THE STUDY RELATED TO THE REGIONAL DEVELOPMENT PLAN OF THE GREATER CARAJAS PROGRAM OF THE FEDERATIVE REPUBLIC OF BRAZIL

[PHASE II]

SUMMARY REPORT

JULY 1985

JAPAN INTERNATIONAL COOPERATION AGENCY
AND
EXECUTIVE SECRETARIAT OF THE INTERMINISTERIAL COUNCIL
OF THE GREATER CARAJAS PROGRAM

THE STUDY RELATED TO THE REGIONAL DEVELOPMENT PLAN OF THE GREATER CARAJAS PROGRAM OF THE FEDERATIVE REPUBLIC OF BRAZIL

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PREFACE

In response to the request of the Government of the Federative Republic of Brazil, the Japanese Government decided to conduct a study on the Development Plan of the Greater Carajas Program and entrusted the study to the Japan International Cooperation Agency (JICA).

A Phase I Study Team consisting of thirty experts and headed by Dr. Saburo Okita was assigned by JICA to conduct a study on the supply and demand trends in the world market up to the year 2000 of twenty-eight agriculture, livestock and forestry products, and thirteen mining and manufacturing products which were considered having high productive potential in the Greater Carajas Program Area. In November 1983, this study team submitted the First Progress Report (Phase I) in four volumes.

Thereafter the JICA sent a Phase II study team of twenty-seven experts headed by Mr. Saburo Kawai to Brazil in July - September 1984. The team conducted further field surveys to ascertain development potentials of agriculture, livestock, forestry, mining and metallurgy in the priority sub-regions of the Greater Carajas Program Area and held discussions with the Brazilian officials concerned. After its return to Japan, the team conducted further studies and has prepared the present final report.

I hope that this report will serve for the development of the Greater Carajas Program and contribute to friendly relations between our two countries.

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

July 20, 1985

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

July 20, 1985

His Excellency Mr. Keisuke Arita
President
Japan International Cooperation Agency
Shinjuku Mitsui Bldg., 2-1 Nishi-shinjuku
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Japan

Dear Mr. President:

I am pleased to submit to you the final report entitled "The Study Related to the Regional Development Plan of the Greater Carajas Program of the Federative Republic of Brazil (Phase II)", in accordance with the contract signed on June 20, 1984 by the Japan International Cooperation Agency and the International Development Center of Japan. It is my great pleasure that the study led to this report has been undertaken under close cooperation of the Governments of Japan and the Federative Republic of Brazil.

Following the First Progress Report (four volumes), this Final Report presents the results of the Phase II Study related to the regional development plan of the Greater Carajas Program Area. The present report consists of five parts: Introduction (Part One); Study of Regional Development Potentials (Part Two); Study of Agriculture, Livestock and Forestry Development (Part Three); Study of Mining Resources Development (Part Four); and Study of Metallurgical Industry Development (Part Five).

I would inform you that the present study could not achieve rich and suggestive results without continual and effective cooperation of the Executive Secretariat of the Interministerial Council of the Greater Carajas Program and other concerned institutions of the Federative Republic of Brazil. I also wish to express my sincere acknowledgements for the tremendous efforts and heartning cooperation given to us from the Japan International Cooperation Agency and other concerned institutions of the Government of Japan.

I hope that the results of this study will give an impetus to the future development of the Greater Carajas Program Area and, thus, contribute to the achievement of the objectives of Japan's international cooperation.

Yours faithfully,

Saburo Kawai
President
International Development Center of Japan

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LIST OF VISITS FOR INFORMATION COLLECTION OF THE PHASE II STUDY

I. Study of Regional Development Potentials

July	4, 1984	SE/PGC (Brasilia; if there is no specification, office of Brasilia is adopted hereinafter)
	5	CONSIDER
	6	TELEBRAS
	9	SE/PGC (Belem), ALBRAS/ALUNORTE
	10	SE/PGC (Belem), SUDAM
	11	Serra dos Carajas, Salobo 3-A (copper)
	12	Logos Promon, Azul (manganese), Carajas town site
	13	GETAT (Maraba), Industrial District (Planned)
	14	Tucurui Dam
	16	SE/PGC (Sao Luis), CODOMAR, Port of Itaqui
	17	ALUMAR, CDI-MA, CONCRETEX, Secretary of Industry, Commerce and Tourism (Maranhao)
	18	SE/PGC (Sao Luis), CVRD (Sao Paulo) Railway Terminal (under construction), Port of Ponta da Madeira
	20	SE/PGC, CVRD (Rio de Janeiro), Kawatetsu-Brasil
	23	SUDENE (Recife)
	24	SUDENE (Recife)
	25	SE/PGC, MINTER, CVRD (Rio de Janeiro)
	26	SE/PGC, PRODIAT
	27	SE/PGC, GETAT, CONSIDER, ELETRONORTE
	30	SE/PGC, Secretary of Planning (Para), PORTOBRAS, CODEBAR
	31	SE/PGC, CDI-PA
Aug.	1	SE/PGC, PRODIAT, CDP, ENASA, SUDAM
	2	SE/PGC, Secretary of Industry, Commerce and Tourism (Maranhao)
	3	SE/PGC, BDM, CEAG-MA
	6	INCRA, MINTER, SEPLAN-MA
	7	SE/PGC, IPEA
	8	SE/PGC, IPEA, ELETRONORTE
	9	SE/PGC, MINTER
	10	ISHIBRAS, MMAJ (Rio de Janeiro)
	13	SE/PGC
	14	SE/PGC (Progress Report for Mining and Metallurgy Presentation)
	15	SE/PGC
	16	SE/PGC
	18	Paracatu
	20	SE/PGC
	21	SE/PGC, PRODIAT
	22	SE/PGC
	23	SE/PGC
	24	SE/PGC
	25	DALBAN, OLEAMA
	27	SE/PGC (Sao Luis), POLONORDESTE, COLONE
	28	Santa Ines, Secretary of Fazenda (Maranhao)

Aug.	29, 1984	Colonization of Alto-Turi, CVRD (Sao Luis), SEPLAN-MA
	30	SEPLAN-MA, SE/PGC (Sao Luis)
	31	SE/PGC (Belem)
Sept.	2	Braganca
	3	SE/PGC, Secretary of Fazenda (Para)
	4	SUDAM, IDESP
	5	CODEBAR
	6	SE/PGC, CODEBAR
	7	Barcarena
	10	GETAT (Imperatriz)
	11	GETAT (Farm of Pimenta do Reino)
	12	GETAT (Araguaina), EMATER
	14	GETAT (Maraba)
	15	Fazenda Primavera (Livestock)
	16	Small and medium size farms at Itupiranga
	17	Carajas II and III (GETAT)
	19	SE/PGC
	20	SE/PGC
	21	SE/PGC

II. Study of Agriculture, Livestock and Forestry Development

Aug.	14, 1984	MA (Presentation of PGC)	Brasilia
	15	INCRA (Activities, policy)	"
	16	MA (Soil mapping, marketing system)	"
	17	MA (Soil conservation service)	"
		EMBRAPA (Crops)	
		IBDF (Forestry development, forest exploitation)	
	19	CENIBRA (Site visit, Discussion)	Belo Horizonte
	20	EMBRAPA (Soil mapping, crop selection)	Rio de Janeiro
		BACEN (Financing policy)	
	21	IBGE (Statistics)	"
		CIBRAZEM (Storage system)	Brasilia
		BNCC (Credit)	"
		PRODIAT (Contents and background data)	"
	22	CFP (Price policy)	"
		Instituto Florestal (Forestry development)	Sao Paulo
	23	PROFIR/PROVARZEA (Irrigation)	Brasilia
		COBAL (Food supply and marketing)	"
	25	OLEAMA (Babassu processing)	Sao Luis
		DALBAN (Wood processing)	"
	27	SE/PGC (Agriculture of Maranhao)	Sao Luis
		SEPLAN (Projeto NORDESTE)	"
	28	EMATER (Discussion with small farmers)	Bacabal
	29	EMATER (Discussion with small farmers)	Alto Alegre
		DVRD (Site visit of forestry experimentation center)	"
Sept.	2	Braganca (Field observation)	Braganca
		Coop. Tome-Acu (Cropping, Farm organization)	Tome-Acu
	3	Coop. Paraense (")	Castanhal
		Coop. Amazonica (")	Santa Isabel
	4	DENPASA (Oil palm plantation and processing)	Belem
		EIDAI do Brazil (Wood processing)	"
		SUDAM (Incentive policy)	"
		Coop. da Ind. Pecuaria (Slaughter house)	"
	5	CPATU (Discussion, site visit)	Belem
	8	Fazenda Santa Maria (Beef production)	Imperatriz
	10	GETAT (Land settlement)	"
		EMATER (Soil, crop, pasture, farm organization)	"
	11	EMBRAPA (Soil, crop, beef production)	"
		Pimenta do reino Fazenda (Site visit)	Acailandia
	12	GETAT (Land settlement)	Araguaina
		EMATER (Extension service, cropping)	"
		EMGOPA (Research projects)	"
	13	Fazenda Paraiso (Beef production)	"
	14	GETAT (Land settlement)	Maraba
		EMATER (Cropping)	"
	15	Fazenda Primavera (Beef production)	"
	17	Projeto Carajas III (Site visit, disucssion)	"

Sept. 19	MA (Cattle disease)	Brasilia
20	CPAC/EMBRAPA (Pasture)	"
	CAMPO (Financial situation)	"
21	MA (Cattle quality improvement)	"
22	IBDF (Material collection)	"
24	CFP (Price supporting policy)	"
25	SE/PGC, MA (Progress Report correction)	"
26	SE/PGC (Progress Report presentation)	"
27	Meat processing plant visit	Sao paulo
28	ABIOV (Oil plant & feed factory visit)	"
	JETRO (Information collection)	"

III. Study of Mineral Resources Development

July	3, 1984	R. de Janeiro	DOCEGEO	
	9	Belem	CPRM, DOCEGEO	
	11	Carajas	DOCEGEO	- Salobo 3A site visit
	12	"	CVRD	- CVRD museum visit - N4-E Iron mine visit - Azul manganese site visit
	13	Maraba		- Proposed industrial site visit
	14	Tucurui	ELETRONORTE	- Power plant dam site visit
	19	S. Paulo	USP	
	20	"	INPE	
	25	Belem	IDSP, SUDAM	
	28	Cumaru		
	29	"		
	30	Carajas	DOCEGEO	- Salobo 3A, Pojuca visit
	31	"	CVRD	- CVRD museum visit - N4-E Iron mine visit - Azul manganese site
Aug.	1	Belem	CPRM	
	6	"	SUDAM	
		S. Paulo	USP	

* Visits of DNPM are excluded in this list.

IV. Study of Metallurgical Industry Development

July	5, 1984	Brasilia	CONSIDER	
	6	"	TELEBRAS	
	9	Barcarena	ALBRAS/ALUNORTE	- Site visit
		Belem	ALBRAS office	
	11	Carajas	DOCEGEO	- Salobo 3A site visit
	12	"	CVRD	- CVRD museum visit
				- N4 ferro site visit
				- Azul manganese site visit
	13	Maraba		- Proposed industrial site visit
	14	Tucurui	ELETRONORTE	- Power plant dam site visit
	16	Sao Luis	CODOMAR	- Itaqui port site visit
	17	Sao Luis	ALUMAR	- Site visit
			CONCRETEX	
			CDI	
			SIC	
	18	"	CVRD	- Railway terminal site visit
				- Ponta da Madeira Port site visit
	20	R. Janeiro	CVRD Head Office	
			KAWATETSU Office	
			MITSUBISHI CORP.	
	23	"	MITSUBISHI CORP.	
	24	"	IHI-BRAZIL	
			DOCEGEO	
	25	"	CVRD	
			SUNOR	
	27	Brasilia	CONSIDER	
			ELETRONORTE	
	30	Belem	Secretaria de Estado (PARA)	
			PORTOBRAS	
			CODEBAR	
			ALBRAS Office	
	31	"	CDI	
Aug.	1	"	CDP	- Belem port site visit
			ENASA	
			SUDAM	
	2	Sao Luis	SIC	
	3	"	BDM	
			CEAG-MA	
	6	"	SEPLAN-MA	
	8	Brasilia	ELETRONORTE	

SUMMARY REPORT

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[I] STUDY OF REGIONAL DEVELOPMENT POTENTIALS

1. INTRODUCTION

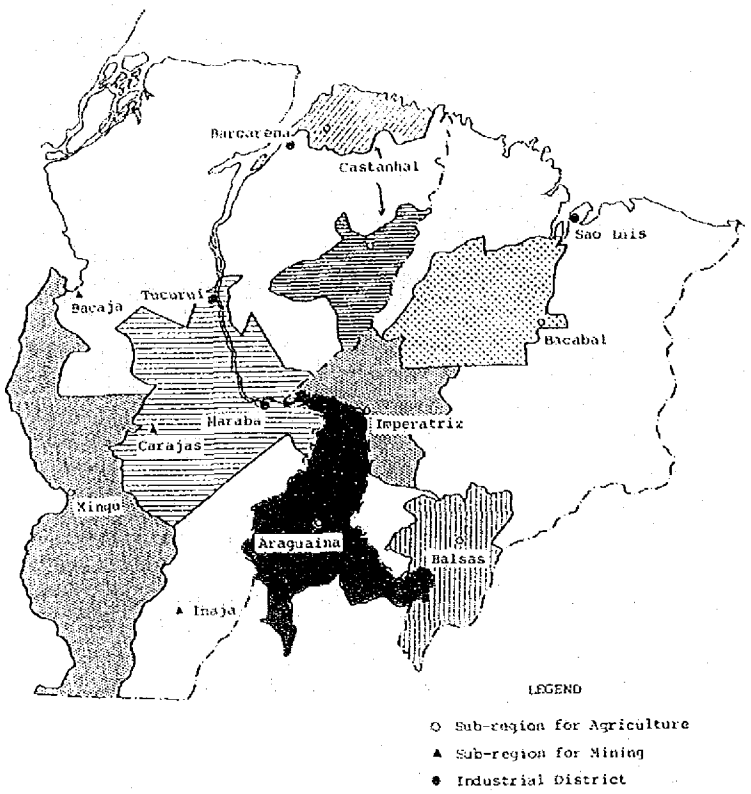
The major objective of the Phase II Study is to conduct studies in four subjects: 1) Regional Development Potential, 2) Agriculture, Livestock and Forestry Sectors, 3) Mineral Resources Development and 4) Metallurgical Industry Development, in the sub-regions and industrial districts of the Greater Carajas Program Area (the PGC Area). Although each of these study subjects has different characteristics in terms of objectives, methods and contents, the common purpose of these studies is nevertheless to contribute to the future development of the PGC Area by the Brazilian Government.

The study on agriculture, livestock and forestry has as its main purpose the preliminary assessment of crops adaptable to the regional conditions, through the analysis of the natural and socio-economic conditions of the selected sub-regions and at the same time to comment the requirements in future development of the agriculture, forestry and livestock sectors. The major objective of the study on mineral resources development is to prepare preliminary proposals regarding the future mineral resources exploration projects in the western part of the PGC Area consisting of the Inaja and Bacaja Areas centering on the Carajas Mountains, based on the data obtained on the mineral resources exploration work carried out in Brazil by government agencies and private organizations in the past. The study on metallurgical industry development places a major emphasis on the comparative study of locational advantages of the four industrial districts of Sao Luis, Barcarena, Maraba and Tucurui in establishing the smelting and refining plants of copper, tin, ferro-manganese, nickel and ferro-nickel.

In the Phase II Study, therefore, no attempt has been made to utilize an approach for integrated regional development planning, in which a certain framework for development of the above-mentioned four study subjects is drawn up with clearcut development goals for each, and studies are made for the development of each subject for the final integration of these programs. For instance, with regard to copper, tin, manganese, nickel and other minerals which are included in the study on metallurgical industry development, no mine development projects have actually been commenced in the PGC Area. The development of these mineral resources still requires more detailed exploration work as pointed out in the Mineral Resources Report of the Phase II Study. In addition, there are many unknown factors such as the approximate size of smelters, as well as the smelting methods and infrastructure required in the industrial districts. Consequently, many pre-conditions had to be set for a comparative study on the locational advantages of the four industrial districts in establishing copper, tin, and other smelters which were indicated in the Terms of Reference (TOR) for the Phase II Study.

Figure I-1 indicates several selected sub-regions and industrial districts under the Phase II Study. Prior to a summary of the Phase II Study, next chapter will examine the various regional development programs presently being undertaken in the PGC Area while also presenting the results of the study on the infrastructures existing in the Area.

Figure I-1 Selected Sub-regions and Industrial Districts for the Phase II Study



2. STUDY OF REGIONAL DEVELOPMENT POTENTIALS

2-1 Current Status of Regional Development Programs

2-1-1 Background and Present Status of the Greater Carajas Program

The Greater Carajas Program (PGC) was launched by the Brazilian Government under the Decree-law No. 1813 and Decree No. 85387, both of November 24, 1980. The area incorporating the PGC (hereinafter called "the PGC Area"), comprising the three states of Para, Maranhao and Goias, is located north of latitude 8° south, sandwiched by the Amazon, Xingu and Parnaiba rivers, with an area of approximately 900,000 km^2 (530,000 km^2 in Para, 310,000 km^2 in Maranhao and 60,000 km^2 in Goias), accounting for 10.6% of the national land area.

The origins of the PGC can be traced back to the discovery in 1967 of iron ore deposits, with estimated reserves amounting to 18 billion tons, in the Carajas Mountains (Serra dos Carajas) located in the PGC Area. Subsequent surveys of the natural resources in the Carajas Mountains revealed the existence of huge mineral reserves of manganese, copper, nickel, gold, etc., in addition to iron ore. Furthermore, favored by natural conditions the area possesses great potential for the development of tropical agricultural products such as oil palm and babassu, as well as rich forest resources and a promising livestock sector.

With the area having abundant natural resources and favorable natural conditions, the PGC has the following principal purposes: 1) the expansion of farming land by effective land utilization; 2) the promotion of immigration into the PGC Area through creation of industrial bases; 3) the decentralization of industries through establishment of new industrial nuclei; and 4) the promotion of private enterprises into the PGC Area by the provision of various incentives with the aim of reducing existing regional disparity.

In terms of mineral resources development, the Carajas Iron Mine, a crucial project of the PGC, has started operations in 1984; and the mining of manganese ore in Igarape Azul, located in the Carajas Mountains, is also expected to start its full operation in the near future. The economic infrastructure has been upgraded with the opening of the Carajas-Ponta da Madeira Railroad (EFPMC) with a total length of 890 km. It will play an important role in the transportation of not only iron ore but also agricultural and forest products and livestock produced in the areas adjacent to the railroad. Furthermore, construction and improvement of port facilities are in progress at a fast rate at the ports of Ponta da Madeira in Sao Luis and Vila do Conde in Barcarena, which are to become the physical distribution bases in the PGC Area.

As regards the industrial projects, the ALUMAR Aluminum Project in Sao Luis started trial operations in 1984, with the ALBRAS/ALUNORTE Aluminum Project expected to commence operations in 1985. To meet the increasing power demand from these projects and other industries in the area, the first phase construction of the Tucurui Power Plant was completed in November 1984 with four million kilowatts of electricity generating capacity.

To promote industrial development in the PGC Area, six industrial districts have been designated under the PGC in Tucurui, Maraba, Carajas, Barcarena, Imperatriz and Sao Luis. The Barcarena Development Company (CODEBAR) has been set up for the purpose of developing the Barcarena industrial district and for promoting the effective development and utilization of land for housing, commerce and farming.

One of the main thrusts of the PGC is the construction of the necessary infrastructure with government funds to encourage the entry of private enterprises into the PGC Area under the principle of market economy. The government created a special system of granting incentives under the Decree-law No. 1813 of November 24, 1980, as a means of such

encouragement. It involves the provision of tax benefits such as exemption both of corporate income tax, and of import duties on equipment, machines, vehicles, apparatuses, instruments, parts, spares, accessories, tools and utensils for private enterprises establishing projects and constructors engaged in construction work in the PGC Area.

Up to August 1984 twenty-six projects, ranging from large-scale projects such as the Carajas Iron Mine (Ferro-Carajas Project), ALBRAS/ALUNORTE and ALUMAR, to the Tucuma Colonization Project, livestock projects, palm-oil refining and charcoal production had received such benefits. Further, twenty-one construction companies have received tax exemptions in connection with the construction work of the aforementioned projects and various infrastructure elements.

