio Negro	603.2	8.8	10.6	12.2	8.2	9.2	9.2	990.0	1,271.0	1,526.0	3	4	5
	I-020	Campo do Tenente	314.0	7.4	8.8	10.1	1.4	1.5	1.5	96.0	123.0	148.0	7	9	11
	I-021	Lapa	2,203.9	32.4	38.9	44.7	20.0	22.3	22.3	700.0	899.0	1,079.0	14	17	21
	I-022	Porto Amazonas	153.0	2.4	2.8	3.3	2.6	2.9	2.9	173.9	223.4	267.8	1	1	2
	I-023	Palmeira	273.4	6.7	8.0	9.2	4.7	5.3	5.3	91.1	117.0	140.5	3	3	4
	I-024	Sao Jose do Triunfo	708.1	6.0	7.2	8.3	6.0	6.7	6.7	0.0	0.0	0.0	2	2	3
	I-025	Antonio Olinto	482.5	3.7	4.5	5.2	13.5	15.1	15.1	0.0	0.0	0.0	6	7	9
	I-026	Sao Mateus do Sul	1,332.8	15.3	18.4	21.1	18.0	20.1	20.1	250.0	321.0	385.0	10	12	15
	I-027	Rebouças	498.9	6.2	7.5	8.6	3.0	3.3	3.3	227.4	291.6	350.9	10	12	15
	I-028	Irati	408.1	4.6	5.5	6.4	8.2	9.2	9.2	0.0	0.0	0.0	12	15	18
	I-029	Rio Azul	642.6	7.5	9.0	10.4	6.4	7.1	7.1	50.0	64.0	77.0	42	52	64
	I-030	Mallet	672.8	6.4	7.6	8.8	20.0	22.3	22.3	864.0	1,109.0	1,332.0	20	25	30
		Sub-total	13,374.2	154.3	184.5	212.5	195.8	218.7	218.7	9933.9	12751.2	15312.4	345.0	424.0	523.0
	I-031	Prudo Frontin	377.5	4.5	5.4	6.2	12.1	13.6	13.6	870.0	1,117.0	1,341.0	27	34	41
	I-032	Paula Freitas	417.0	4.6	5.5	6.4	3.5	3.9	3.9	650.0	834.0	1,002.0	1	1	2
	I-033	Uniao da Vitoria	773.9	27.9	33.5	38.5	5.0	5.6	5.6	120.0	154.0	185.0	15	19	23
	I-034	Porto Vitoria	220.2	2.9	3.5	4.1	3.2	3.5	3.5	0.0	0.0	0.0	4	5	6
	I-035	General Carneiro	1,063.7	20.1	24.1	27.7	3.8	4.2	4.2	0.0	0.0	0.0	10	12	15
	I-036	Bituruna	1,209.7	19.5	23.4	26.9	25.0	27.9	27.9	50.0	64.0	77.0	350	435	530
	I-037	Cruz Machado	1,500.5	15.7	18.8	21.6	57.0	63.7	63.7	139.0	178.0	214.0	56	70	85
II	I-038	Inacio Martins	879.9	8.6	10.4	11.9	10.2	11.4	11.4	0.0	0.0	0.0	59	74	89
	I-039	Guarapuava	3,402.7	56.2	67.4	77.6	41.8	46.7	46.7	0.0	0.0	0.0	180	225	273
	I-040	Pinhao	2,875.2	67.3	80.6	92.8	28.3	31.6	31.6	0.0	0.0	0.0	0	0	0
	I-041	Palmas	3,125.5	64.8	77.7	89.4	6.5	7.3	7.3	0.0	0.0	0.0	190	236	288
	I-042	Clevelandia	708.4	30.5	36.5	42.0	7.6	8.5	8.5	288.0	370.0	444.0	125	155	189
	I-043	Honorio Serpa	806.6	8.5	10.1	11.7	4.7	5.3	5.3	0.0	0.0	0.0	1	1	2
	I-044	Mangueirinha	801.3	22.0	26.3	30.3	9.9	11.1	11.1	0.0	0.0	0.0	10	12	15
	I-045	Candoi	999.8	61.8	74.0	85.2	18.8	21.0	21.0	0.0	0.0	0.0	0	0	0
	I-046	Cantagalo	774.1	13.5	16.2	18.6	16.8	18.8	18.8	0.0	0.0	0.0	0	0	1
		Sub-total	19,996.0	428.4	513.4	590.9	254.2	284.1	284.1	2,117.0	2,717.0	3,263.0	1,028.0	1,279.0	1,559.0
	I-047	Virmond	198.4	4.2	5.0	5.8	11.8	13.2	13.2	0.0	0.0	0.0	0	0	0
III	I-048	Laranjeiras do Sul	1,052.7	20.7	24.8	28.5	14.6	16.3	16.3	0.0	0.0	0.0	20	26	31
	I-049	Chopinzinho	992.5	44.0	52.8	60.7	19.2	21.5	21.5	1,824.0	2,341.0	2,812.0	60	75	91
	I-050	Coronel Vivida	681.5	33.6	40.3	46.3	22.1	24.7	24.7	170.0	218.0	262.0	36	45	55
	I-051	Pato Branco	570.2	25.8	30.9	35.6	13.1	14.6	14.6	3,658.0	4,696.0	5,639.0	15	19	23
	I-052	Mariopolis	232.1	9.6	11.5	13.2	5.0	5.6	5.6	480.0	616.0	740.0	6	7	9
	I-053	Vitorino	326.1	11.1	13.3	15.3	17.0	19.0	19.0	1,360.0	1,746.0	2,096.0	17	21	26
	I-054	Renascenca	434.7	17.0	20.4	23.5	12.0	13.4	13.4	500.0	642.0	771.0	40	50	61
	I-055	Bom Sucesso do Sul	135.3	13.4	16.1	18.5	10.0	11.2	11.2	600.0	770.0	925.0	30	37	45

Table7.1 Projection of Future Livestock and Fish Pond Area in Iguaçu River Basin (2/2)

Div.	Code	Municipality	Area (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)
	I-056	Itapejara D'Oeste	246.0	12.1	14.5	16.7	23.4	26.1	26.1	2,700.0	3,466.0	4,162.0	10	12	15
	I-057	Vere	345.6	16.2	19.4	22.4	13.0	14.5	14.5	900.0	1,155.0	1,387.0	32	40	49
	I-058	Sao Joao	408.9	26.1	31.3	36.1	16.3	18.2	18.2	3,966.0	5,091.0	6,114.0	11	14	17
	I-059	Sulina	158.5	13.4	16.1	18.5	7.5	8.4	8.4	132.0	169.0	203.0	16	20	24
	I-060	Saudade do Iguacu	147.8	11.2	13.4	15.5	3.0	3.4	3.4	1,000.0	1,284.0	1,542.0	4	5	6
	I-061	Rio Bonito do Iguacu	459.3	5.9	7.0	8.1	7.4	8.2	8.2	0.0	0.0	0.0	0	0	0
	I-062	Nova Laranjeiras	578.8	17.1	20.5	23.6	6.8	7.6	7.6	40.6	52.3	62.7	0	0	0
	I-063	Guaraniacu	495.0	40.2	48.2	55.5	10.7	12.0	12.0	626.4	804.2	965.5	6	7	8
	I-064	Quedas do Iguacu	1,192.9	35.8	42.9	49.4	12.0	13.4	13.4	318.0	408.0	490.0	7	9	11
	I-065	Sao Jorge do Oeste	385.1	16.4	19.7	22.6	8.0	8.9	8.9	900.0	1,155.0	1,387.0	21	26	32
	I-066	Cruzeiro do Iguacu	96.6	7.4	8.9	10.2	5.0	5.6	5.6	3,498.0	4,490.0	5,392.0	1	1	2
III	I-067	Boa Esperanca do Iguacu	249.4	11.1	13.3	15.3	10.7	12.0	12.0	312.0	401.0	481.0	10	12	15
	I-068	Dois Vizinhos	372.7	22.4	26.8	30.9	46.0	51.4	51.4	5,000.0	6,419.0	7,708.0	7	9	11
	I-069	Enesa Marques	234.7	15.3	18.3	21.0	26.2	29.3	29.3	372.0	478.0	573.0	4	5	6
	I-070	Francisco Beltrao	696.7	34.1	40.8	47.0	37.5	41.9	41.9	2,270.0	2,914.0	3,499.0	104	129	158
	I-071	Marmeleiro	449.9	15.3	18.3	21.1	30.0	33.5	33.5	650.0	834.0	1,002.0	15	19	23
	I-072	Flor da Serra do Sul	94.7	10.4	12.5	14.4	14.3	15.9	15.9	205.0	263.0	316.0	92	114	139
	I-073	Barracao	386.3	20.9	25.0	28.8	6.7	7.4	7.4	150.0	193.0	231.0	5	6	8
	I-074	Salgado Filho	506.4	35.0	42.0	48.3	20.0	22.3	22.3	800.0	1,027.0	1,233.0	4	5	6
	I-075	Santo Antonio do Sudoeste	313.8	19.1	22.9	26.3	1.4	1.6	1.6	380.0	488.0	586.0	66	82	100
	I-076	Pranchita	297.1	10.3	12.3	14.2	15.3	17.1	17.1	150.0	193.0	231.0	30	37	45
	I-077	Pinhal de Sao Bento	107.6	3.5	4.2	4.8	8.0	8.9	8.9	120.0	154.0	185.0	7	9	11
	I-078	Ampere	307.9	14.7	17.6	20.3	17.0	19.0	19.0	4,600.0	5,905.0	7,091.0	4	5	6
	I-079	Nova Esperanca do Sudoeste	176.9	17.8	21.3	24.5	18.8	21.0	21.0	1,000.0	1,284.0	1,542.0	3	4	5
	I-080	Salto do Lontra	336.9	17.9	21.5	24.7	16.0	17.9	17.9	3,950.0	5,070.0	6,089.0	55	68	83
	I-081	Santa Izabel do Oeste	330.5	15.8	19.0	21.8	17.0	19.0	19.0	1,200.0	1,540.0	1,850.0	4	5	6