The policies incorporated in the PGC, encompassing economic development, construction and improvement of the socio-economic infrastructure, are interwoven with those of various government agencies such as the Superintendency for the Development of Amazonia (SUDAM), Superintendency for the Development of Nordeste (SUDENE), National Institute of Colonization and Agrarian Reform (INCRA), Araguaia-Tocantins Lands Executive Group (GETAT) and Araguaia-Tocantins River Basin Development Project (PRODIAT).

2-1-2 SUDAM and the Greater Carajas Program

SUDAM, a government agency administered by the Ministry of Interior, was established in October 1966 to be responsible for the development of a defined area of the Amazonia, the so-called Legal Amazonia. In connection with the PGC Area, the state of Para and the area west of longitude 44° west in the state of Maranhao are also part of the SUDAM program. SUDAM has so far formulated the following development plans: 1) Initial Amazon Development Plan (1967-1971), 2) the First Amazon Development Plan (1972-1974), 3) the Second Amazon Development Plan (1975-1979), and 4) the Third Amazon Development Plan (1980-1985). Of these plans, POLAMAZONIA (Program for Agro-livestock and Agro-mineral Poles of Amazonia), a federal special program in operation since 1974 for the development of designated poles for agro-livestock, minerals and forestry resources, is closely related to the Greater Carajas Program. Under POLAMAZONIA, fifteen areas were selected as priority development areas to incorporate a comprehensive development of Amazonia, and a number of studies have already been conducted in addition to the construction of socio-economic infrastructure in the development poles. Of the fifteen development poles, "Polo Carajas", "Polo Altamira", "Polo Pre-Amazonia Maranhense" and "Polo Araguaia-Tocantins" are closely related to the PGC Area. In addition, another SUDAM federal special program related to the development of the PGC Area is PRONORPAR (Program for Socio-economic Redevelopment of Northeast Para) which has been carried out since 1976 for the purpose of socio-economic redevelopment of the 91,350 km^2 of northeastern area of Para.

These federal special programs are financed by PIN (National Integration Program), PROTERRA (North and Northeast Region Land Distribution

and Agroindustry Promotion Program) and FND (National Development Fund). Funds have been allocated to almost all the program areas: in the agricultural industry (for agro-livestock surveys, infrastructure for storage, distribution and supply of commodities, titling and distribution of agricultural lands and colonization projects); for the economic infrastructure (construction and improvement of roads, airports, ports and mine facilities), for urban development (construction of water supply and sewerage systems and power plants in Maraba, Tucurui and other principal cities); and for the social infrastructure (education, public health and labor). Expenditure by SUDAM in the PGC Area under these federal special programs amounts to Cr$6 billion for Polo Carajas, Cr$3.5 billion for Polo Altamira and Cr$7.1 billion for Polo Pre-Amazonia Maranhense during the period 1975-1984 under POLAMAZONIA (aggregate amounts of the expenditure for each year at current price), and Cr$7.5 billion (in 1983 constant price) from 1979 to 1983 under PRONORPAR. However, reflecting the severe economic conditions in Brazil, the financial resources of SUDAM itself and for POLAMAZONIA and PRONORPAR have been decreasing substantially since 1980.

Let us look at the spatial overlappings between the sub-regions of PGC Area and the areas under POLAMAZONIA. In terms of agriculture, Polo Carajas and Polo Altamira coincide with the PGC's sub-regions of Maraba and Xingu and Polo Pre-Amazonia Maranhense coincides with the Bacabal sub-region in the PGC Area. The PRONORPAR area coincides with the Castanhal sub-region in the PGC Area. POLAMAZONIA will play an important role not only in the surveys of mineral resources now under way in Polo Carajas and Polo Altamira, but also in the development of the industrial districts of Maraba, Tucurui and Barcarena and in the improvement of related infrastructure required for the development of the metallurgical industry as well as for urban development.

2-1-3 SUDENE and the Greater Carajas Program

SUDENE, an agency administered by the Ministry of Interior, was established in 1960 for the purpose of developing the northeastern region (Nordeste) of the nation. The PGC Area in the state of Maranhao is part of SUDENE program area. Cited as major programs of SUDENE are; Program for Integrated Area Development of Nordeste (POLONORDESTE), Special Support Program for the Development of the Semi-arid Region of Nordeste (Project SERTANEJO), Program for Hydro-resource Utilization of Nordeste (PROHIDRO), Irrigation Program of Nordeste, Special Support Program for Sugarcane Cultivated Area of Nordeste (PROCANOR) and Program for Agroindustry Development of Nordeste.

These special programs, financed jointly by the federal government and domestic and foreign financial institutions, are aimed at raising agricultural productivity and creating favorable conditions for the marketing of farm produce through production assistance and construction of the socio-economic infrastructure, thereby improving the living standards and insuring the long-term settlement of people in the northeastern region.

Of these special programs, the one bearing the greatest importance for the present Study is POLONORDESTE which was commenced in 1974 to achieve integrated rural development through technical and financial assistance to medium- and small-scale farmers in selected areas where it is possible to increase agricultural production by utilization of natural conditions and the existing infrastructure. There are three POLONORDESTE projects being undertaken in the state of Maranhao: The integrated rural development projects of Baixada Ocidental Maranhense and Medio Vale Mearim, and Colonization Alto Turi. The program area of these three projects is the central and northern parts of the state of Maranhao covering an area of 50,667 km^2 with a population of 1.2 million (as of 1980). The projects cover wide-ranging fields including titling and distribution of agricultural lands to small-scale farmers, economic infrastructure such as rural roads, rural electrification and utilization of substitute energy sources, social infrastructure such as education, public health and sanitation, as well as agricultural financing, technical guidance, agricultural research, provision of materials and supplies, agricultural mechanization, farmers' cooperatives, and assistance in sales and storage of products.

SUDENE outlayed Cr$77.5 billion (1982 constant price) in POLONORDESTE between 1979 and 1982, of which Cr$6.3 billion, or 8.1%, was allocated to the above-mentioned three projects in the state of Maranhao. However, with the substantial decrease in available funds since 1980, and in view of the fact that the above-mentioned program measures have been taken sporadically over such a vast area, a review of such programs will be necessary to limit the project areas and concentrate funds in specific limited sectors.

These projects are scheduled for completion in 1985, and SUDENE is now making preparations for the launching of a new PORJECT NORDESTE in 1985, by making an across-the-board reorganization of POLONORDESTE in coordination with the Maranhao state government. PROJECT NORDESTE is expected to be financed by the World Bank and the program area in the state of Maranhao will be expanded further, with the addition of four projects in the areas of Pindare, Cocais, Grajau and Balsas.

Of these projects, Medio Vale Mearim, Pindare and Balsas overlap regionally with the sub-regions of Bacabal and Balsas included in "the Greater Carajas Agriculture Program,"[1] and therefore careful discussion and coordination with the government agencies concerned will be required in the execution of agricultural development of these areas.

2-1-4 GETAT, INCRA and the Greater Carajas Program

GETAT began operations in April 1980 as an agency controlling titling and the distribution of lands and colonization projects in the basin area (452,000 km^2) of the Araguaia and Tocantins rivers. Dividing the area into the seven program areas - Tucurui, Conceicao do Araguaia,

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1) Preliminary Version by the Ministry of Agriculture

Sao Geraldo, Araguaina, Acailandia, Imperatriz and Sunorte - GETAT has implemented measures to promote the migration and settlement of medium- and small-scale farmers in the area; so far 43,000 lots of agricultural land have been titled with each lot usually not more than 100 ha. GETAT expects to have distributed 1.16 million ha of land by titling 14,000 lots by the end of 1984. To help small-scale farmers settle in the area, the agency is also engaged in the construction of such socio-economic infrastructure elements as rural roads, schools, public health and sanitation facilities.

The major colonization projects of GETAT are Carajas II and Carajas III, undertaken since 1982 in the area south of the Carajas Mountains. In these projects, 520 families, mostly possessing 50-ha farms, settled during 1983 and an additional 1,343 families are expected to settle during 1984.

INCRA, like GETAT, is also responsible for titling and distribution of agricultural land and colonization projects, but its program area extends throughout the nation, as opposed to the limited areas of GETAT. In its relation with the PGC Area, INCRA has carried out colonization projects in the area along the Trans-Amazon Highway which was constructed in the 1960s and also has program areas centering around Altamira and Paragominas in the state of Para and Bacabal in the state of Maranhao.

Since the Greater Carajas Program also gives priority to colonization projects for small-scale farmers, the roles of INCRA and GETAT will become even more important in the future.

2-1-5 PRODIAT and the Greater Carajas Program

PRODIAT, a program for formulation of the integrated development plan of the 935,000-km^2 basin area of the Araguaia-Tocantins rivers extending across the states of Goias, Mato Grosso, Para and Maranhao, aims at the establishing of regional development poles to counterbalance the economic influence of the south and southeast regions. The formulation of the program was commenced in 1981 as a joint project of the Organization of American States and the Ministry of Interior of the Brazilian Government and its final report is expected to be released in April 1985.

The program area of PRODIAT is divided into twenty-three sub-regions based on the basic statistical unit of "micro-region." The program is composed of: a global plan to incorporate an overall development strategy for the whole program area; a regional approach to formulate individual development programs for the seven priority areas (Immediate Program Area: IPA) selected under the global plan; and sector plans to institute programs for the sectors to be developed.

Of the selected Immediate Program Areas, those located in the PGC Area are: IPA No. 1 Baixo Tocantins and IPA No. 3 Maraba in the state of Para; IPA No. 5 Imperatriz and IPA No. 7 Tocantinopolis in the state of Maranhao; and IPA No. 8 Araguaina in the state of Goias.

The individual programs for these IPAs, although they are still in the process of preparation, have as their major aim the promotion of agricultural development by adopting the most suitable patterns of farming operations in consideration of the regional natural conditions. Since PRODIAT is an integrated development program in which a part of the PGC Area is also included, the individual projects proposed in PRODIAT will influence the direction of development in the PGC Area, and in this respect they will have an important bearing on the future development of the PGC Area.

2-2 Current Economic and Social Conditions of the Greater Carajas Program Area

2-2-1 Population Changes

Of the three states of Para, Maranhao and Goias composing the PGC Area, Para and Goias showed a high rate of population increase during the 1970s, far in excess of the nationwide average, while the population growth in Maranhao was comparatively slow, being almost equal to the national average. The net population increases due to migration (the number of immigrants less the number of emigrants) in Para and Goias have risen since the 1960s, while in Maranhao the number of emigrants surpassed that of immigrants after 1970, resulting in a net decrease in the migrated population. As a total, the population of the three states rose 39% during the 1970s as against the 28% national increase. Consequently, the proportion of the three states' population in the national total rose from 8.4% in 1960 to 9.5% in 1980.

The population of the PGC Area increased from 4.89 million in 1970 to 7.12 million in 1980, a rise of 46%, and its ratio to the total population of the three states also went up from 60.4% in 1970 to 63.2% in 1980.

The population of the seven sub-regions in the PGC Area rose 52% from 1.47 million in 1970 to 2.24 million in 1980, reflecting a rapid concentration of population in these sub-regions. The population of the seven sub-regions accounted for 31.5 % of the PGC Area's total population as of 1980. The population in the PGC Area was made up of 79.7% of that of Para, 97.8% of that of Maranhao and 7.9% of that of Goias in 1980.

As regards the population growth for each sub-region, from 1970 to 1980 Maraba rose 258%, Xingu 225% and Imperatriz 114%, very large increases compared with the average of 52% for the seven sub-regions combined. On the other hand, Castanhal and Bacabal, which have relatively long histories of development, have large increases of populations despite their low growth rates, and will continue to hold an important position in the development of the PGC Area.

The rural population in the PGC Area was a very high 61.9% in 1980 as against the urban population of 38.1%, although the proportion of the latter has been rising (The national rural population was 63.8% in 1950).

2-2-2 Changes in Employment Structure

The proportion of the economically active population in the total population of each sub-region, which is an indicator of the employment situation, ranges from 32.3% in Bacabal to 20.1% in Xingu (in 1980), levels lower than the national average which improved remarkably from 31.7% in 1970 to 36.3% in 1980. Except for the slight upturn posted in Imperatriz, the proportion of the economically active population declined in the sub-regions from 1970 to 1980; one of the reasons being that although the improved social and economic infrastructure such as roads and the various projects like the iron ore mining project in the Carajas Mountains had brought about a concentration of population in these sub-regions during the 1960s and 1970s, the surge of population exceeded the employment opportunities. It is therefore important to secure more employment opportunities in the future in the PGC Area.

With regard to economically active population by industry, the proportion of workers in the primary industry in the seven sub-regions declined from 78.5% in 1970 to 63.1% in 1980. However, it still reflects the importance of the agriculture sector in the PGC Area compared with the nationwide average of 29.3% as of 1980. The number employed in the primary industry in these sub-regions increased by 71,000 persons during the period, and it was equivalent to 32% of the increase in the economically active population of all industries.

The economically active population also substantially increased particularly in the sub-regions of Maraba, Xingu, Imperatriz and Araguaina. In Maraba, Imperatriz and Araguaina, while the number of workers in primary industry increased much faster than that in the other sub-regions, the number of workers in the secondary and tertiary industries registered a higher growth than that of the primary industry during the 1970s. This suggests increased activity not only in agricultural production but also in investment activities centering around the agricultural products processing industry in the sub-regions; and also that the distribution and service sectors in the cities of these sub-regions were vastly improved to support the production activities of the surrounding areas.

According to data for 1981, government spending per capita (Federal, state and municipality expenditure) was an average of Cr$37,700 across the nation, while in the states of Para and Maranhao the levels were Cr$10,000 and Cr$7,850 respectively, or only about one-fourth of the national average.

Although the basic infrastructure has been improved since the second half of the 1960s by the construction of the Belem-Brasilia Highway, Tucurui Dam and the Carajas Railroad, the infrastructure in the PGC Area, such as transportation, communications, electricity and energy supply systems is still inadequate on the whole, and in this respect the level of fiscal spending for the PGC Area should be raised further.

2-3 Analysis of Physical Infrastructure

2-3-1 Introduction

The Greater Carajas Program Area occupies 10.6% of the nation in area and 9.5% in population 1980 figures. Since statistical data for the PGC Area alone are difficult to obtain, the data on the three states of Para, Maranhao and Goias are used as substitute material for analysis of the physical infrastructure of the Area. Since the respective proportions of the population of the three states making up the PGC Area are 79.7% in Para, 97.8% in Maranhao and 7.9% in Goias, it is obvious that the features of the PGC Area are represented in the main by those of Para and Maranhao, and the features and data of Goias should only be considered as reference (The population ratios of the three states to the whole country are 2.86% in Para, 3.36% in Maranhao and 3.24% in Goias, while their ratios in terms of area are higher than those of population, with 14.66% in Para, 3.86% in Maranhao and 7.54% in Goias).

2-3-2 Present Status of Infrastructure in the PGC Area

The present infrastructure in the PGC Area is generally inadequate considering the proportion of the population and area relative to the whole nation. Table I-1 shows the proportions for each of the three states in terms of the national totals by road length, road and marine shipments, electricity output, and the number of telephones. For example, in comparison with the population proportions of Para and Maranhao to the whole country, their share of the national total in the volume of road shipments, electricity output and number of telephones is less than a half of the population proportion in Para and one-fifth to one-tenth in Maranhao.

In Para, for instance, an average length of the federal roads is 3.0 m/km^2 (7.6 m/km^2 nationwide), the state and regional roads 4.8 m/km^2 (16.1 m/km^2 nationwide), and the municipal roads 9.4 m/km^2 (139.0 m/km^2 nationwide). This indicates the low standard of the road system in Para, with the federal roads being one-half of the national average, the state and regional roads one-third, and the municipal roads less than one-tenth. The situation, however, is different in Maranhao where the federal, state, regional and municipal roads are all around the national standards, in contrast to the low levels of other kinds of infrastructure.

The low level of economic activity in the PGC Area is reflected in the ratio of the volume of road shipments to the population which is, compared to the national average of 1.85 tons per capita, only 0.27 ton in Para and 0.02 ton in Maranhao which has a road system comparable to national standards. Another exception in the Area is the high level of marine shipments centering at Belem Port in Para, with its proportion to the whole country standing at 3.15%. This suggests that Belem Port is the sole center of marine cargo transportation in the Area although there is also the port of Itaqui in Sao Luis.

Table I-1 Infrastructure in the Three States Relative to the Whole Country

State	Population (%) (1980)	Area (%) (1982)	Federal Roads Length (%) (1982)	Federal Roads Length per km^2 (m) (1982)	State and Regional Roads Length per km^2 (m) (1982)	Municipal Roads Length per km^2 (m) (1982)
Para	2.86	14.66	5.84	3.0	4.8	9.4
Maranhao	3.36	3.86	5.20	10.0	12.8	134.4
Goias	3.24	7.54	6.77	6.8	27.1	126.0
Whole Country	100.00	100.00	100.00	7.6	16.1	139.0

State	Overland Transport Cargo Volume: Proportion to Whole Country (%) (1981)	Overland Transport Cargo Volume: Volume per Capita (tons) (1981)	Marine Cargo Volume: Proportion to Whole Country (%) (1982)	Marine Cargo Volume: Volume per Capita (1,000 tons) (1982)
Para	0.43	0.27	Belem 3.15	2.09
Maranhao	0.04	0.02	Itaqui 0.18	0.01
Goias	1.59	0.90	-	
Whole Country	100.00	1.85	100.00	1.97

State	Electricity Output: Proportion to Whole Country (%) (1982)	Electricity Output: Output per Capita (MW) (1982)	Number of Telephones: Proportion to Whole Country (%) (1980)	Number of Telephones: Per 100 persons (1980)
Para	1.23	0.0013	1.11	2.4
Maranhao	0.27	0.0002	0.48	0.9
Goias	1.33	0.0013	1.80	3.5
Whole Country	100.00	0.0003	100.00	6.2

Source: IBGE, Anuario Estatisico do Brasil, 1983

2-3-3 Major Infrastructure Programs in the Greater Carajas Program Area

(1) Electricity

The Tucurui Power Station of ELETRONORTE started operations in November 22, 1984, with a power generation capacity, in its first phase, of 4,000 MW, which will be sufficient for the power supply to the PGC Area. The capacity will be increased to 8,000 MW in the second stage, thereby having the potential to substitute the present supply of power from CHESF in the future. ALBRAS/ALUNORTE in the Barcarena Industrial District and ALUMAR in the Sao Luis Industrial District have already finished construction of transmission lines (construction of an auxiliary line is now under study) and substations, and are now awaiting the power supply to be connected from the Tucurui Power Station. In the industrial districts of Maraba and Tucurui the construction of substations and facilities for receiving the power supply is expected in the future as factory construction programs make progress.

(2) Water transportation

The major shipping ports in the PGC Area are Belem in the state of Para and Itaqui in the state of Maranhao. Belem Port is connected with Tucurui by the Tocantins river along which barges are used as the main means of transport. Its capacity is already fully extended, and it is too shallow to accommodate vessels over 10,000 tons. For this reason, the role now performed by Belem Port will be assumed in the future by the Vila do Conde Port in Barcarena, presently under construction, which can berth vessels of the 40,000-ton class; it is also close to the industrial districts.

In Sao Luis, in addition to the port of Itaqui with its relatively small cargo-handling capacity (448,000 tons handled in 1982 as against the 1,887,000 tons handled in Belem Port), the Ponta da Madeira Port is now being constructed by Companhia Vale do Rio Doce (CVRD). Having the capacity to berth 280,000-ton class vessels, it will have great influence on the whole PGC Area in the future when the port is used not only for the shipment of mineral products from the Carajas Mine but also for shipment of general cargo because of its access to the Carajas Railroad.

(3) Railroads

The CVRD Carajas Railroad runs over a distance of 890 km from the Carajas Mine to the port of Ponta da Madeira in Sao Luis. The whole line was opened in February 28, 1985, and because of its use not only for transport of mineral products but for the carriage of general commodities and agricultural products including forestry and livestock products as well, the railroad will have considerable impact on the area in view of the conceivable reduction of transportation costs (One estimate predicts a reduction of transportation costs to about one-tenth that of trucking costs).

(4) Road transportation

The main federal roads running through the PGC Area are the Belem-Brasilia (BR-010) and Trans-Amazon (BR-230) highways, to which the state roads are linked to connect the major cities. Although these roads are still adequate in terms of transportation capacity, one problem is that the roads have not yet been fully paved. The percentage of paved federal roads in the state of Para in particular is a very low 16.5% compared with the national average of 65.8% (1982 figures). The percentage of paved federal roads in Maranhao is 53.7%. The percentage of paved state roads are only 28.6% in Para and 18.5% in Maranhao as against the national average of 30.4%. Such a situation suggests that the paving of roads is a matter of urgency.

2-4 Comments on the Potentials of the Greater Carajas Program Area

Various development programs are currently being undertaken in the PGC Area by government agencies. SUDAM has formulated the third 5-year Amazon Development Program (1980-85) which involves, among other projects, preliminary studies for natural resources development and comprehensive development plans for major river basins in the Amazon region. POLAMAZONIA and POLONORDESTE have been implemented by SUDAM and SUDENE as federal special programs. INCRA and GETAT have carried out colonization projects and programs for titling and distribution of agricultural lands with the objective of promoting the settlement of medium- and small-scale farmers. An integrated regional development plan of the Araguaia-Tocantins river basin has also been worked out under PRODIAT.

POLAMAZONIA aims at utilizing the abundant natural resources and favorable natural conditions in the Amazon area. It incorporates a wide range of development projects, such as basic surveys on mineral resources; promotion of the agro-livestock industry; processing of agricultural products; establishment of industrial districts; construction of roads; power supply facilities and communications systems; promotion of public health and sanitation and education. On the other hand, POLONORDESTE aims at integrated rural development in the Nordeste region mainly through the titling and distribution of agricultural lands in order to promote the settlement of small-scale farmers in the area.

Although POLAMAZONIA and POLONORDESTE are the principal measures for regional development of the PGC Area, SUDAM and SUDENE have other means of promoting regional development, such as fiscal and financial incentives and investment funds (FINOR and FINAM) which may encourage private business in the PGC Area. If these programs and measures, in addition to the benefits given to private business by SE/PGC, are taken into account, the policy measures required for the regional development of the PGC Area appear to be virtually complete.

With regard to the population changes in the PGC Area, remarkable increases have occurred in the southwestern region of Para (Maraba and Tucurui) and in the western region of Maranhao (Imperatriz, Acailandia, Santa Luzia and Santa Ines) - the forefronts of agricultural development.

On the other hand, both the northeastern region of Para and the eastern region of Maranhao, which have relatively long histories of development and settlelement, had slow rates of population growth, or even decreases in certain areas, during the 1970s.

In terms of the sectoral employment structure in the PGC Area, the proportion of the economically active population in the primary sector is extremely high compared with the other regions of the nation. Moreover, the number of workers in the primary sector of the PGC Area has increased as a result of agricultural development, while that of the nation has decreased, in recent years.

One of the main tasks in the further development of the PGC Area is the improvement of the infrastructure at regional and sub-regional levels. In this regard, it is crucial to improve the network of feeder roads in the areas along the Carajas railroad and the major trunkline roads such as the Belem-Brasilia highway (BR-010), the Trans-Amazon highway (BR-230) and state highway PA-332. The construction of feeder roads will be conducive to the smooth flow of physical distribution and services in the area, resulting in heightened development of the agriculture, forestry and livestock industries.

Another task in the transport infrastructure is the betterment of river navigation systems. It is necessary to secure stable navigation of the major rivers in the PGC Area, which will obviously contribute to the development of the Area. In more specific terms, the betterment of the navigation systems necessitates the construction of the lockages in Tucurui and Santa Izabel dams, and the dredging of Tocantins riverbed. This will facilitate large-scale river transportation between the major inland cities and the major coastal cities (Barcarena and Belem), extending to Aruana in the state of Goias, about 2,200 km from the coast. Together with the completion of both the Carajas railroad and the feeder road network connecting the major trunkline roads, the betterment of the river navigation systems may greatly advance the development of the inland areas.

During the 1970s a rapid inflow of population was seen mainly in the cities of Araguaina, Imperatriz and Maraba located along the Belem-Brasilia highway, but in the future the population is expected to move toward the inland areas as the access to the inland area west of the highway is improved, thus resulting in a movement of the agricultural development fronts further toward the western regions.

There are several matters to be resolved when considering the future development of the PGC Area. First, in regard to the direction of the Area's development, it is necessary to clarify, especially in respect of agricultural land utilization and development of the agriculture, livestock and forestry sectors, the Area's long-term prospects and its role in the national development perspective.

Secondly, the allocation of financial resources to those regional development agencies has declined in recent years, reflecting the severe economic conditions of the nation since 1980. The fundamental objective

of the Greater Carajas Program is the attraction of private industry into the PGC Area through the improvements of economic infrastructure. However, the recent substantial decreases in funding are a great stumbling block in the construction of the required economic infrastructure.

Thirdly, the areas covered by the federal special programs are vast, making it difficult to undertake public investment in an effective and concentrated manner.

As pointed out in the Study Report on agriculture, the newly-developing agricultural front areas face a large number of problems in the establishment of land titles; income raising for traditional self-sufficient farmers; and production increases for farms producing marketable crops. In order to solve those problems and enhance the agricultural development, it is necessary to formulate an integrated package of measures such as rural extension, improvement of the feeder road network and storage facilities, land price regulation and security of land titles, and rural credits as well as price controls.

The Study Report on the development of the mineral resources indicates that the geological and mineral explorations in the area are at the reconnaissance stage requiring better knowledge of the geology through mapping, geochemical and geophysical surveys.

The Study Report on the development of the metallurgical industry also points out the necessity of positive efforts for improvement of the transport infrastructure (mainly by utilization of the rivers), industrial water supply, and housing development in the industrial districts to be constructed in Maraba, Tucurui, and Barcarena.

If the aforementioned regional development programs and their execution schedules are viewed from the standpoint of the Phase II Study, the limited funding available will necessitate a concentration of the existing development measures into the selected sub-regions on a more coordinated basis than previously.

〔II〕 STUDY OF AGRICULTURE, LIVESTOCK AND FORESTRY DEVELOPMENT

1. INTRODUCTION

In the Phase I Study undertaken in 1982-83, the JICA Study Team examined trends in the international markets of twenty-eight agriculture, livestock and forest products of the Greater Carajas Program Area. At the same time, a Brazilian counterpart conducted a study on the domestic production and domestic market trends of these products. The present study on the agriculture, livestock and forestry development in Phase II contains seven survey items (see Part I of the Final Report, Annex I-3). Based on the results of the study on the international markets in Phase I and those on the domestic production and markets conducted by Brazilian team, this study aims to examine the products that should be given priority for future development of the agriculture, livestock and forestry sectors, in consideration of the natural, social and economic conditions of the Area, and to provide comments on the various conditions necessary to realize the Area's development potentials.

Since this study covered a wide geographical area and a diversified range of study items, it was decided that the conduct of the study should be clearly defined in order to facilitate completion of the tasks within the limited time available. That is, regarding the method of study, in full coordination with the Brazilian authorities, we: (i) fully utilized the existing materials and data, (ii) draw on the interviews with the Brazilian people concerned, (iii) restricted the number of main crops for study (as described in the Inception Report), and (iv) visited the representative sites of the Area after discussing thoroughly with Brazilian officials. When compiling the report, focus was particularly placed on (i) the interrelationships of the study items, (ii) the distinctive features of the regions examined, and (iii) the preliminary screening of products suitable for production in the Area and an examination of the conditions necessary for development.

The full cooperation provided by Brazil meant the survey proceeded smoothly. However, the expanse of the PGC Area and the limited time for the survey meant that diversified aspects had to be handled, and therefore certain parts of the survey leave something to be desired. In fact, although we received generous cooperation from Brazil, the areas where the Study Team was able to visit were limited, and inevitably there were constraints on the collection of data. We attempted to compensate for this lack of information through discussions with Brazilian and Japanese specialists.

Areas covered by each sub-region are, as a principle, marked according to the classifications in Programa Grande Carajas Agricola (Preliminary Version).

2. OUTLINE OF THE STUDY

The study on agriculture, livestock and forestry development covers a wide range of study items. The studies by item are summarized in the following sections. The results of the whole study will be outlined in this section by focussing on the current situation of agriculture, livestock and forestry sectors, preliminary screening of priority products and conditions for their development in the PGC Area.

2-1 The Special Features of the PGC Area's Agriculture, Livestock and Forestry Sectors

The special features of the PGC Area's agriculture, livestock and forestry sectors which were clarified from comparisons of the Area with Brazil as a whole, and between the sub-regions of the Area can be summarized as follows:

(1) The Area is endowed with abundant land resources, and in general many forests and much unused arable land exist.

(2) However, rapid large-scale conversion of forests to arable land (mainly pasture) is under way together with a wide-spread practice of shifting cultivation, showing signs of deterioration of natural environment in some areas.

(3) The structure of agricultural production is characterized by the coexistence of large number of small-size farms producing mainly subsistence food crops and large-scale cattle farms. The percentage of pastureland in the total area of arable land is remarkably high. The percentages of tenants and occupants in the total number of farm units are also high compared to other regions. The cultivation of commercial crops such as oil palm and soybean by using modern techniques has emerged in some sub-regions, but in general the technical level and land productivity are low.

(4) The utilization of forest resource is still at a primitive stage. The artificial reforestation is very limited.

(5) The seven sub-regions can be roughly divided into three groups according to natural conditions, history of settlement, and distances from main roads: (a) Bacabal, Balsas and Imperatriz with a relatively long history of development, large number of small- and medium-size farms, and high percentages of tenant farms; (b) Araguaina, Maraba and Xingu with land conversion for agriculture being under way, relatively high percentages of medium- and large-size farms, and large percentages of pasture area; and (c) Castanhal with a relatively long history of settlement, a large percentage of small- and medium-size farms, a high percentage of owner-farms, and farmer's willingness to be engaged in commercial crop production by using modern technology.

From the above observations, the following viewpoints seem essential for the future development of the PGC Area's agriculture, livestock and forestry sectors:

(1) The need to enhance efficient use of land resource to actualize the Area's development potential;

(2) Promotion of policy measures for improving the incomes of the overwhelmingly large number of small farms, and for immobilizing shifting farmers;

(3) Strengthening the competitiveness of commercial crops suitable to the utilization of local conditions; and

(4) Harmonizing development and environmental conservation.

2-2 The Surrounding Conditions of the PGC Area's Agriculture, Livestock and Forestry Sectors

The present conditions of the major natural and secio-economic factors surrounding the agriculture, livestock and forestry sectors of the PGC Area can be summarized as follows:

(1) The Area is favored geographically by being covered with vast land, and the land price is relatively low.

(2) The PGC Area belongs to the tropical zone, but there are differences among the sub-regions in soil and rainfall. Although there are differences among the sub-regions in the possibility of agricultural land expansion, in general the Area has high potential of land development for agricultural use.

The maximum rainfall is registered in the Castanhal Sub-region (annually 2,700 mm or more). In the PGC Area, generally the rainfall is high in the Northwest and gradually decreases southeastward, with the minimum being registered to the south-southeast of Bacabal (annually 1,100 mm or less). Sub-regions Xingu, Maraba, and Imperatriz, and part of sub-region Bacabal have soil of relatively high fertility. (The prevailing soil types are PV. LV at Maraba, LV. AQ at Imperatriz, LV. PV. AQ at Araguaina, LA at Castanhal, TR. PV at Xingu, PV. HL at Bacabal, and LV.AQ at Balsas.)[1] Generally, considerations for the conservation and improvement of soil fertility are necessary. Xingu, Maraba, and Araguaina have relatively high potential for agricultural land expansion. Sub-region Maraba has large area of steep land.

The forests in the PGC Area are characterized by heterogeneous structures, although there exist high-quality species. Reflecting the pattern of rainfall distribution, the potential growing stock

1) See Chapter 2 (Final Report) for details of soil classification.

per unit area of the Area is high in the north and gradually declines southeastward.

(3) In general, the so-called social capability —— technical acceptance, production practice, etc. —— in the Area is low, except in some areas in sub-region Castanhal and at relatively large-size farms.

(4) All the sub-regions of the PGC Area are located in areas remote from such central markets as Sao Paulo and Rio de Janeiro. As Belem and Sao Luis are the largest cities within the Area, Castanhal and Bacabal are relatively favorable in terms of local market, compared with other sub-regions. The same thing can also be said with respect to international market. In sub-regions Maraba and Imperatriz, the size of local market which is small at present is expected to be enlarged along with rapid increase in population.

(5) The access of most of the sub-regions to the central markets of Brazil and the world markets have been substantially improved by the construction of such main transport infrastructure as the Trans-Amazon and Belem-Brasilia highways, and the Carajas railroad. However, with the exception of Bragantina (in Castanhal sub-region) and some other municipalities, the Area is lacking a well-consolidated network of transport infrastructure. As a result, the development in the Area has been limited to the areas along the main roads, and the formation of producing areas has not been efficiently promoted.

(6) The construction of processing and marketing facilities in the Area is also far behind that in the southern states of Brazil. This is, needless to say, closely related to the small size and instability of the production of the Area's agriculture, forestry and livestock sectors. It is observed that those areas close to Belem, Sao Luis and Imperatriz tend to be favorable in processing and marketing facilities, although the situation is dependent on the types of products. The Area is also backward in terms of agricultural cooperative activities, except in some limited zones. This seems to be due to the fact that the number of commercial-product-oriented and medium-size farms, which are the core of agricultural cooperative activities, is still small in the Area.

(7) Some special features of the PGC Area are also observed in its institutional aspect. The Area has plenty of land of which the ownership is still not established. Moreover, the technical extension services are not sufficiently provided, due mainly to inadequate transport infrastructure and farmers' low technical acceptance capability.

With respect to credit and price policies, preferential treatment has been given for the whole North and Northeast regions including the PGC Area. However, the Area has relative disadvantages due to its timing of development and other specific conditions. For

examples, as the Area started to develop at a large scale when Brazil entered a period of credit squeeze, the Area is not favorable in the production of capital-intensive products, and some of the important products of the Area are not familiar to be covered by the present price support system.

2-3 Comments on Preliminary Screening of Priority Products and Necessary Conditions for Development

(1) A preliminary screening of suitable products for the Area was made, based on the development perspective of the Area's agriculture, livestock and forestry sectors (2-1), their surrounding conditions (2-2), and the major characteristics of the products. Of the products which can be produced in the Area, those of high priority are stated in the following together with the major reasons for their selection.

(a) Rice, maize, feijao and cassava which are widely cultivated in all sub-regions, and suitable to the objectives of self-supply of food and increase in the incomes of small- and medium-size farms;

(b) Rubber, cacao, and other perennial crops for the purpose of farmer's immobilization and farm-management stabilization;

(c) Oil palm (Castanhal) and soybean (Imperatriz, Araguaina, Balsas, and the southern part of Bacabal) as newly-emerged commercial crops of relatively high profitability and being suitable to the utilization of local conditions;

(d) Babassu (Bacabal) and Brazil nut (Maraba) which are the Area's special products;

(e) High-quality tropical fruits and pepper suitable to the utilization of the Area's natural conditions (Castanhal);

(f) Fresh vegetables for local markets (Castanhal and Bacabal at present, and Imperatriz, Maraba and Xingu in the future);

(g) Rubber (Imperatriz, Xingu, etc.) and sugarcane as commercial crops, provided that market trend is favorable and production is promoted collectively to some reasonable scale at an area;

(h) Beef cattle utilizing abundant land resource of the Area;

(i) High-quality timber products benefited by the huge forest resources, and trees for wood industry material to be planted correspondingly to the Area's natural and economic conditions.

Needless to say, the above-mentioned products were preliminary selected on the basis of the various conditions which are presently given to the PGC Area. As already referred to, any changes

in these conditions will bring about changes in the priority of products. The fact that the emergence of a new soybean variety has made the production of this crop promising in the Area presents a good example of the impact of the influencing factors on the product selection.

Any favorable changes for the above selected products in their surrounding conditions are expected to facilitate the achievement of the product screening's objectives.

(2) It is from the above point of view the Study Team elaborated the following comments on product screening and necessary conditions for the development of the PGC Area's agriculture, livestock and forestry sectors:

(a) Promotion of Basic Food-Crop Production

Rice, maize, feijao and cassava were recommended as high priority crops for their suitability to the natural conditions and their wide-spread cultivation as the basic food-crops for large number of small farmers. The objective of the promotion of the production of these four crops is to improve the level of these farmers' living standard. For this purpose, a package of supporting measures including improvement of extension services, activities related to cooperatives and other types of farmers' organizations, and processing and marketing facilities, as well as establishment of land-ownership seems desirable. This policy package is expected to work towards increasing the yield levels and the commercialization rates of these crops.

(b) Farmer's Immobilization

The shifting cultivation system which is presently practiced by large number of farmers in some sub-regions of the PGC Area is said to result in low farm incomes and deterioration of natural environment. Therefore, a transition of these farmers from the shifting cultivation system to a sedentary cultivation system is desirable for increasing their incomes and conserving the Area's natural environment. Some suitable measures for this purpose seem to be (i) reduction of the costs of soil fertility maintenance through research and technical services related to the sedentary cultivation system, and improvements in farmers' access to current inputs, (ii) establishment of land-ownership, and (iii) financial and technical supports for the introduction of perennial crops.

(c) Strengthening the Competitiveness of Commercial Products

The major commercial products which presently come to attention are (i) crops such as oil palm, soybean and pepper, (ii) local specialities such as babassu and Brazil nut, (iii) beef, and (iv) forest products such as high-quality timber products and other wood material for industries.

Regarding the commercial crops, oil palm is suitable mainly for Castanhal sub-region, and soybean mainly for Araguaina, Imperatriz and Balsas sub-regions. These sub-regions are expected to become producing areas of these two crops. Improvements in the access of cultivators to credits and in processing and marketing will be recommended in addition to suitable measures with respect to seed production, soil fertility maintenance, and cultivation.

For such special products as babassu (Bacabal) and Brazil nut (Maraba), development of new and comprehensive uses and promoting cultivation upon necessity are expected to strengthen the utilization of these precious resources.

The Area, specially in those sub-regions with high land-labor ratios, has high potentials for beef cattle raising. In order to enhance the competitiveness of this product it will be necessary to improve both the productivity of pastureland and the quality of beef cattle, to improve infrastructure for transportation both within the production area and from the production areas to markets, to plan the future location of slaughter houses, and to work out a beef cattle production plan for the Area in line with long-term demand and supply forecasts.

Forest resources may be used in two ways depending on the locational features of the areas: as a source for high-quality timber products, or as material for wood industries. In either case, the transport infrastructure needs to be improved, but the former urgently requires quality standardization to be acceptable to overseas markets; and the problems of the latter concern the possibility of establishing pulp mills, alcohol plants, and charcoal-consuming factories close to the forest site.

(d) Environmental Conservation and Integration of Development Policies

Following are some additional comments related to the development of the PGC Area's agriculture, livestock and forestry sectors.

The first is on harmonization of environmental conservation and development. As previously referred to, in the PGC Area generally land utilization is extensive and land productivity is low. On the other hand, there has been a high pace of conversion of forests into cropping or pasture land, and in some areas this conversion has given an impression of indiscriminate development. Though development is essential, the most pressing issue in the Area seems to be how to harmonize agricultural land development and environmental conservation. In solving this issue, it seems desirable that, on the one hand the productivity of the existing agricultural land be raised as much as possible, and on the other hand priority of new land development be assigned to areas favored by good natural conditions and well-established infrastructure. The so-called growth-pole development formula, seems effective in harmonizing development and environmental conser-

vation, as well as allowing for efficient use of financial resources.

Scenes in which forests were burned near the top of mountains and on steep land were also observed during the field observations. Careful considerations seem desirable in choosing the way of land clearance, as the Area belongs to a tropical zone where the rainfall strength is very intense.

The second comment is on the position of the PGC Area in the whole Brazil in terms of commodity production. The selection and production of agriculture, livestock and forest products depend not only on the natural conditions, the level of technology, and various factors such as the allocation of transport infrastructure and processing facilities, and land price, but also on institutional factors such as credit and support price and other policies. One example of the impacts of socio-economic factors including institutional systems on development is seen in the rapid conversion of forests to pastureland along the Belem-Brasilia highway, as induced by improvements in transport infrastructure, low land price, and policy incentives. Some of these areas could be converted to soybean production if soybean price, financing conditions, processing facilities and other surrounding conditions were favorable to this product. As mentioned in the above example, the products to be produced will change considerably according to the series of policies to be taken. In this sense, it will be very important to define, in relation to national policies, the position of the Area in Brazil as a whole as to what kinds and amounts of products are to be expected to the Area.