	I-082	Nova Prata do Iguacu	333.0	31.5	37.8	43.5	54.0	60.3	60.3	198.0	254.0	305.0	9	11	14
	I-083	Perola do Oeste	330.1	13.2	15.8	18.2	22.0	24.6	24.6	60.0	77.0	92.0	9	11	14
	I-084	Planalto	337.1	34.0	40.7	46.9	20.3	22.7	22.7	0.0	0.0	0.0	5	6	8
	I-085	Realeza	351.9	25.2	30.2	34.7	19.5	21.8	21.8	160.0	205.0	247.0	3	4	5
	I-086	Capanema	403.9	30.4	36.5	42.0	10.0	11.2	11.2	800.0	1,027.0	1,233.0	25	31	38
	I-087	Tres Barras do Parana	521.7	33.6	40.2	46.3	21.2	23.7	23.7	420.0	539.0	647.0	5	6	8
	I-088	Catanduvas	593.9	18.6	22.2	25.6	10.1	11.2	11.2	346.0	444.0	533.0	12	15	18
	I-089	Iberia	148.3	8.5	10.2	11.7	2.1	2.3	2.3	352.0	451.8	542.7	11	14	17
	I-090	Cascavel	1,198.9	39.3	47.1	54.2	25.0	27.9	27.9	1,264.8	1,623.8	1,950.0	27	33	41
	I-091	Boa Vista da Aparecida	232.2	16.7	20.0	23.1	1.8	2.0	2.0	240.0	308.0	370.0	2	2	3
	I-092	Capitao Leonidas Marques	279.8	16.6	19.9	22.9	8.5	9.5	9.5	1,100.0	1,412.0	1,696.0	15	19	23
	I-093	Santa Lucia	137.1	20.6	24.7	28.5	3.7	4.1	4.1	192.0	246.0	296.0	0	0	0
	I-094	Lindoeste	273.2	33.5	40.2	46.2	8.0	8.9	8.9	125.0	160.0	193.0	8	10	12
	I-095	Santa Tereza do Oeste	235.5	9.5	11.3	13.1	6.4	7.1	7.1	70.1	90.1	107.9	7	9	11
	I-096	Ceu Azul	937.2	20.9	25.1	28.9	27.7	30.9	30.9	403.4	518.0	621.6	6	8	9
	I-097	Matelandia	601.4	26.9	32.3	37.1	27.1	30.2	30.2	346.3	444.6	534.1	25	30	37
	I-098	Medianeira	621.1	31.6	37.9	43.6	37.8	42.3	42.3	598.4	767.9	922.5	32	40	48
	I-099	Sao Miguel do Iguacu	455.7	23.4	28.1	32.3	16.6	18.5	18.5	159.0	204.3	245.0	15	18	22
	I-100	Santa Terezinha de Itaipu	162.1	9.5	11.3	13.0	3.1	3.4	3.4	47.0	60.4	72.2	2	3	3
	I-101	Foz do Iguacu	312.2	9.5	11.4	13.1	2.8	3.1	3.1	32.8	42.0	50.5	8	10	12
		Sub-total	22,465.8	1097.8	1315.7	1514.3	850.5	949.7	949.7	50746.8	65141.4	78225.7	968.0	1203.0	1470.0
		Total	55,776.0	1,681.0	2,014.0	2,318.0	1,301.0	1,453.0	1,453.0	62,798.0	80,610.0	96,801.0	2,341.0	2,906.0	3,552.0

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

Table-7.2 Projection of Future Livestock and Fish Pond Area in Tibagi River Basin

Div	No.	Municipality	Area Involved (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	15,282.1	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	Primaro de Maio	142.8	3.5	4.2	4.9	1.3	1.5	1.5	172.9	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	5893.1	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