The third comment is on comprehensive implementation of policy instruments at the regional or sub-regional level. In implementing the policy measures, it is desirable that these measures are well adjusted to suit the specific conditions at the regional or sub-regional level. It is effective that these policy instruments, such as improvement of infrastructure including rural roads, processing and marketing facilities, establishment of land-ownership, enhancement of technical extension service system, and provision of necessary financial funds are consistently coordinated and implemented.

As the PGC Area has great potential for development, it is hoped that the Area will be developed through a carefully-devised program which is based on long-run perspective and ensures optimal utilization of the Area's development potential.

3. NATURAL CONDITIONS

The objectives of this part of the Study are to survey the geography, geology, climate, soil, vegetation and other natural conditions of the PGC Area. More specifically, this part aims to examine the relationships between current land use and agricultural production; to indicate the natural conditions which will influence crop selection, and subsequently, to consider the methods of land development and the measures to conserve and improve soil fertility along with development, and finally to assess the potentials for crop production.

3-1 Climate of Sub-regions

The annual average temperature is approximately over 25°C, and the maximum-minimum range is large in inland areas and small in coastal areas.

Rainfall shows the highest level around Belem (over 2,700 mm annually). In general, the rainfall in the Area is high in the northwest and gradually decreases southeastward. The minimum annual rainfall is registered at Barra do Corda 150 km to the south-southwest of Bacabal (less than 1,100 mm).

The annual sunshine duration is not inversely proportional to the rainfall. Sunshine is relatively little in inland areas, explaining the above observations on temperature range.

As the annual average temperature is high, the fundamental determinant factor of the growth of crops is duration of soil dry reflecting differences in annual rainfall between the areas.

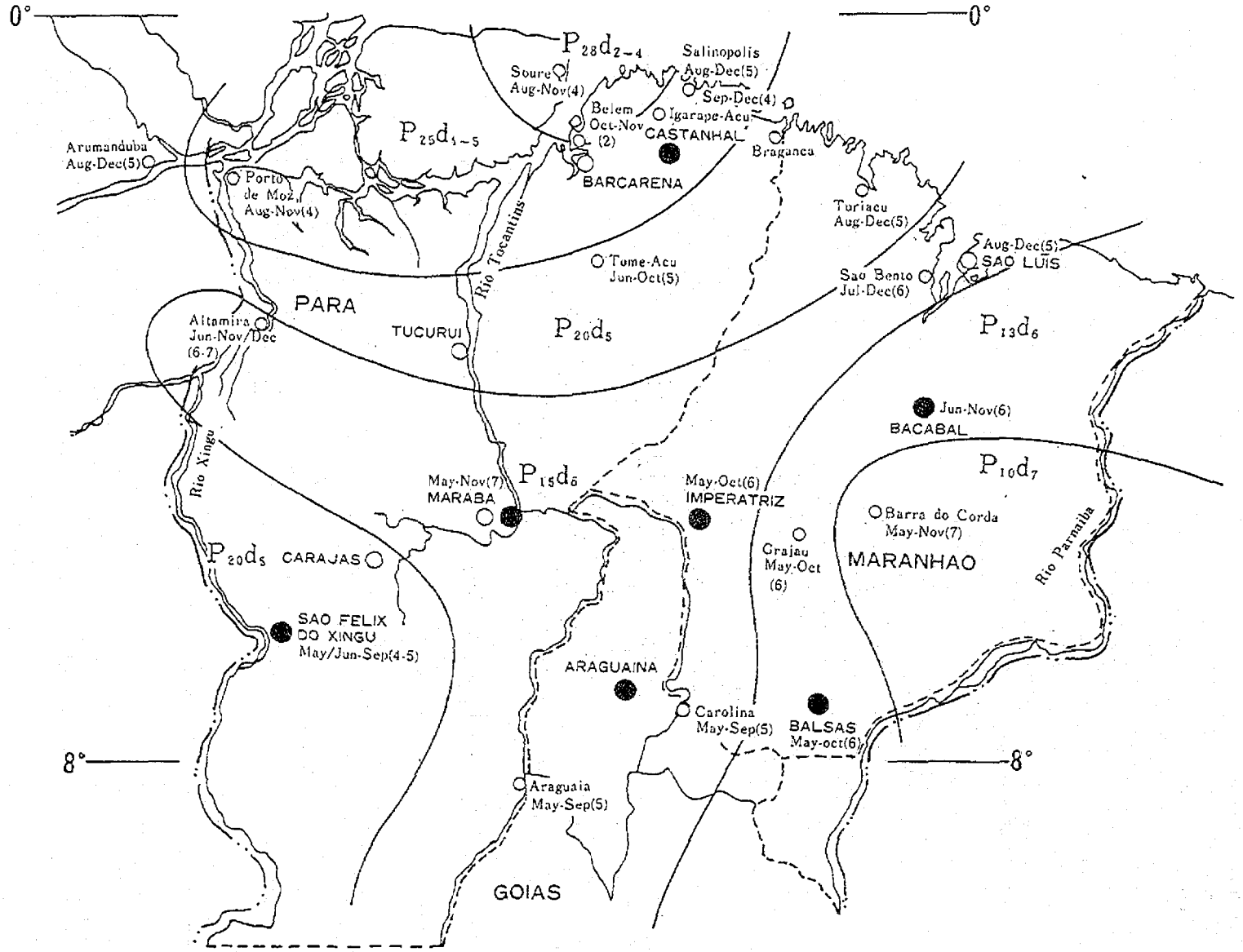
A "Climate Map of Soil Dry Period" (Figure II-1) was drawn, indicating the dry soil months and annual rainfall based on the Thornthwait moisture balance charts made from monthly rainfall and water loss due to evaporation for each area.

The climates are distributed as follows: the Belem district is $P_{28}d_{2-4}$, most of the Castanhal sub-region is $P_{25}d_{4-5}$, the remainder of the Castanhal sub-region and the Xingu sub-region are $P_{20}d_5$, Maraba, Imperatriz, and Araguaina are $P_{15}d_6$, Bacabal and Balsas are $P_{13}d_6$, and the southeast part of Barra do Corda is $P_{10}d_7$ (See Figure II-1.).

3-2 Topography of the Sub-regions

Bacabal Sub-region: Mainly a rolling plain 100 m or less above sea-level, with swamps in low areas. Development is advancing gradually from the outskirts of the state roads to more remote areas. But as yet there are no paved roads leading to these areas, and the clay-rich podzolic soil area is difficult for traffic especially in the rainy season.

Figure II-1 Climate Map of Soil Dry Period



Note: P_i means an annual rainfall of i x 100 mm.
d_j means a duration of j months of soil dry.

● Sub-region for Agriculture

Castanhal Sub-region: The whole area of Bragantina is a coastal plain 100 m or less above sea-level, and very gently rolling.

The coastal areas have many swamps with seawater.

Over one half of the total area of Paragominas is a plain 100 m or less above sea-level, and gently rolling. But the southern area around the national highway is a rolling plateau and hills about 200 to 300 m above sea-level.

Imperatriz Sub-region: The area around the national highway is a plateau 150 m high, but the areas north of Acailandia and in the eastern part of the sub-region are hills 200 - 400 m above the sea. Development is in progress in every part of the sub-region.

Araguaina Sub-region: The area around the national highway is a rolling plateau about 200 m above sea-level, and its western part consists of hills and mountains 300 - 400 m high.

Maraba Sub-region: The western part is dominated by the slopes of the Carajas Mountains of several hundred meters above sea level. The field observation of the Carajas Settlement Project III showed that the plateau and gently sloping areas were being developed. In Itupiranga District, the alluvial plain of the Tocantins river and the mountainous area behind it have been developed. Even the steep mountainsides have been converted into pasture. In the east part of Maraba which consists of alluvial areas and plateaus, the land in Sao Domingo and its neighborhood is currently under development.

3-3 Soils of the Sub-regions

On the northern side of the line linking Altamira, Tucurui, Acailandia, and Barra do Corda, yellow latosol LA is widely distributed. On the area south of this line and west of a line crossing south to north of Araguaina, and the areas around the line running from the southeast end of Castanhal sub-region (Bragantina) to Bacabal sub-region, red-yellow podzolic soil PV extends widely. The area extending from the Carajas Mountains to both sides of the Araguaia river and the proximity of Imperatriz contain much red-yellow latosol LV (See Figure 2-2 in Chapter 2 of Part III, Final Report).

Quartz sands soil AQ is widely distributed on the basins of the Tocantins river and the rivers which flow into the Tocantins, and ground water laterite HL is distributed on the northeast area on the edge of the PV area extending from the southeast end of the Castanhal (Bragantina) sub-region to Bacabal.

LA (26.5%) and PV (28.4%) account for 55% of the Area's soil, and the combination LV (12%), AQ (9.2%) and HL (7.4%) accounts for about 30%. The order of productivity of these main soils is $AQ<LA<LV\leq PV$.

The fertile soils formed from weathered basis rock which are scattered throughout the Area are dark-red latosol LE (1.4%), reddish brown lateritic soil eutrophic TR (1.3%), red-yellow podzolic soil eutrophic PE (0.6%), reddish brunizem BA (0.2%), and dusky red latosol LR (0.1%).

The main types of soil in the sub-regions are:

Sub-regions	Main soils
Bacabal	PV, HL, LA
Castanhal	LA
Imperatriz	LV, AQ
Araguaina	AQ, LV, PV
Balsas	LV, AQ
Maraba	PV, LV
Xingu	PV, TR

Results of the Soil Sample Analysis

The field of a well-managed truck farm at Bacabal was fertile through application of compost. The surface soil to a depth of 3 - 4 cm of grass land was moderately good even though it had not been cultivated. However, the lower layer was strongly acidic and deficient in phosphoric acid. The ashes from burnt mountain forests have a pH of 8 or more, and are rich in bases and available phosphoric acid, but the lower layer in which they were not mixed also consists of the same acid soil.

The grey humus soil of Braganca contains 11.3% humus, but it shows very strong acidity and is deficient in bases and available phosphoric acid.

Although soil of the uncultivated parts of the Cerrado is strongly acid even on the surface, the surface soil of vegetated areas in the PGC Area is not as strongly acidic. This seems to be due to differences in vegetation.

3-4 Some Comments on Soil Conservation and Improvement

(1) Land Use

Generally speaking, flat and gently-sloping areas are occupied by large cattle farms, while slopes and mountains are awaiting development. Many regions adopt a development system in which mountain forests are burnt to enhance fertility of the surface soil before commencing crop production. Despite the danger of severe water erosion on cleared mountainsides, there are cases where entire mountains, including the crest, have been cleared and burnt for cultivation. Such problems were observed in connection with land use in the PGC Area.

(2) Cultivating Methods (Clearing and Burning)

Development areas are normally cleared and burnt by man power — a huge task for developers. It is said that after burning, the soil fertility begins to decline in the 4th - 5th years in the case of primary forests, and in the 2nd - 3rd years in the case of secondary forests. For those developers who cannot obtain inputs, it is difficult to find an appropriate method to retain or enhance soil fertility. A recent follow-up study of the results of shifting cultivation practiced in northern Thailand showed that an increase in nitrogen as well as the necessary increase in basic substances in the surface soil can be brought about by partial burning rather than complete burning. This suggests that the burning methods in shifting cultivation deserve studies for searching ways to prevent fertility loss.

As a result of burning and cultivation many slopes are intensely eroded by rain. The use of organic mulch to prevent erosion seems worthy of consideration.

(3) Soil Fertility Conservation and Improvement

In Section 3-3, the productivity order of the main soils in the Area was given as $AQ<LA<LV\leq PV$. Globally, red-yellow podzolic soil is widely distributed in and around the state of Georgia, in the southeastern U.S.A. The property of this type of soil is similar to that of most soil in the PGC Area (low humus and strong acid).

In the U.S.A., up to present this soil had not been used, but recently soil improvements has been carried out on the soil of the coastal plateau with a view that the area can be developed to a highly productive area. This type of soil can be productive if treated with lime and phosphoric acid fertilizer.

The LV and LA surface soils in the PGC Area are sandy with little clay. PV is ranked above LV and LA in terms of fertility for its high clay content, but this type of soil has a disadvantage in that the high clay content makes the underlayer dense and less permeable to water.

In the Area, sloping lands are generally intensely eroded.

From the above observations the following measures with respect to the conservation and enhancement of soil fertility seem desirable:

1) Preventing erosion; and
2) Improving acid soil and increasing bases.

At present, generally after cropping the burnt field is converted to pasture before soil fertility declines. Fertility declining can be prevented by adding organic materials. A truck farm at Bacabal has obtained good results by applying this method. Mulch is very effective as a source of organic material and in helping to retain moisture in the soil.

The next improvement step is the application of lime and phosphoric acid, which is currently practiced in the Cerrado region. In this case, too, it is desirable that organic substances be applied at the same time.

An ideal improvement method is to intensively use low furnace slag (3 - 5 times the amount of lime). This slag consists mainly of calcium silicate but includes also magnesium, phosphoric acid, manganese, iron and boron, and therefore is a highly effective soil improvement agent if applied at the rate of 10 - 20 tons/ha.

4. PRELIMINARY CROP SELECTION ON THE BASIS OF NATURAL AND TECHNICAL CONDITIONS

The PGC Area covers an area of 840,000 km^2, and its diverse climate ranges from the tropical rain forest zone in the north to the cerrado-type tropical savanna zone in the south. Soil types vary widely from alluvial soil in the basins of small and large rivers, to red latosol, yellow latosol and red-yellow podzolic soil. Various crops are being cultivated: tropical perennial woody crops (for example, rubber and cacao); recreation crops characteristic of the Amazon (for example, guarana); and typical tropical crops such as rice and cassava. Further, useful plants such as the Brazil nut and pinhao grow naturally. This Area is a treasury of palms, with a number of useful palms such as oil palm and babassu being cultivated or growing naturally.

The selection for the preliminary crops by sub-region was made from the natural and technical points of view on the basis of field surveys on the natural conditions in different areas and present crop cultivation; through interviews with Brazilian government officials, researchers, farmers, staff members of agricultural cooperatives, and extension workers; and through analysis of the collected research materials.

4-1 Summary of Natural Conditions by Sub-region and Crop Cultivation

4-1-1 Castanhal Sub-region

The climate of the Castanhal sub-region is of the tropical rain forest type, with annual rainfall of more than 2,000 mm, and the tropical monsoon zone type, showing high proportion of perennial woody crops. The vegetation is characterized by the existence of many species of palms including coconut, tucum, pupunha, and assai.

Cassava, rice, maize and feijao are the ordinary crops mainly cultivated on small- and medium-scale farms. Larger number of crops such as cotton, tobacco, and castor bean are cultivated in this sub-region compared to the other sub-regions. This sub-region is also characterized by the cultivation of tropical fruits such as cupuacu and recreation crops such as guarana.

Pepper cultivation has been stagnant in recent years due to disease, but its cultivation is continuing in disease-free areas.

The crop which has recently drawn much attention and has been given priority as a local speciality is oil palm. The large-scale cultivation of oil palm is now mainly being undertaken by DENPASA and Japanese-descended farmers of some agricultural cooperatives, with further development being expected in the future.

4-1-2 Bacabal Sub-region

The Bacabal sub-region, situated in the tropical humid savanna climatic zone, is characterized by babassu forest, and has wide distributions of such useful palms as tucum, assai, buriti, carnauba and coconut palm. Many pastures formed by burning babassu forest can be seen in this sub-region, but in the southern areas the vegetation is shifting to the cerrado type.

As the basic crops for general farming, rice, cassava, maize and feijao are being cultivated mostly for self-consumption. In particular, the northern area of this sub-region, unlike the other sub-regions, is marked by extensive paddy fields. In addition, there is some cultivation of sugarcane, and various species of vegetables are cultivated and consumed locally. The Bacabal sub-region has large swamp area extending to the coast in the northern region, and paddy-rice production is expected to increase as the zone is developed.

4-1-3 Imperatriz Sub-region

The northern part of the Imperatriz sub-region is covered with Amazon-type tropical rain forest; in the southern part there is cerrado-type vegetation, and in the central part, extensive babassu forest.

The climate is of a tropical humid savanna-type with relatively low rainfall (around 1,230 mm) compared with the other sub-regions of the PGC Area. The existence of various species of palm is a special feature of the sub-region, with piacava palm being dominant, although macauba palm and babassu are also abundant. Other useful palms include buriti, coconut, and tucum.

Rice, cassava, maize and feijao are crops cultivated mainly for self-consumption. Castor bean and pepper, and in recent years soybean and Para rubber trees have been introduced. As a result of the development of the alcohol industry through the National Energy Plan, the production of sugarcane as a biomass resource can be anticipated.

4-1-4 Maraba Sub-region

Though lying in the tropical humid savanna zone, the Maraba sub-region has relatively high rainfall (around 1,800 mm). In the southern

part, the vegetation is of the cerrado type, while the northern and western parts are close to the tropical monsoon zone with distribution of forests.

The conversion of forests into farmland is under way, and full-scale mountain clearing by burning is being carried out in some parts of the sub-region. The sub-region is characterized by heavily concentrated Brazil nut forest, and the collection and utilization of the nuts are a major concern for agriculture in the sub-region.

Rice, maize, cassava and feijao are the major crops cultivated for self-consumption and sale, with castor bean, sugarcane, sorghum, and pineapple also being cultivated. Sweet potatoes are being planted in settlement sites after the mountains have been cleared. Because of the favorable climatic conditions, perennial crops such as cacao and coffee are also cultivated.

4-1-5 Araguaina Sub-region

The Araguaina sub-region lies in the tropical humid savanna zone where the cerrado-type vegetation is dominant. In the northern part of the sub-region, there are extensive babassu forests.

Rice, maize and feijao are the main crops cultivated for self-consumption and sale, and the cultivation of cassava is relatively rare. In addition, sugarcane, cotton, sorghum, and pineapple, and in recent years, soybean are also cultivated. The existence of babassu provides a major hindrance to the development of pastureland in this sub-region.

4-1-6 Balsas Sub-region[1)]

The Balsas sub-region, which lies in the tropical humid savanna zone, has relatively low rainfall (about 1,260 mm) compared to the other sub-regions. The vegetation is mainly of the cerrado type, with babassu forest in the northern areas.

Rice, maize and cassava are the main crops cultivated for self-consumption and sale. This sub-region seems promising in soybean production.

4-1-7 Xingu Sub-region[1)]

The Xingu sub-region, which lies in the tropical monsoon zone and has an annual rainfall of more than 2,000 mm, is heavily forested. A number of palm species are growing naturally in the forest. With regard to other crops, castor bean cultivation is observed, and rubber trees are ranging in low and damp areas.

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1) In this sub-region, only an over-flight for general observation was conducted.

Although presently characterized by the existence of wide-spread forests, the sub-region has high potential of crop production because of excellent natural conditions.

4-2 Technical Problems in Crop Production

In the PGC Area there are crops like soybean and oil palm of which the breeding and introduction of excellent varieties rapidly improved their productivities. However, there are many crops like paddy rice in the Castanhal and Bacabal sub-regions, Para rubber in the Imperatriz sub-region, and tobacco in the Castanhal sub-region, of which the presently-diffused varieties are not necessarily suitable. In some cases like that of oil palm, the variety itself is good, but the high price and difficulties in the procurement of seedlings (imported) present an obstacle to cultivation. Thus, for oil palm which is adaptable to the environment and highly profitable, it will be necessary to improve the present varieties and develop seedlings by introducing the tissue culture method and other new techniques.

The acquisition of seeds and their distribution to farmers — the starting point of crop cultivation — often create problems in tropical zones because of the high temperatures and humidity. Although the cultivation of soybean, which was begun only recently in the Area, is highly promising, soybean seed is susceptible to high temperature and humidity compared with cereals, and therefore requires proper facilities and technology for storage. In the Bacabal and Imperatriz sub-regions, the loss of soybean seeds as a result of the shortage of such facilities has become one of the major problems.

In the tropics, especially the humid tropical zone, one of the biggest causes of losses in crop production is the presence of diseases and pests; this applies to the PGC Area as well. For example, the disease of pepper and the pest of papaya in the Castanhal sub-region, the disease of Para rubber in the Imperatriz sub-region, and the pest of cacao, vegetables and grass in the Maraba sub-region, all require countermeasures in the form of new varieties and cultivation control.

A comparison of the yield of major crop in Brazil with main producing countries and several tropical Asian countries reveals that Brazil is around or above the world average but considerably low compared with the main producing countries in the production of cassava, soybean and sugarcane. The unit yield of maize is particularly below the world average. Regards the productivity levels in the Area as compared with the national average, the Castanhal and Balsas sub-regions rate lowly as the crops compared (rice, maize, cassava and feijao) are produced in many cases on small farms with a low level of technology, under relatively unfavorable soil conditions, and mainly for self-consumption. It may be said that the traditional varieties and cultivating methods cannot easily raise the productivity of those crops in these sub-regions. In all sub-regions, the maize yield was lower than the national average, indicating the need to improve its varieties and cultivating methods.

4-3 Crop Selection by Sub-region (See Figure II-2)

The following points were taken into consideration for crop selection in the PGC Area, based on the natural and technical conditions: (a) environmental adaptation, (b) crop characteristics and related problems, and (c) information and materials obtained during field observations.

In all sub-regions, four crops —— rice, cassava, maize and feijão —— play an important role in small- and medium-scale farming in terms of farmers' self-consumption and cash income.

In Castanhal sub-region, in addition to the above food crops such perennial commercial crops as oil palm, guarana and Para rubber suitable for the tropical rain forest zone or tropical monsoon climate seem important. Pepper is also important as a commercial crop in those areas free of disease. Various kinds of tropical fruits such as papaya, cupuacu, and mangosteen are also important as local specialities. In addition, sugarcane, cotton, tobacco, and cacao are suitable, and in the suburbs of the northern cities, various kinds of vegetables are promising.

In the Bacabal sub-region, by utilizing marsh and irriguous land the production of rice is expected to be increased. Para rubber, cacao, cotton and sugarcane can be considered as complement commercial crops. In the southern areas where cerrado is dominant, soybean is adaptable, and in the suburbs of the northern cities, vegetables are important. As for babassu which is abundant in the sub-region, in addition to its current use, new applications such as intensive use as a crop in specified areas or integrated utilization are worthy of consideration.

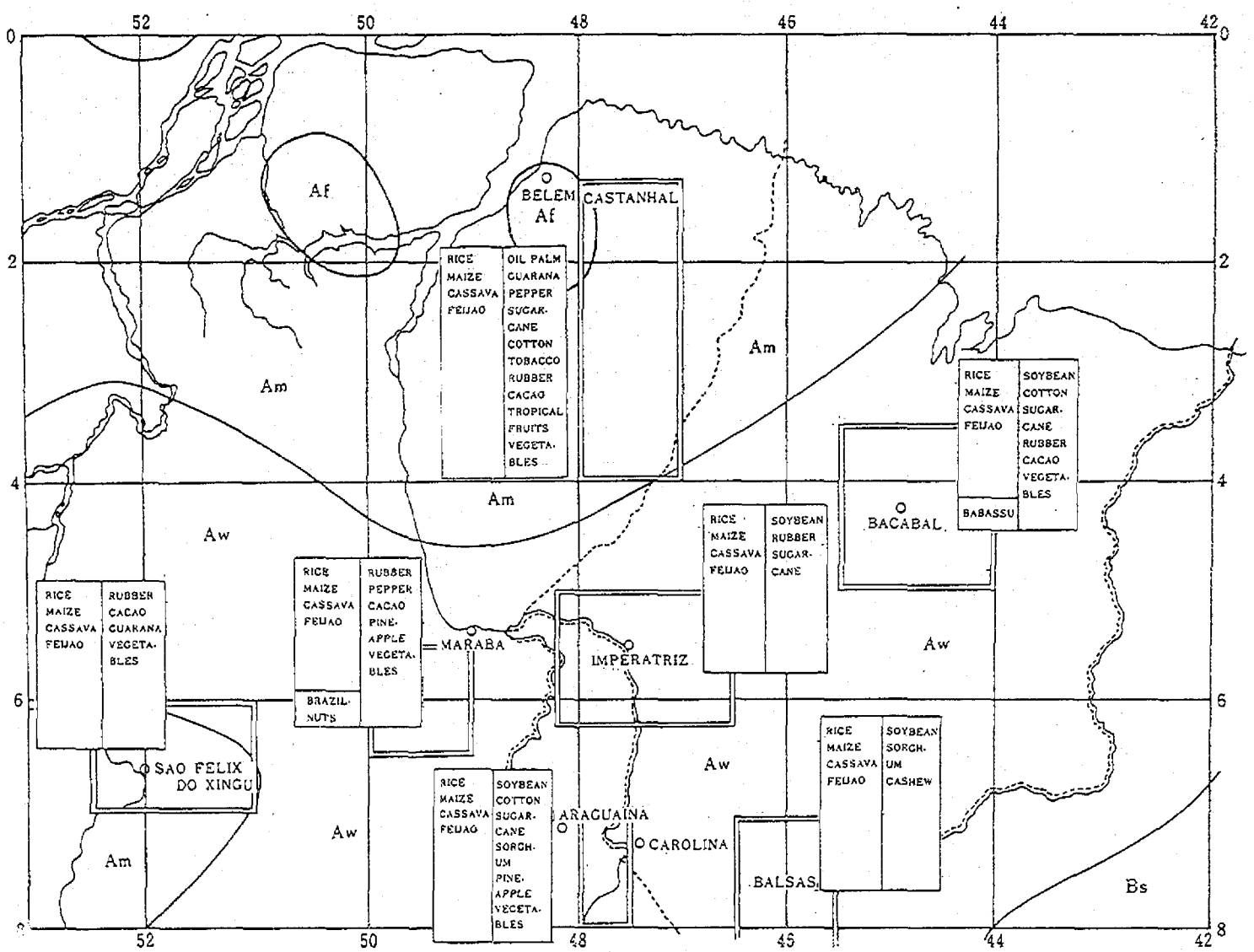
Regarding the Imperatriz sub-region, in the southern part which belongs to a cerrado region, soybean and sugarcane are suitable. In the northern part, low rainfall during the leafing time has a preventive effect on leaf blight disease so that Para rubber can be expected to be cultivated.

In the Maraba sub-region, due to plentiful rain, Para rubber, cacao and pepper are suitable in the northern and western parts, while in the southern cerrado part, pineapple and vegetables are suitable. With regard to Brazil nut trees which are concentrated in this sub-region, it seems necessary to enhance intensive use as a cultivated crop through introduction of new varieties of low trunk and high productivity, in addition to the current use.

In the Araguaina sub-region, which is in general of a cerrado-type environment, such relatively drought resistant crops as soybean, cotton, sorghum, and pineapple may be suitable.

In the Balsas sub-region, soybean seems to be the most promising crop.

Figure II-2 Suitable Crops by Sub-Region
(Based on Natural and Technical Conditions)



Finally, in the Xingu sub-region, which lies in the tropical monsoon zone with its abundant rainfall (similar to the Castanhal sub-region), Para rubber, cacao, guarana, and tropical vegetables are suitable. Since this sub-region is rich in fertile soil and has high potential of crop production, there is a possibility of large increase in the production of these crops in the future.

5. FARM STRUCTURE ANALYSIS

This chapter aims to clarify the features of the farm structure in the PGC Area and the cropping patterns of the sub-regions which are further dealt with in Chapter 7 of the Final Report. For this purpose, following a review of the existing studies included in the documents related to the Programa Grande Carajas Agricola and the PRODIAT Project concerning the Area, comparisons between the seven sub-regions and the whole country, and between the sub-regions themselves will be undertaken with a focus on: (1) the current use of land and labor, (2) trends in the production of main crops, (3) the distribution of farms by size, and (4) the form of land ownership. In this way, the position of the Area in the whole Brazil and the differences between the sub-regions will be clarified. The analysis in this chapter is based on the statistics of Brazilian Institute of Geography and Statistics (IBGE), Censo Agropecuario for the years 1970, 1975 and 1980.

5-1 Farm Structure in the PGC Area: An Outline

The purpose of this section is to summarize the farm structure in the Area by comparing its seven sub-regions with the nation as a whole. For this purpose, the farm structure has been divided into four elements as above mentioned. Regarding the current use of land and labor, comparison between the seven sub-regions and the whole country was made in terms of the area under cultivation (perennial and annual crops), the area of grassland (natural and improved pastures), the area of forests, unused arable land, and the ratio of land to labor. With regard to trends in the production of the main crops, in addition to the basic annual crops such as rice, maize and cassava, and the main perennial crops of cacao, coffee, oil palm and soybean, which have not yet been well developed, but which will play an important future role in the development of the Area, were studied in terms of the time serial changes in output and area to facilitate comparison between the seven sub-regions and the whole country.

Regarding the distribution of farms by size, farm sizes were divided into five categories (0 - 10 ha, 10 - 100 ha, 100 - 1,000 ha, 1,000 - 10,000 ha, and over 10,000 ha), and a distribution curve was constructed. Based on this curve, the features of the distribution patterns of the seven sub-regions were clarified. As for land ownership, the total number of farms was divided into four types: owners, tenants, occupants and administrators, and the percentages of each group were compared (The results are summarized in Section 5-3 below).

5-2 Farm Structure by Sub-region

This section clarifies the similarities and differences between the sub-regions in the Area. For this purpose the farm structure was divided into the four elements detailed above. In order to clarify the features of the sub-regions, comparison was made between the sub-regions (The results are summarized in Section 5-3 below).

5-3 Study Results

The results of the study analysis are as follows:

(1) The PGC Area has undergone rapid agricultural development since 1970 based on expansion of pasture and cropping areas. In the comparison between the seven sub-regions and the country as a whole, in terms of trends in the production of main crops, the production of the main crops in each sub-region showed a strong increase, largely due to the expansion of the area under cultivation, rather than to an increase in the level of yield.

The recent increase in the area of pasture is remarkable, especially in the state of Para which registered the highest increase in Brazil in the decade 1970-80. One of the reasons was that there remained much unused arable land and many forest areas in the Area, resulting in relatively cheap land prices; and a lot of public investment was made in infrastructure during the 1970s with the focus on transportation.

(2) Although the area for cultivation of crops and pasture has been rapidly expanded, a considerable part of the Area still has unused arable land and forests. Statistics prepared by IBGE based on the agricultural census shows that in 1980 the percentage of unused arable land and forests was about 35% of the total area on a national basis, and 60% on a sub-regional basis. Such a high percentage of unused arable land and forests indicates high potentials for the future development of the Area.

(3) The PGC Area is becoming a production area for beef cattle with the ratio of pasture area to cropping area exceeding the national average, suggesting that beef cattle production is being carried out with modern technology in relatively new and large farms.

(4) Rice, maize, feijao and cassava are cultivated by most small- and medium-scale farmers in each sub-region. Through the field survey, however, it was observed that the cultivation patterns of these four food crops vary from sub-region to sub-region, although, in general, they can be divided into three types: first, shifting cultivation in which farmers burn forests to cultivate the crops and shift to another place after harvesting; secondly, land rotation in which farmers burn forests to cultivate crops for a certain period of time (1 - 5 years), and fallow the land for 10 - 20 years in order to recover the fertility of the soil, after which

they use it again; and finally, sedentary agriculture in which farmers continue to cultivate crops on the same land each year without fallowing. The first and second patterns are seen in the Maraba and Araguaina sub-regions, where many forests still remain, while the third pattern is common in the Bacabal sub-region which is a relatively old settlement district, and the average area size is small.

(5) In the PGC Area, oil palm and soybean are the new promising commercial crops. The cultivation of oil palm adaptable to the weather conditions of the Castanhal sub-region began as a result of the rise in its price in the domestic and international markets in the second half of the 1970s. On the other hand, soybean began to be cultivated instead of pasture by some farmers at that time in the Araguaina and Balsas sub-regions. The popularity of soybeans reflected the fact that the new variety called "tropical," adaptable to the natural conditions of the sub-regions, had become commercial, and also reflected the tendency for the price of soybeans to rise.

(6) Despite being below the national average in 1970, the average size of farms in the seven sub-regions rose rapidly thereafter to exceed the national average by the second half of the 1970s. Compared with the national average, however, the pattern of farm-size distribution of the whole seven sub-regions is characterized by a high percentage of small- and large-scale farms and a low percentage of medium-scale farms, due to the remarkable differences in the distribution patterns of farm-size of the sub-regions with small-scale farms, namely Castanhal, Bacabal, Imperatriz and Balsas, and the sub-regions with large-scale farms, namely Xingu, Maraba and Araguaina. Also, it reflects the coexistence of large farms and small farms in each of the sub-regions.

(7) In terms of land ownership, the Area is remarkable for the number of occupants, due to the presence of many newly-developed districts where the land ownership system has not yet been established.

6. INSTITUTIONAL SYSTEMS RELATED TO AGRICULTURE

This chapter examines the major institutional systems related to agriculture, in terms of crop selection, formulation of producing areas, and realization of the development potentials of the PGC Area.

6-1 Outline of Institutions

(1) Farmland system

Progress in large-scale Agrarian Reform instituted under the Land Statute enacted in 1964 has been slow. Apart from the political resistance of large land-holders, the difficulty in implementing the

Reform is the complexity of the land ownership, occupation and utilization. This situation is especially true in the state of Maranhao and other PGC Areas.

The government is now making efforts to define land ownerhsip and utilization. In particular, the northern and northeastern parts of Brazil have received priority under the North and Northeast Region Land Distribution and Agroindustry Promotion Program (PROTERRA). Also in the Program for Integrated Area Development of Nordeste (POLONORDESTE) partly funded by the World Bank, land definition is an important component of the project.

Official settlement projects are carried out under the jurisdiction of the National Institute of Colonization and Agrarian Reform (INCRA) (in some regions, under GETAT) in combination with Agrarian Reform, and prior to settlement land ownership is certified. Fifty-four official settlement projects have been implemented since 1970 throughout Brazil, with project area totaling approximately 12 million ha.

Farmland tax (rural property tax) is used as a means for developing small- and medium-scale farms, and promoting rational and efficient land use, rather than simply as a means of national revenue. Provisions concerning this tax are contained in the Land Statute.

(2) Institutional Credit and Price Support

The current farm credit system, carried out as "The National Rural Credit System (SNCR)" under the Rural Credit Law of 1965, is composed mainly of preferential agricultural credit and the obligatory credit by commercial banks.

Rural credit expanded dramatically after the creation of SNCR, but after peaking in 1975, it was gradually tightened due to the worsening financial situation of the country. While total rural credit was as high as 105% of agricultural output in 1975, it dropped to 20% in 1982.

Following stringent government finance, the amount of the obligatory rural credit by banks, designed to enable the investment of private funds in agriculture, was gradually raised; the rate, which was initially 10%, now ranges from 10% to 55% (the rate varies according to the size of the bank).

As for preferential credit, in line with the national policies for fostering small- and medium-scale farms and improving land productivity, selective measures have been taken for credit standard, credit limits, and interest rates. In the financing of production costs, for example, high-yielding farms are eligible for larger amounts of loans than low-yielding farms.

Since the commencement of the price support in 1943, patterned after the U.S. Credit Corporation (CCC), Brazil has had considerably

long experience in the price support schemes of farm products. The basis of the current price support is the minimum price guarantee program (PGPM). PGPM covers main agricultural products and their processed goods (raw silk, grape juice, wine, cassava powder, etc.) except for coffee, sugar and wheat, whose prices are controlled by other schemes. PGPM involves government purchasing at a minimum price (AGF) and government loan using products as collateral (EGF). The latter is designed to prevent a fall in market price immediately after harvest caused by producers hasty sales. Conditions for the EGF loans comply with those under the SNCR above mentioned. In the AGF and EGF transactions in 1983/84, rice was the largest in terms of amount, followed by soybean, feijao and maize.

(3) Agricultural Cooperatives

About 1,000 agricultural cooperatives are now in operation in the country. Besides these active cooperatives, there are considerable number of non-operating cooperatives, especially in the state of Para. The main activities of the cooperatives are marketing and processing. Of the items marketed, soybean ranks first, in which 64% of the 1981/82 output was handled by agricultural cooperatives, and representing 25% of the total sales of the cooperatives. Milk, maize, wheat and rice were the other main items handled. There are about 600 agricultural cooperatives engaged in processing, mainly in dairy products, cotton and coffee.

Credit service is carried out by credit cooperative independent of agricultural cooperatives (there are about 100 agricultural credit cooperatives), but multi-purpose agricultural cooperatives may extend credit upon approval by the Central Bank. In addition, it is common for agricultural cooperatives to deal with credit in the form of advance payments for delivered products, and deferred payments for purchased materials. The government also extends loans as one of the forms of the above-mentioned EGF on the collateral of products collected by agricultural cooperatives in order to facilitate the marketing activities of the cooperatives (called Pre-EGF).

Agricultural cooperatives range from small local cooperatives with a few dozen of members to large ones with thousands of members. There is no nationwide federation as in Japan, but there are about forty federations consisting of several cooperatives each.

(4) Research and Extension

Research works on agriculture (including livestock and forestry) are conducted under the national research system centered on the Brazilian Agricultural Research Enterprise (EMBRAPA) under the jurisdiction of the Ministry of Agriculture. They involve the research institutes and experimental stations and centers of EMBRAPA, and the agriculture research corporations of the states. EMBRAPA has twelve regional and crop-wise research institutes. The Genetic Research Institute, the Food Processing Technology Center, Soil Survey Service and Seed Production Service also belong to EMBRAPA.

Extension works are carried out by the Agricultural Technical Assistance Corporation (EMBRATER) under the jurisdiction of the Ministry of Agriculture. State extension corporations and their district offices and local offices, under the supervision and assistance of EMBRATER, perform the extension services. There are about 3,200 local offices throughout the country.

Because of its huge area and poor road conditions, the number of farms that can be covered by the extension service in the PGC Area is limited. When the Imperatriz extension office was visited during the field survey, it was informed that it covered about 15% of all farms in the area.

6-2 Agricultural Institutions in Relation to Agricultural Development in the PGC Area

(1) Land system

Although land ownership certification is a prerequisite for development, it may take a long time to complete it in the huge PGC Area. For this reason, early implementation focusing on high-priority areas is required.

It is conceivable to incorporate perennial crops such as oil palm and rubber into farming operations in the PGC Area, or to develop major producing areas thereof, but ownership certification is particularly required because the planting of perennial crops requires long-term investment.

In the development of the PGC Area, it is essential that attention be paid to protection of the natural environment. The Land Statute stipulates that the fundamental purposes of development are natural protection and rational land use. The forestry regulations also stipulate strict measures for conservation. During the field observations, however, it was often witnessed that the summit and steep slopes which are not usable for agriculture or pasturage had been burned.

In the course of land distribution in the U.S.A. throughout the 19th century, the U.S. federal government reserved the public land for national forests, national parks, wild life reserves, etc., for natural protection. The total areas of the federal land accounted for about one third of the total land area of the country. Yet, problems of erosion and desertification have been arising in recent years. It must be fully kept in mind that tropical ecology is much more prone to such dangers than in temperate zone.

In order to preserve natural forest as much as possible, the productivity of the land already opened or planned for development must be as high as possible. Hence, productivity is a key element for selection of crops and areas for planning agricultural development of PGC.

In this regard, the type of shifting cultivation practiced in PGC Area is a problem both from conservation and productivity aspects. The present practice is said to result in natural destruction and concentration of land into large and extensive pasture of low productivity. However, the traditional long-cycle land rotation system practiced for centuries in the tropical areas in Southeast Asia is now revaluated because of its advantages of preserving natural ecology and of low cost agricultural production without fertilizers and other input.

(2) Institutional Credit and Price Support

The rural credit under SNCR rapidly expanded in the period of 1965-1975 and then continued to shrink. The demand for credit from small and medium farmers in the PGC Area was insignificant during the former period. And, when it began to emerge during the latter period, it coincided with the decreasing SNCR. It seems, therefore, that the small and medium farmers in the region had not been benefited much from SNCR, due to this time gap. Assuming that fund will be also be tight in future, preferential measures have to be considered to encourage small- and medium-scale farmers in the priority sub-regions of PGC.

Price support through the PGPM influences crop selection to a great extent because it encourages the production of favorably priced crops. At the same time, however, it discourages the produciton of other crops for which the prices are set relatively low.

It is notable that institutional credit and price support are jointly operated in a successful way. In recent years funds have gradually become tighter, with the result that there has been a shift in emphasis from credit policy to price policy. There are, however, functional differences between credit and price policies, so that the former cannot be replaced by the latter in all respects. For example, in the case of production credit, preferential measures for loan standard value (VBC) and credit limit are applicable for small- and medium-scale farms and high-productivity farms, but different support prices cannot be applied according to the producers category.

Preferential credit actually involves government subsidies, but, in one or another way, direct subsidies may possibly attain the same aim more efficiently. For instance, it is conceivable that for specified development areas, the provision of production material and equipment is extended to producers at subsidized price or free of charge under the guidance and supervision of extension service.

(3) Agricultural Cooperatives

The agricultural cooperatives in Brazil appear to be a mixture or co-existence of American and Japanese types. In the U.S.A., agricultural cooperatives are generally of large-scale, each covering a large area with a large number of members. Large-scale cooperatives have the advantage of scale-merit and are high in economic or managerial efficiency, but the cooperative spirit of the members are inevitably

low. Whereas, Japanese cooperative are of small-scale both in membership and covering areas. They are strong in cooperative spirit but weak in business efficiency. The lack of scale merit, however, is complemented by the federations organized on prefectural and national levels. It is hoped the agricultural cooperatives will grow in Brazil combining the merits of both types of cooperative system.

Whereas cooperatives are fairly well established in the southern and southeastern regions, they have not yet fully developed in the northern and northeastern parts. In the state of Para, in particular, there are many inactive cooperatives, with the reason being said to be the hasty formation of cooperatives "from top to bottom" in the Amazon development, despite the absence of human and physical infrastructure.

Agricultural cooperatives may play an important role in fostering independent small- and medium-scale farms aiming at commercial production in the PGC Area. Promotion of cooperatives in combination with SNCR, PGPM and extension service is expected in the Area. It must be kept in mind, however, that the formation of agricultural cooperatives should begin not with over-ambitious manner, but in realistic and steady way.

In the Mearim settlement in the state of Maranhao visited during the field observations, the Northeast Settlement Company (COLONE) operates a pepper processing plant, to which the settlers' agricultural cooperative sells the raw material. The plan is to transfer the plant to the cooperative when the managerial ability becomes sufficiently high to handle processing business. In the Paraense Agricultural Cooperative in the state of Para, the fresh fruit bunches of oil palm harvested by the members are sold by joint delivery to the nearby oil mill, but the cooperative plans to have its own mill as the production of fruits increase. It is conventionally thought that oil palm production cannot be operated economically without the integrated processing in a large estate farm, but a cooperative system of small farms in production and processing deserves attention as a new type of palm oil industry.

6-3 Research and Extension

The system of research and extension is fairly well organized in Brazil as a whole. In Brazil, a huge land with varying natural conditions, research and extension services should comply with the conditions of each region, but many of the extension pamphlets and teaching materials seen at the extension offices during the field observations had been uniformly and centrally prepared.

When implementing the Greater Carajas Program, it is particularly necessary to pay close attention to locating extension works in the selected priority areas to be developed, focusing their activities on small- and medium-scale farms. In such areas, it is recommended that the package development system be adopted in which extension services, SNCR and the formation of agricultural cooperatives are closely integrated.

7. AGRO-INDUSTRY

The purposes of this chapter are to clarify the current situation of agro-industry as a given condition of agricultural production, with a view to contributing to the selection of suitable crops and to examining the feasibility of developing producing areas in the PGC Area. In the study, agro-industry is regarded as the process to realize the value of agricultural products, and its current situation is analyzed in terms of what requisites should be established for producers to select crops, and on the problems confronting crop selection with particular focus on the processing sector conducive to creating higher value added and the marketing sector in which prices are determined.

7-1 Current Situation of Processing and Marketing of Agricultural Products

7-1-1 General Situation

Most of the major processing plants of agricultural products in Brazil are concentrated in the southeastern and southern regions, while in the northern and northeastern parts in which the PGC Area lies crop production is generally small and unstable compared with southern Brazil; therefore, the processing industry using agricultural products as raw materials has not fully developed. On the other hand, from the point of view of agricultural production, the absence of a modern agricultural processing industry is a disadvantageous factor for the agricultural management in the Area, which is far from the consumption centers and has poor infrastructure.

7-1-2 Characteristics of Products in Terms of Processing and Marketing

In this section, prior to the analysis of the current situation of agro-industry in the PGC Area, the characteristics of products will be examined in terms of whether quality will be considerably impaired and the bargaining power of producers will decline if products are not processed immediately upon harvesting. Agricultural products are roughly divided into three categories: (1) those requiring processing; (2) those not necessarily requiring processing; and (3) those for sale without processing. Crops belonging to the first category are oil palm, rubber, sugarcane and cassava, all of which are likely to decline in quality and incur reduced weight as time passes after harvest, and therefore, their value as commodities can be determined by the existence of local well-equipped processing facilities. The second category includes babassu, soybean and maize which, unlike those of the first category, can withstand relatively long-term storage and transportation, and their cultivation is possible even if there is no processing plant within immediate reach of the harvesting place, although there is problem concerning freight bearing capability. The third category includes tropical fruits and vegetables.

7-1-3 Current Situation of Processing and Marketing by Major Product

(1) Oil palm

In the areas centering around Belem in the state of Para (located in the Castanhal sub-region), oil palm cultivation is being undertaken by agricultural cooperative members in parallel with the development of plantations by private businesses. These areas are regarded as suitable for the cultivation of oil palm because of good natural conditions and favorable economic circumstances —— the most advanced infrastructure in the Area and favorable market prices. Furthermore, in terms of technology, the farmers have experience in commercial production and the related technical procedures. However, in addition to the acquisition of seeds and credits, the establishment of an oil mill is a crucial problem facing farmers in attempts to expand production and stabilize management.

(2) Babassu

In Maranhao, where babassu grows naturally (more than anywhere else in the country) and has an economically important position as a speciality crop, nut production depends solely on collection through an obsolete marketing system, causing problems in securing stable supply of material for the oil extraction industry. Moreover, the existing processing facilities, many of which are old and inefficient, are economically less competitive. The stabilization of the babassu industry requires improvements in the marketing system, the promotion of industrialization to enable the integrated utilization of babassu as well as the study of planting technology.

(3) Para rubber

The state of Para ranks high on a national basis in the production of Para rubber, most of which has to be obtained from native trees, and processed by extremely primitive methods. In addition, a poor marketing system has led to overall low productivity. In order to promote the cultivation of natural rubber in the Area with favorable natural conditions for cultivation, besides capital procurement, improvements in processing including technical improvement in the process from collection to processing, and in marketing are major tasks.

(4) Soybean

Although the production of soybean has only recently launched in southern Maranhao as a prelude to its future introduction into the north and northeast, the crop is already being crushed at an oil mill within the Area. Soybean requires no processing immediately after harvest, but in terms of transportation costs, proximity to the oil mill is advantageous, and at present it may be difficult to construct an oil mill on the cultivation site or sell in the southern and southeastern regions, and therefore it seems reasonable that production will aim at consumption inside the Area.

(5) Maize

Although maize is produced throughout the PGC Area, its most important feature is as a crop for self-consumption, being cultivated jointly with other subsistent crops such as rice and beans through land rotation, and the total output is not large. The demand for maize as a feedstuff inside the Area is supplied with the product from the south and central-west and for the time being, it is probably advisable to aim production at providing maize as a substitute for these imports.

(6) Cassava

Cassava, like maize, has been cultivated as a crop mainly for self-consumption in the Area, most of the output being processed into farinha (meal) to be eaten in or near the village. Judging from the present demand, there is little possibility of heavy consumption inside the Area or sales outside of the Area in the processed form such as pellets and chips of feedstuffs; but for mini-farms at least, it is essential that small-scale processing facilities and a distribution system be provided nearby so that cassava can be selected as a profitable crop.

(7) Sugarcane

While the sugarcane production in southern Brazil has been increasing due to the expansion of alcohol production, that in the PGC Area has been stagnant in recent years, and used almost exclusively for sugar production. To ensure the long-term expansion of its cultivation in the prospect of meeting the demand for alcohol, as is the case with other crops, capital procurement, and improvements in processing technology and the infrastructure are the major tasks.

7-2 Processing and Marketing of Agricultural Products and Crop Selection

The processing and marketing facilities necessary for farmers to select crops vary according to the form and scale of management as well as to the characteristics of products. Large- and medium-scale farmers undertaking commercial production may need relatively high levels of processing and marketing system to enable products to be more competitive in the market, while small-scale farmers who produce mainly for self-consumption may require, as measures to increase the commercialization rates most of the crop, small-scale processing and storage facilities and the dissemination of information. For these farmers not favored with such basic conditions as infrastructure, capital and technology, it is necessary to implement comprehensive programs for cultivation, processing, and distribution, for example, financing the construction of small-scale processing and storage facilities, the extension of technology and knowledge in combination with the credit, and the improvement in the marketing system, including transportation and information.

8. AN APPROACH TO CROP SELECTION ON THE BASIS OF SOCIAL AND ECONOMIC CONDITIONS

This chapter will try to undertake a preliminary crop selection and the establishment of producing areas, based on socio-economic conditions and from the point of view of agricultural development in the PGC Area. For this purpose, first, four farm models representing the fundamental patterns of agricultural management in the Area were constructed based on the results of analyses in Chapters 2 through 6 of the Final Report. Discussion on the conditions for crop selection and for realizing development potentials will be made by examining the influence of each condition on the level of farm income and cropping patterns for each of the four models. Then, a preliminary crop selection was attempted, based on the surrounding conditions of the Area and the characteristics of the major crops, with considerations of the development objectives.

8-1 Cropping Patterns and Farm Models

Based on the results of the analysis contained in Chapter 4 of the Final Report, the following four farm models were constructed to show the farm structure of the seven sub-regions and shed light to the major problems faced by farmers in these sub-regions. (i) A subsistence-farm model common in each sub-region; (ii) a medium-size perennial-crop model seen in the Castanhal sub-region; (iii) a middle-size soybean-farm model seen in the Balsas and Araguaina sub-regions; and (iv) a land rotation model used to show the transitionary process from shifting cultivation to sedentary agriculture. These will now be described in more detail.

(i) Subsistence-farm model

Method of analysis:	Linear programming
Land area:	5 ha
Labor:	Three family workers
Crops:	Rice, cassava, maize, and feijao
Other variables:	Lower limits of production needed to secure self-consumption food (a 7-member family)
Objective:	Cash income

The above model is designed to allow the examination of (1) the impact of fluctuations in product prices and (2) the impact of technical improvements.

(ii) Medium-size perennial crop model

Method of analysis:	Cost-benefit analysis
Area:	200 ha
Crop:	Oil palm
Technical data source:	Agricultural Cooperative at Castanhal

This model is designed to examine the conditions necessary for establishing producing areas for oil palm, given the situation that the medium-size oil palm production is technically feasible in the

Castanhal sub-region where the natural and technical conditions are favorable.

(iii) Middle-size soybean-farm model

Method of analysis:	Cost-benefit analysis
Area:	500 ha
Crop:	Soybean

Reflecting the recent trends in price and technology, there is a movement among middle- and large-size farms at Imperatriz, Balsas, and Araguaina towards soybean cultivation. Although soybean production seems profitable, soybean farming faces a number of problems: a huge amount of investment required for purchasing machinery and equipment; large working capital; and the impact on management decisions of transportation cost. The model is designed to clarify the conditions necessary for soybean production through a cost-benefit comparative analysis of beef cattle and soybean production.

(iv) Land rotation model

Method of analysis:	Linear programming
Area:	100 ha (including 50 ha of forests)
Labor:	Three family workers
Crops:	Rice, cassava, maize, and feijao
Cropping pattern:	Land rotation

This model is designed to prove that traditional land rotation is appropriate to the present situation in which land area is large and the price of inputs like fertilizer is high, and to specify the conditions facilitating the shift from shifting to sedentary agriculture.

8-2 Analysis Results

The results of analyses based on the above four models can be summarized as follows:

(i) Estimates were obtained for the subsistence farm model by artificially fluctuating the prices and yield of crops. As a result, it was apparent that: crops which become profitable in terms of the farm gate price through improvements in transportation and price support policy will be cultivated more; farm income will be improved to some degree as the level of farm technology rises through improving extension service; and though those crops which become disadvantageous in terms of the above conditions will be reduced in respect of output and cultivated area, their outputs will not be reduced below the level required for securing self-consumption.

(ii) The perennial crop model revealed that oil palm is promising crop in terms of its being able to raise farm income, but the expansion of this crop's production largely depends on the availability of investment capital. According to data from the Castanhal Agricultural

Cooperative, it takes five years from the time of planting to the harvest. Calculated at August 1984 prices, the cost per ha is Cr$2.13 million in the first year, Cr$684,000 in the second and third years, Cr$930,000 in the fourth and Cr$1,056,000 in the fifth; the cumulative cost during the first five years being Cr$5,485,000. On the other hand, the harvest is estimated from the past results at 5 tons/ha on average in the fifth year, 10 tons in the sixth, 15 tons in the seventh, and 20 tons in the eighth and following years. The expected gross profit per ha on a basis of Cr$170/kg is Cr$0.85 million in the fifth year, Cr$1.7 million in the sixth, Cr$2.55 million in the seventh, and Cr$3.4 million in the eighth. Under these circumstances, it will take about ten years for investment to be returned from farm income when there is no interest, while it will take thirteen years given an interest rate of 20%. The cost-benefit analysis showed that an oil palm project would be feasible under reasonable assumptions on market, transport infrastructure, oil mills and financing conditions. However, the project's feasibility would be largely affected by changes in these conditions.

(iii) The results obtained from the comparison between beef cattle and soybean production showed that the feasibility of soybean farming at Imperatriz, Araguaina and Balsas also depends largely on the conditions of market, transport infrastructure, oil mills and financing.

(iv) The application of the land rotation model showed that a farmer with a planted area of 50 ha will initially choose land rotation under certain conditions, and gradually shift to sedentary agriculture as the conditions change, for example, a fall in the price of fertilizer, an increase in family members, or easier access to investment funds for perennial crop cultivation.

8-3 Preliminary Crop Selection on the Basis of Social and Economic Conditions and Necessary Conditions for Agricultural Development

The selection of crops for certain specific region is to search for a combination of crops which is (1) consistent to the aims of agricultural development in the region as well as to the objectives of farm units which are the core of agricultural production, (2) under the current situation and foreseeable changes of the various conditions surrounding the agricultural sector, and (3) various attributes of crops with respect to cultivation and marketing.

Regarding the objectives of development in the PGC Area, based on the basic lines of the Inception Report and results of the field observations the following aspects were taken into considerations: (1) realization of the potential of land resources, (2) raising the living standards of small-scale farm and immobilizing shifting farmers, (3) strengthening the competitiveness of commercial crops, and (4) conservation of natural environment.

The special features of the PGC Area and its sub-regions were expressed in terms of present situation and foreseeable changes in the

socio-economic conditions surrounding crop production. The main factors considered here are availability of land for cultivation, land-ownership, size of farm units, labor endowment, levels of production techniques, access to markets, situation of transport and marketing infrastructure, and situation of processing facilities.

Regarding the major characteristics of crops, the socio-economic characteristics of the crops considered most suited to the natural and technical conditions (results of the study in Chapter 3 of the Draft Final Report) were examined in terms of degree of requirement of labor, capital and technology, necessity of processing, and freight bearing capability.

In light of the characteristics of each sub-region and of each crop, a preliminary selection of crops to be given priority for promotion was made with considerations of the above-outlined objectives. Although for selecting the specific crops suitable for production in the sub-regions of the PGC Area in terms of socio-economic conditions, still more factors and information are necessary, the tentative results of the selection is summarized in Chapter 2, "Outline of the Study."

9. LIVESTOCK (BEEF PRODUCTION) DEVELOPMENT

The purpose of this section is to clarify the current beef cattle production in the PGC Area and the factors to be considered for future beef cattle production development. The analysis of the current situation focuses on the beef cattle production system, pasture utilization, beef cattle production technology and the marketing system. The work is mainly based on statistical data and study reports such as IBGE, Censo Agropecuario (three years of 1970, 1975 and 1980) and the CIAT (International Center for Tropical Agriculture) Report.

9-1 Beef Production and the Position of the PGC Area in Brazil

With almost as many cattle as people spread across its huge land area, Brazil is one of the world's leading beef producers.

The main purpose of cattle raising is to produce beef, but the ratio of slaughter (the percentage of cattle slaughtered to cattle raised) is as low as 12% compared with other beef producing countries due to poor productivity. For this reason attempts were made to balance demand and supply through imports in the years when demand and supply in the domestic beef market was tight.

The number of cattle raised increased annually during the 1970s by an average of 2.17%, and 79% of the total (in 1980) was raised in the southeastern, central-western and southern parts of Brazil.

Of the three states making up the PGC Area, namely Para, Maranhao, Goias, Goias is one of the major domestic beef cattle producing areas,

while both Para and Maranhao have a level of 2 million cattle each, representing only 2% of the domestic total, and thus reflecting their low position in beef cattle production.

The increase in the number of cattle in these regions after 1975, however, has substantially exceeded the national average, while the increases have flattened out in the advanced southeastern region. Judging from the improvements in the grassland areas, trends in beef cattle production in parts of the PGC Area suggest the emergence of a newly developed producing area, even though various problems are involved.

Almost half of the usable area in Brazil is used for agriculture as pasture, with the focus on grassland livestock raising, particularly beef cattle. Livestock production in the three states is low compared to other advanced regions in terms of production value, but it is significant to mention that the weights of livestock production are high and specially the degree of specialization in beef production is high compared to that of other industries within each of these three states.

9-2 Current Situation of the PGC Area

The analysis of the current situation of the PGC Area was based on (1) materials collected during the field observations, (2) reports of international research institutes, and (3) information obtained from EMBRAPA and EMATER experts and the federal government officials.

Few materials were, however, available for the analysis of each of the sub-regions. Grass production affected by climate and soil is the basic difference between the tropical humid-type and cerrado-type regions, but there are fundamentally no major differences in terms of other factors relating to beef cattle production between the sub-regions. Thus, the report aims at qualitative analysis and description of the Area, including analysis of some sub-regions (Maraba, Imperatriz, Araguaina) of which some data are available.

(1) Land utilization and pasture development

The whole PGC Area has a high percentage of forest and unused land. Pasture takes up 47% of the total area of the Araguaina sub-region, a level almost equal to the national average and higher compared with the other two sub-regions, while the percentages of Maraba and Imperatriz are still as low as 24% and 35% respectively, indicating large potential for future development. On the other hand, the proportion of pasture in farmland is remarkably high (around 80%), and land utilization is concentrated on pasture for beef cattle production.

The three sub-regions have a very high percentage of improved pasture, with the figure for Maraba being 96%, remarkably high compared to the national average of 35%. Forty-four percent of the entire pasture area in Para is concentrated to farm units of sizes over 5,000 ha. This tendency of land concentration to large-scale farms is remarkable and seems to be due to the inflow of people in the southern and central

advanced regions with access to capital and technology. These people have moved into southern Para for the following reasons: expectation of future development of the northern and northeastern regions, expansion of pasture by acquisition of cheap land, trunk road construction, and SUDAM financial incentives (incentivo).

(2) Types and size of beef cattle farms

According to the agricultural census, beef cattle management in Brazil is classified into seven types, including the basic types of breeding, rearing and fattening, as well as combination types. Of beef cattle producers, 43% are of the breeding type, 21% the rearing type, 8% the fattening type, and the remaining 28% comprising the combination types.

There are many differences in the number of cattle by type with breeding being operated on a small scale and fattening on a large scale. In particular, the scale of integrated operation of breeding, rearing and fattening is outstandingly large.

Fattening operation and integrated operation of breeding, rearing, and fattening in Para are operated on a large scale compared with the national average, though they do not surpass Goias as an advanced production area, presumably due to the establishment of new large-scale cattle farms in southern Para by new comers.

The structure of beef cattle raising in Brazil can be classified into two extremes: a large number of small-scale farms and a small number of large-scale farms. About half the producers own less than ten head of cattle, 68% own less than twenty head, and 84% less than 50 head, although these producers (raising less than fifty head) share only 20% of the total number of cattle. Those having more than 500 head of cattle account for only 1.5% of the total number of producers, but they raise 40% of cattle, and the group with 1,000 or more raises 27% of the total number of cattle. Small-scale farmers are adopting combined farming with other product items.

The above-described diverse raising structure brings about some difficulties to the modernization of beef cattle production and the stabilization of beef demand and supply. It seems that the problems of beef industry cannot be overcome by policies based merely on economic efficiency.

(3) Productivity level and its explanatory factors

Productivity is low in beef cattle production across the country as the first calf is born relatively late, parturition interval is long, and the mortality of calves is high. The time period prior to slaughtering is long, and the carcass weight is low. Although there is problem concerning low quality of cattle, the fundamental factors explaining this low productivity are poor nutrition owing to pasture management, and inefficient breeding.

In natural pasture and even improved pasture, grass production is gradually declining due to a lack of fertilization, and grassland is being devastated by naturally growing palm and ever-green trees as a result of over stocking. For this reason, stocking capacity will fall, and the economic efficiency of grassland declines dramatically. Cattle are said to be the product of the soil, and improvement in the productivity of beef cattle production depends to a great extent on improved pasture management.

It is considered that such special measures as special technical guidance and financing are required for pasture development and administration to achieve effective land use, continuous natural ecology, and preservation of national land.

(4) Cattle marketing and slaughter

Cattle are traded from many breeding farms to a few fattening farms either directly or through dealers. Fattened cattle are transferred for slaughter in the southern and southwestern regions where there are large slaughterhouses in the hinterland of the major consumption areas. Because of the small number of beef cattle, very few slaughterhouses in the PGC Area have large-scale operations or modern facilities.

The government is devoting its efforts to the modernization of slaughter facilities, and as a result the total capacity of slaughter in Brazil is presently exceeding the number of cattle for slaughter. There is a problem that, due to the curtailment of small-scale slaughterhouses, about 30% of all slaughtered cattle are being consumed without going through inspection by the Federal Government.

In order to compete with the advanced beef cattle production areas elsewhere in Brazil, the development of the PGC Area requires the establishment of producing areas on a scale sufficient to ensure the profitability of slaughterhouses and examination of favorable location for slaughterhouses.

9-3 Perspectives of Beef Cattle Production in the PGC Area

(1) Importance of beef cattle

Beef cattle is an important production item in the PGC Area, given the following conditions: the amount of available land, the shortage of skilled agricultural workers, the relatively cheap price of land, market conditions of agricultural products, and poor infrastructure network, as well as the demand and supply situations in the international and domestic beef markets.

(2) Necessary Considerations in Promoting Beef Production

(i) Role of PGC Area in Brazilian beef production

In recent years there have been considerable fluctuations in the pattern of Brazilian meat consumption: a decrease in beef con-

sumption and an increase in poultry consumption. It is necessary to examine a long-term outlook of demand and supply and to clarify the desirable position of the Area in Brazilian beef production.

(ii) Beef cattle producers

It is necessary to undertake studies to determine where emphasis should be placed —— on the efficiency of beef cattle production, on beef cattle development from the viewpoint of social policy, or equally on both —— so that the types of producers to be promoted can be clarified. The entrance of new settlers from the south and central parts of Brazil into large pasture areas in the southern part of Para should be considered as an important factor in determining this policy emphasis.

(iii) Improving cattle quality and pasture productivity

Financial measures suitable to the long cycle of beef cattle production, and enhancement of extension service for promoting various technologies established in research institutes seem necessary, in particular for small- and medium-scale producers.

(iv) Improvements in production environment

Since farmland is developed closely with the transportation network, consideration is desirable to be given to the establishment of main producing areas and suitable infrastructure such as feeder roads and slaughter facilities, and to avoid extensive and scattered development of grassland which raises transportation costs and reduces the profitability for beef cattle producers and the competitiveness of slaughterhouses.

10. FORESTRY DEVELOPMENT

This chapter aims to clarify the current situation of forest development in the PGC Area, and to discuss development in terms of the effective use of forest resources and conservation of environments. The analysis of the current situation looks at forest resources, forest exploitation, forest industries and reforestation. Discussion will center on site classification, forest production, reforestation and the introduction of agroforestry and forest industries.

10-1 Background of Forestry Development

10-1-1 Situation of Forest Resources

The forests in the PGC Area lie in the belt that stretches from the northwest district to the southeast district. They fall into three types: (1) tropical humid forests, (2) tropical sub-humid forests, and (3) tropical semi-humid ∿ semi-arid forests.

The first type constitutes part of the Amazonia forest, one of the world's three great tropical rain forests, along with the tropical humid forests in Southeast Asia and West Africa. The Amazonia forest resources, compared with those in Southeast Asia which are most utilized in the world, are very good in terms of the timber quality of the tree species, although they are characterized by heterogeneity of tree species. The growing stock per unit area in the region tend to rather poor. For this reason, forest resources are considerably underutilized at present, compared with the rather homogeneous and rich forests with Dipterocarpaceae in Southeast Asia.

The second type, the intermediate zone between the tropical humid forests and the semi-humid forests, is relatively high in the utilization of timber resources because the forest is located in a readily-developed region, though its growing stock is inferior to that of the humid forests.

The third type of forest, cerradao and cerrado mixed with deciduous trees is highly evaluated for its function of protecting the natural environment, though the value of its timber resources in terms of quality and stock is low.

10-1-2 Forest Exploitation

Forest exploitation in the PGC Area is carried out in the form of conversion of forests into farmland (clearing and burning) and forest utilization as forestry (logging operations). In the former, clear cutting is operated, fallen trees except for some commercial tree harvests are burnt, and farmland is widely developed, causing a rapid deforestation. The Forest Code stipulates that one half of the natural forest in the area of colonization should be conserved, but forest conservation is not sufficient, and there are many cases of large areas of pastures and farmland lying continuously, because the Code does not specify which individual forests are to be conserved. Effective measures for forest protection still must be reinforced.

In terms of forest utilization as forestry, because almost all the forests in the region are natural, timber is being harvested by selective cutting. Accordingly, as far as logging operations are concerned, forests are rarely destroyed or depleted. The task for the future is, however, the securing of a technically rational natural forest management system for timber harvesting and the prevention of forest degradation.

10-1-3 Current Situation of Forest Industries

Forest industries in the PGC Area will be described in terms of logging operations and the timber processing industry involving sawmills and plywood mills. Logging operations in the Area consist of extraction and transportation by the residents in traditional ways while timber processing companies directly operate mechanized timber extraction and transportation. In both cases, there is no enterprise specializing in

logging, and for this reason current log production and productivity are at low levels due to the existence of the heterogeneous forests and poor infrastructure, even though the Area has abundant forest resources.

Timber processing is mainly operated by sawmills and plywood mills. The advantage of the industry includes the large availability of resources; good-quality tropical hardwood used as fancy wood is available as raw material; and stumpage and log price are low compared to international standards. The disadvantages of the industry are that the homogeneous tree species of light hardwood (floater) do not grow in form of concentration; processing technology, standardization, and marketing are underdeveloped; and the consumption centers are distant.

10-1-4 Current Reforestation

In the PGC Area, artificial reforestation is remarkably poor compared with the southern states. In the humid forest zone in the Area, forests are mainly being sustained by natural regeneration, but this natural forest management system, now at an experimental stage, has many problems to be resolved, both technically and economically.

The districts surrounding the Bacabal, Imperatriz, and Maraba sub-regions are relatively well-developed in the sub-humid zone of the Area and are in the first stage of artificial reforestation with Eucalyptus. Accordingly, the development of artificial reforestation that has taken place in Sao Paulo and Minas Gerais can be expected in the near future.

10-2 Comments on Forestry Development

In the Area there are many valuable forests constituting a part of the world's largest tropical rain forest, the Amazonia Forest; and it is desirable to strongly emphasize forest conservation in the development of the Area through appropriate natural forest management. From this standpoint, the following discussion on the relationship of development and location is made.

10-2-1 Site Classification in Forestry Development

Strategies for forestry development in the PGC Area are considered in terms of the following location groupings.

As mentioned in Section 10-1-1, there are three forest zones: tropical humid forest - H; tropical sub-humid forest - S; and semi-humid forest - A. The Castanhal sub-region and the lower basins in the Maraba and Xingu sub-regions belong to the H-zone, the Bacabal and Imperatriz sub-regions and the upper basin of the Xingu sub-region belong to the S-zone, and the Balsas and Araguaina sub-regions belong to A-zone.

These zones are further sub-divided into two sections: (a) areas with favorable transportation conditions between the logging site and

processing site or market, and (b) areas devoid of such conditions. In this way, there are six combinations of the above-mentioned zones and areas: H-a, H-b, S-a, S-b, A-a and A-b. Each of the six site classes will be described below in terms of forest exploitation, reforestation and the introduction of agroforestry.

10-2-2 Forest Exploitation

As already mentioned, forests in the Area will be basically conserved. In this sense, it is recommended that forest utilization for agricultural purposes should be carried out specifically in the major areas that have favorable natural and infrastructure conditions. Under this presumption and in considering forest utilization relative to location (for forestry and agriculture) in terms of the afore-mentioned site classes, several conclusions can be drawn. The following are the development strategies for forests for agriculture and forestry uses.

In the H-a site class, active development seems possible to achieve the effective utilization of forest resources and greater land use; at the same time, it is recommended that specific forests be set aside for natural conservation, and that natural forest management be strengthened as a principle, although artificial reforestation is desirable to be carried out where necessary in order to rehabilitate and increase the value of forest resources.

In the H-b site class, forest conservation will be fundamental policy, and utilization for agriculture and forestry will remain passive until the utilization of tropical forest resources in the twenty-first century.

In the S-a and S-b site classes, forests are being intensively converted into farmland. Therefore, it is desirable that natural forests will be preserved through the designation of protected forests according to natural conditions, and promoting artificial reforestation in the areas where natural forests have disappeared or degraded.

In the A-a site class, many areas of forests have already disappeared. It is desirable that measures be made to protect the remaining forests and enrich their quality, and to develop man-made forests for public interests such as environmental conservation.

In the A-b site class, the existing forests should be preserved as much as possible for environmental protection. Although the establishing of man-made forests with Eucalyptus spp. and Prosopis spp. which are drought resistance is desirable, commercial reforestation seems difficult for the time being because of prevailing economic and natural conditions.

The most important principle of forest exploitation for any site class seems to be that measures to secure proper forest development in compliance with laws and regulations should be reinforced; for example, a concrete system such as designating which forests to be reserved should be examined so that the designated forests can be fully protected by the restriction of forest exploitation.

10-2-3 Forestry Industries

Since the current logging business in the Area is underdeveloped and unorganized, it needs to be modernized to achieve higher productivity and rational forest management. In order to make utilization of the huge amount of logging residues unused and burnt in logging operations, easing and expanding the restrictions on log exportation deserves consideration.

As for timber processing industry, forest products with high value added can be produced and exported by improving quality through improvements in equipment, standardizing, quality grading, and marketing.

There is no pulp or alcohol industry using wood as a raw material in the Area, but the development of these kinds of industries can be anticipated with the development of man-made forests with Eucalyptus spp. in the future and the construction of the infrastructure such as roads.

10-2-4 Reforestation

To implement reforestation in the Area, the following silviculture systems are conceivable for each zone.

H-a site class: In principle, reforestation is based on natural forest management (involving enrichment planting according to conditions) by the shelter wood system. To promote the utilization of lesserknown tree species and thereby enrich forests, exempting the harvesting of these tree species from restrictions on harvest deserves consideration.

In this site class capoeira forests degraded due to past logging operations and shifting cultivation will be artificially rehabilitated with non-fast growing species by line planting such as the Recru and Anderson methods. When conducting clear cutting and artificial reforestation in this site class, the availability of access to market for the produced goods should be considered.

H-b site class: This is principally the area where efforts should be made for the time being to preserve virgin forests as a source of timber production in the future. For some types of forest exploitation, selective cutting and natural regeneration should be adopted under a well-managed system.

S-a site class: Efforts should be made in preserving the remaining natural forests, but when forests are disappeared or degraded, artificial reforestation would be undertaken with Eucalyptus, Pinus and, other fast growing species or high-quality hardwood species for plywood.

S-b site class: Efforts will be made in preserving the remaining natural forests, but when developing the areas for forestry or agriculture is attempted, silvicultural works in natural forest or artificial reforestation by line planting is desirable.

A-a site class: In this area, the conservation of natural forests should be emphasized, but it is desirable that degraded natural forests be improved into rich forests by artificial reforestation. In this case, drought resistant and fast growing species like Eucalyptus and Acasia spp. would be mainly used. When stand improvement is made by artificial reforestation, a restriction of 50% of the forest area may be worthy to reappraise.

A-b site class: Efforts should be made in maintaining and improving the existing natural forests. Artificial reforestation with fast growing species may be considered after roads are improved.

It is often thought that the establishment of man-made forest that rises homogeneous forest is unwise in any site class, but it is recommended that this method be emphasized as compensation for the disappearance and degradation of the present natural forests.

10-2-5 Introduction of Agroforestry

The following proposals are made as models of agroforestry to be introduced in each site class:

H-a site class: Fast growing trees (shade trees) + cacao, Brazil nuts, non-fast growing trees (sawtimber) + rice, maize, etc. (intercropping)

H-b site class: Attempts will be made upon necessity to rationally systematize shifting cultivation, though in principle this area is not included under agroforestry.

S-a site class: Fast growing trees (shade trees) + coffee (on the fertile soil)
Non-fast growing trees (sawtimber) + annual crops (intercropping)

S-b site class: Babassu + native pasture

A-a site class: Fast growing trees (fodder trees, firewood) + improved pasture

A-b site class: Not covered by agroforestry

10-2-6 Introduction of Agro-industry

The production of charcoal and mold fuel wood by the utilization of logging or mill residues occurring in the Area is considered to be a promising agro-industry if the results of modernization, reorganization, and marketing research are favorable.

〔Ⅲ〕 STUDY OF MINERAL RESOURCES DEVELOPMENT

1. INTRODUCTION

The exploration of mineral resources in the PGC Area is most advanced in the Carajas Mountains (Serra dos Carajas) area and in the bauxite region of Paragominas and kaolin region of Rio Campim. In the former area and its vicinity, a number of deposits of different ore types have been found embedded in Grao Para Group and Rio Fresco Formation as well as in the granite and ultrabasic bodies that intrude into the former two geologic units.

Accordingly, an attempt was made to identify areas that exhibit similar geological characteristics to those of the Serra dos Carajas area on the basis of the analysis of the data and information related to the particular geology that embeds various types of ore deposit. Among other areas, the probability of the existence of mineral ore deposits is considered especially high in the following three areas:

2. MAJOR FINDINGS

2-1 Inaja Area

In the Inaja area which covers the mountain range of Serra Inaja, gold (Au) is the only mineral resource currently mined at a small scale and no other mineral resources have been discovered. The geological analysis in the Phase II Study, however, revealed that the area has similar geological characteristics to those of the Serra dos Carajas area and, therefore, the probability of the existence of ore deposits such as copper (Cu), nickel (Ni) and tin (Sn) in addition to Au is considered very high in this area.

The geology of the Inaja area consists of Xingu Complex, Grao Para Group, Rio Fresco Formation and Gorotire Formation. In addition, two kinds of granite are widely distributed in these geologic units. The Grao Para Group in this particular area is intercalated with metabasic volcanics and iron formations and thereby resembles the rock facies of the Grao Para Group of Serra dos Carajas.

Grao Para Group and Rio Fresco Formation are distributed in the N-S direction in and to the west of the mountain range of Serra Inaja. These geological strata exhibit a tendency to continue to the Serra dos Gradaus area. The analysis of airborne magnetic and radiometric surveys revealed that magnetic anomaly is distributed along Serra Inaja, indicating the existence of iron formations and metabasic volcanics of Grao Para Group. Furthermore, the distribution of circular intrusive bodies in three parts of the western edge of Serra Inaja corresponds to the distribution of low thorium (Th) areas as identified in the airborne radiometric survey, suggesting the probability of the intrusive bodies such as alkaline intrusive rocks. Geochemical exploration results also indicated that there is the anomaly of Cu-Ni-Co along the Grao Para Group of Serra Inaja.

2-2 Bacaja Area

No geological or geochemical data are available to make it possible to evaluate the potential of mineral resources in the Bacaja area in a comprehensive manner. It is known, however, that metabasic-amphibolite is distributed in and around the Rio Xingu and that quartz veins accompanied by gold (Au) mineralization is distributed around the granite that intrudes into the rock body.

Our analysis of the Landsat images and geophysical surveys suggests that Grao Para Group is probably widely distributed in the Bacaja area. Further, the airborne magnetic survey analysis indicates that magnetic anomaly of the same scale as that of the Serra dos Carajas area is widely distributed to the north of the NE-SW fault that cuts across Serra dos Carajas. As the distribution of magnetic anomaly seems to correspond to that of Grao Para Group, the probability of the existence of mineral ore deposits in this area is considered very high.

2-3 Serra dos Gradaus Area

This area covers the mountain ranges of Serra dos Gradaus, Serra da Seringa and Serra das Andorinhas. In Serra das Andorinhas, DOCEGEO's exloration discovered the mineralization of gold (Au), lead (Pb) and copper (Cu), in addition to iron formation. At Cumaru to the south of Serra dos Gradaus, Au is mined by diggers (garimpeiros). According to DOCEGEO, the metabasic volcanics distributed in Serra dos Gradaus and Serra dos Andorinhas are considered to consist "greenstone belt" sequences incorporated in Xingu Complex.

However, our analysis suggests that the metabasic-volcanics sequence seems to correspond to the Grao Para Group distributed in the Serra dos Carajas area. In addition, Rio Fresco Formation and numerous granite rock bodies are distributed in the Serra dos Gradaus area. It is therefore quite reasonable to assume the existence of Au, Cu, iron (Fe), manganese (Mn), tin (Sn) and other mineral resources in the area.

The granite of Serra da Seringa and Serra dos Gradaus is classified into the Carajas Granite type and has been considered to have no particular connection with Sn mineralization. However, the radiometric survey analysis revealed the distribution of a number of thorium anomalies of small scale around these granite bodies, in the same pattern as recognized in the area between Serra das Andorinhas and the east of Serra dos Carajas. Since it is considered that these thorium anomalies suggest the existence of the granite type known as "Velho Guilherme Granite" which accompanies Sn mineralization, the probability of the existence of Sn ore deposits is particularly high in the Serra dos Gradaus area.

3. FUTURE EXPLORATION PROJECT IN THE GREATER CARAJAS PROGRAM AREA

In general, a particular method of exploration is chosen in views of the current state or stage of mineral exploration and of geological conditions as well as types and forms of ore deposit assumed to exist in the area concerned. From these viewpoints, the PGC Area can be described as follows:

- Mineral exploration in the Area is at the stage of reconnaissance and regional geological survey.

- Grao Para Group and Rio Fresco Formation as well as the granite and ultrabasic bodies that intrude into the former two geologic units, provide for the major geological environment for mineral resources in the Precambrian section of the Area.

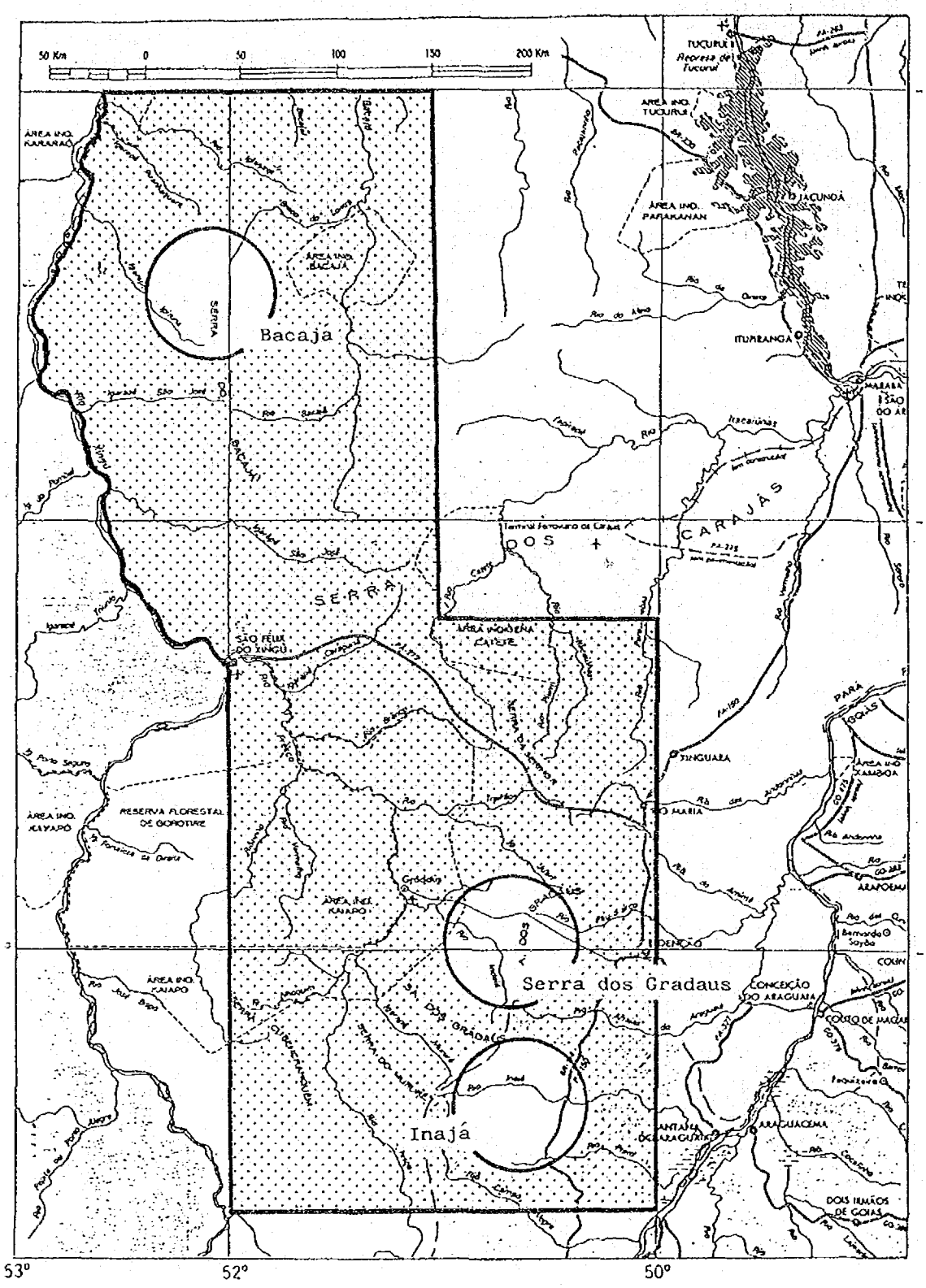
- The major types and forms of mineral resources expected to exist in the Area are copper ore deposits of the impregnate type, placer deposits of gold and tin, lateristic deposits of nickel and manganese, bauxite and rare earth mineral deposits associated with the intrusive rocks. Other potential deposits are copper and nickel ores of the massive sulphide type, zinc ore, wolframite of vein and alluvium types, asbestos in the ultrabasic bodies, as well as minerals of the platinum group.

As pointed out in the outset, three areas (Inaja, Bacaja and Serra dos Gradaus) are some of the most promising areas in which major efforts shall be concentrated, besides the Serra dos Carajas itself. Other areas such as the Precambrian section at the Maranhao-Para states border and the Araguaia river region, both in Para and Goias states, not studied in detail in this report, must be not overlooked. Although some geological and geochemical surveys have been carried out in and around these areas, these surveys actually covered only a small portion of the areas under discussion and the data obtained in such surveys are not necessarily reliable. As a result, not much is known at present as to geological and geochemical characteristics of the three areas. Therefore and in due consideration of economic efficiency, it is recommended that a super-regional geochemical and geological survey covering all the three areas shall be carried out. As described hereinunder, this super-regional survey aims to clarify geological characteristics, geologic units and structural sequences or anomaly distribution of a particular mineral or minerals and to define the most appropriate exploration method for the exploration sites to be pin-pointed by the super-regional survey.

3-1 Recommended Project

Figure III-1 shows the area of approximately 100,000 km^2 including Inaja, Bacaja and Serra dos Gradaus for which the super-regional geological and geochemical survey is recommended. The project being recommended will prove to be highly important to formulate a comprehensive mineral resources development program for the western side of the PGC

Figure III-1 The Recommended Area of Regional Geological and Geochemical Survey



Area since the probability of various kinds of mineral (e.g. Cu, Au and Sn) being discovered in the proposed project area is considerably high. The following is an outline of the proposed project:

(1) Area: Approximately 100,000 km^2

(2) Objective

To carry out a series of geochemical studies of stream sediment samples as well as geological surveys of the Area and to compile a comprehensive geological map and a distribution map of metal elements.

(3) Basic Map: 1:250,000

Compilation of a new drainage map based on the radar images of RADAM Project is required since the existing drainage map compiled by DNPM is so roughly drawn that it cannot be used for the proposed project.

(4) Survey Team and Duration of Project

A total of twelve (12) geologists and geochemists organized into five field survey teams can work on the project for the duration of three to four years.

(5) Geological Survey

- Compilation of Geological Maps at scales of 1:250,000 and 1:1,000,000
- Collection of rock samples for thin-section: 180 samples
- Collection of ore samples for polished-section: 100 samples
- Chemical analysis of rock samples: 110 samples
- Chemical analysis of ore samples: 80 samples
- Measurement of geologic ages of samples: 80 samples

(6) Geochemical Survey

(a) Sampling

- Stream Sediment: 5,000 samples (Sampling Density: 15-20 km^2/sample).
- Panning Samples: 1,000 samples.

Sampling points shall be selected on the new drainage map (1:250,000) at the sampling density of 15 - 20 km^2/sample. For those areas outside the drainage basin, panning sampling shall be used. Although a higher sampling density is generally preferred for

the purposes of geochemical survey, the above density is considered reasonable in view of the scales of geologic units and ore deposits expected to exist in the Area. In addition, the Area is not quite accessible to permit sampling at higher density. It is expected that this regional geochemical survey will effectively reveal target areas in which more detailed surveys may be carried out.

(b) Geochemical Analysis

- Stream Sediment: Elements to be analysed include Au, Cu, Zn, Sn, Ni, Co, Cr (and rare elements, if necessary)

- Panning Samples: Semi-quantitative analysis for 30 elements and quantitative measurement of heavy minerals

3-2 Exploration Method for Each Area

Under the current circumstances, the following methods and contents of exploration are considered most appropriate for each of the three areas - Inaja, Bacaja and Serra dos Gradaus, although these are to be re-defined and refined in detail in respect to the scope, contents methods of exploration on the basis of the super-regional geochemical and geological survey discussed above.

(1) Inaja Area

Geological, geochemical and geophysical methods are recommended as follows:

(a) Geological Survey: Major purposes of this survey are to identity rock formations and to confirm rock types of the circular intrusive bodies.

(b) Geochemical Survey: This survey is required since existing geochemical data are insufficient. The survey shall cover such elements as Au, Sn, rare earth, Cu, Ni, Cr and Co.

(c) Geophysical Survey: Airborne magnetic and radiometric surveys are required for the area west of longitude 51° west.

(2) Bacaja Area

The super-regional survey is a prerequisite for the compilation of a more accurate geological map and for the delineation of anomaly areas.

(3) Serra dos Gradaus Area

The super-regional survey is required to define geological stratigraphy of the area and to confirm the existence of Velho Guilherme Granite.

4. REQUIRED SURVEY ITEMS IN SALOBO AND POJUCA COPPER DEPOSITS

As a result of initial exploration surveys carried out by the Brazilian side at the Salobo and Pojuca ore deposits, it is known that the principal mineral composition at the former ore deposit is bornite-chalcocite-magnetite while it is chalcopyrite-pyrite-bornite-magnetite at the latter ore deposit. In addition, it is also known that the two deposits are different in their ore formations. In due consideration of these differences and on the basis of our own analysis of the survey results, a series of preliminary studies as outlined below is proposed for the formulation of a comprehensive development program for the two copper deposits:

(1) More precise ore reserve calculation and investigation of the formation and mineral composition of the ore bodies. A supplemental test mining and pit prospecting may be carried out.

(2) Selection of the most effective and economical mining method

The ore bodies generally dip steeply and open-pit mining is quite difficult. In addition, ore-containing veins and unproductive veins are complexly intermingled. Therefore, a careful study of mining plan and the selection of the most appropriate mining method are quite important to maintain ore quality.

(3) Selection of the most effective ore dressing method

A study of ore dressing methods to select the most effective method is indispensable. In particular, adverse effects of clay minerals produced by the alteration of basic and ultrabasic rocks to ore dressing shall be taken into consideration.

(4) Research related to smelting methods

In particular, investigation of the degree of sulfur recovery when the Pojuca ore consisted mainly of chalcopyrite and pyrite is mixed with the Salobo ore consisted mainly of bornite and chalcocite, is required.

(5) Preliminary evaluation of economic viability

The first substantial data for the evaluation of economic viability of the two deposits are obtained in the studies related to the above items (1) to (4). An overall economic analysis shall then be performed on the basis of rough engineering and structural designs related to mining, dressing, smelting, etc., in due consideration of construction and operation costs as well as current and future metal prices.

(6) Other items to be considered are:

(a) Mining plan in terms of the optimum amount of mining
(b) Design of underground mining

(c) Selection of machinery
(d) Production control plan
(e) Design of dressing and tailings disposal facilities
(f) Design of supplementary facilities
(g) Overall development plan

〔Ⅳ〕 STUDY OF METALLURGICAL INDUSTRY DEVELOPMENT

1. INTRODUCTION

Following the data collection in Brazil, the work performed in Japan had two basic aims: first, to compile the data related to the construction and operation of the hypothetical model plants; secondly, to discuss the "gap adjustments of the infrastructure," which would counterbalance the deficiencies in the present infrastructures regarding to material transportation, electric power, service water and housing facilities to ensure adequate raw materials, sub-materials, utilities and labor power required for the model plants.

By incorporating the construction and operation costs that had been amended by the gap-adjustments, the financial aspects of the hypothetical model plants were calculated, and the order of priority in investment efficiency was examined by comparing the four industrial districts on the basis of the FIRR (Financial Internal Rate of Return).

2. THE MAJOR PREMISE

2-1 Hypothetical Model Plants

(1) Copper smelting plant

The smelter would consist of a Mitsubishi-type continuous smelting furnace that combines smelting and electrolytic refining, having an annual production capacity of 100,000 tons. The estimated total costs necessary are: US$257 million for Sao Luis, US$277 million for Barcarena, US$266 million for Tucurui, and US$288 million for Maraba. The construction period is estimated at three years for Sao Luis, three and a half years for Barcarena, and four years for Tucurui and Mabara. The ore is expected to come from the Salobo deposits of the Carajas Mountains which require pyrite as a combustion improver.

(2) Ferro-manganese smelting plant

The plant would have two ordinary closed-type electric furnaces, designed to simultaneously produce ferro-manganese alloy and ferro-silico-maganese alloy with an annual production of 72,600 tons ferro-manganese. The estimated total costs necessary are: US$137 million for Sao Luis, US$146 million for Barcarena, US$143 million for Tucurui, and US$154 million for Mabara. The construction period is the same as that for the copper smelting plants, and the ore is expected to come from Azul deposits of the Carajas Mountains.

(3) Nickel smelting plant

The process to be adopted involves a system to produce nickel briquette from laterite nickel ore by leaching with ammonia; annual production would be 12,000 tons. The estimated total costs necessary

are: US$173 million for Sao Luis, US$180 million for Barcarena, US$175 million for Tucurui, US$193 million for Maraba, with the same construction period as that for the copper smelting plants. The expected ore is laterite nickel from Vermelho deposits located to the south of the Carajas Mountains.

(4) Ferro-nickel smelting plant

An ELKEM-type electric furnace would be installed because it is already being used in Brazil, and the expected annual outlay is 48,000 tons of ferro-nickel or 12,000 tons of pure nickel. The estimated total costs necessary are: US$170 million for Sao Luis, US$181 million for Barcarena, US$173 million for Tucurui, and US$185 million for Maraba, with the same construction period as that for the copper smelting plants. The ore is also expected to come from Vermelho deposits.

(5) Tin smelting plant

The plant will employ a pyrometallurgical smelting system involving the following processes: common electric furnace smelting and dry refining methods followed by improved electrolytic refining to produce extremely pure electrolytic tin. The estimated total costs necessary are: US$70 million for Sao Luis, US$75 million for Barcarena, US$73 million for Tucurui, US$85 million for Maraba, with the same construction period as that for the copper smelting plants. The expected ore is from Antonio Vicente deposits located to the north of Sao Felix do Xingu.

2-2 Infrastructure Gap Adjustments

(1) Transportation

There are no problems in the transportation of the ore from the Carajas mine to Mabara and Sao Luis because of the railway facilities available, but for the transport of the ore to Tucurui and Barcarena, there is no alternative except along the Tocantins river. To be able to use this waterway effectively requires the construction of transferring facilities and a new port at Maraba, and requires new harbour facilities to be used exclusively for unloading the ore at Tucurui and Barcarena. Although there are already loading and unloading facilities at Tucurui and Barcarena, they are insufficient to unload the quantity of ores required for the model plants from barges in a short period of time, and construction of a special type harbour near each plant shall be essential.

With the additional costs of barges and pushers, the expenditure on facilities for the Tocantins Navigation system mentioned above will be enormous, making it impractical for the plants at Tucurui and Barcarena to be burdened with the outlay alone; thus a third financial source should provide the investment necessary to improve these transportation infrastructures. However, in this case the costs related to depreciation, interest and operation of these transportation facilities

would be incurred by the plants in the form of freight charges on raw materials.

(2) *Electric power supply*

According to the basic plan formulated by ELETRONORTE, a primary substation for the main transmission line is to be installed in each of the four industrial districts, and the cost for the installation of the transmission lines between the primary substation and each plant is to be accrued for each plant in the form of a gap adjustment cost.

(3) Industrial water supply

For Sao Luis, a pipeline should be laid which connects into the water treatment facilities of the main pipeline of ITALUIS industrial water supply system. For the other three industrial districts, the water should be pumped from the Tocantins River by pipeline.

(4) Communication facilities

No problems are expected in this area because of the great reputations dedicated to the Brazilian organizations on the capability for realization of communication networks.

(5) Workforce and housing

In Sao Luis, which has a population of approximately 450,000, there should be no additional expenditure so as to newly employ workers or provide company housing, judging from the experience of ALCOA when they settled in the area. In Tucurui, there will be no need for housing because the new towns provided by ELETRONORTE can be substituted for the company housing. For Barcarena and Maraba, the costs incurred in providing company housing will be included in the gap adjustment costs.

Wage rates have been calculated on the basis of those in Sao Luis and Barcarena, taking into consideration the inconvenient plant location and the social rules covering employee transfers.

2-3 Compilation of Input Data

Ore prices were examined by separating them into mine-site prices and freight charges. The mine-site price of copper ore was determined by using SUNOR (an affiliate of Companhia Vale do Rio Doce) calculation on copper concentrate which was based on the present international trading rules, because the mine-site price includes many uncertain factors at a time when the mine has not yet been developed. The mine-site price of manganese ore was also based on the SUNOR calculation while that of iron ore followed the DNPM's Price List for Mineral Resources. For nickel ore the current domestic trading price surveyed by CONSIDER was taken as the mine-site price. For tin ore the average domestic trading price quoted from "Anuario Mineral Brasileiro 1983" by DNPM was adopted as the mine-site price.

The freight charge was estimated on the assumption that the copper concentrate is trucked from the Salobo mines to the Carajas terminal, then railed directly to Maraba and Sao Luis; and thereafter transported by barge along the Tocantins river to Tucurui and Barcarena from Maraba. The freight charges for manganese ore and iron ore were determined in the same manner as that for copper concentrate because of their similar transport quantity with one exception. The exception is that costs were not included for transportation from the Azul mine to the Carajas terminal because it is scheduled to be carried out using a cableway. The freight charge for nickel ore was estimated on the assumption that the transport route would involve trucking from Vermelho to Maraba and then by the Tocantins Navigation system to Tucurui and Barcarena, because the SUNOR calculation indicated that the charge will be less by trucking from Vermelho directly to Maraba than by trucking from Vermelho to Carajas railway terminal and then by rail to Maraba. Similarly, the freight charge for tin ore was estimated assuming trucking from Antonio Vincente to Maraba by routes PA-279 and PA-150 via Sao Felix do Xingu. From Maraba to Sao Luis, the use of railway was assumed. Then, the Tocantins Nativation System was assumed from Maraba to Tucurui and Barcarena.

Prices of sub-materials were examined by separating them into the suppliers' offered prices and freight charges: the FOB prices at Sao Luis and the freight charges originating at Sao Luis (or Barcarena) were calculated by using a variety of sources, because most sub-materials are either shipped from southern Brazil or imported.

The product prices were estimated by ignoring the current international prices so that reasonable FIRR values (10 to 20%) could be obtained. It is the reason that the product price was initially to be regarded as the export price by adopting the current international market price; however, these export prices would make minus balance between sales revenue and production cost, resulting in negative, or even incalculable, FIRR values.

Accordingly, the mine-site prices input should presently be regarded as the anticipated costs for ore production at the new mines, with the sales prices of the products being set at a level where investment returns can be expected for implemented projects drawn up using the anticipated raw material prices.

Other than those described above, the additional assumptions used for financial analyses are as follows:

Share capital/Long-term debt ratio: 3:7

Interest on borrowing: 12% annually

Repayment conditions: Equal repayments annually for 10 years following a 5-year deferment period

Depreciation:

Process plant, utility plant and vehicles: 5 years
Buildings, including warehouses: 10 years

Indirect construction costs:	20 years
Outside facilities:	30 years
Intangible fixed assets:	5 years
Interest during construction period:	5 years

Annual maintenance costs:
3% of total construction expenditure on process plant, utility plant and outside facilities

Insurance levy for taxes and public dues:
Annually 1% of unamortized property

Sales expenses: 2% of total sales

General administration costs: 20% of plant personnel costs

Corporate income tax: 50% of taxable income following a 10-year 10-year tax exemption period

Working capital:

Accounts receivable:	Sales receipts equivalent to one month
Accounts payable:	Total expenditure on raw materials and sub-materials equivalent to one month
Product stock:	Sales receipts equivalent to one month
Stock of raw materials:	The value of production equivalent to one month

3. RESULTS AND CONSIDERATIONS

3-1 Three Factors and Case Classification

In considering the FIRR values, the following three factors can be considered to affect the results.

- Factor A: The proportion of the freight charge in the overall raw material cost
- Factor B: Costs for infrastructure gap adjustments included in the construction costs (costs of outside facilities, such as electric power transmission lines, water intake and pipelines, company housing)
- Factor C: Regional differences in the costs of construction and operation (differences in inland transportation costs included in construction and operation costs, interest incurred during construction work, personnel expenses and others)

Factors A and C are peculiar to certain areas, while the discrepancies caused by factor B can be equalized with the development of the infrastructure. Supposing that the discrepancies caused by Factor B can be uniformized by the implementation of social development policies, the results achieved will enable a comparison to be made of the locational advantages of each industrial district under Factors A and C.

A comparison between Maraba, which has the most advantageous position in Factor A, and Sao Luis, which has the most advantageous position in Factor C, will indicate which of the two factors, A or C, will be more critical in the Greater Carajas Program Area. Factor B in Tucurui is similar to that in Sao Luis because of the benfits derived from the dam construction work of ELETRONORTE power station, so that locational advantage or disadvantage in Tucurui over Sao Luis can be compared under the influences of Factors A and C. The Factor B component in Barcarena can be considered as similar to that of Sao Luis except for the cost incurred in constructing company housing. Therefore, a revision of construction cost of company housing as a Gap Adjustment makes a comparison between Barcarena and Sao Luis possible with regard to Factors A and C.

It should be noted that Maraba and Tucurui have a locational disadvantage in Factor C over Barcarena and Sao Luis, because almost all materials, except raw material ores, have to be transported over a long distance via ports of either Sao Luis or Barcarena.

On the basis of the above considerations, comparative advantages of four industrial districts were calculated for each smelter on the Base Case in which the current data were input, and on the Gap Adjusted Case in which Factor B in Maraba, Tucurui and Barcarena was revised to level similar to that of Sao Luis.

3-2 Comparative Advantages of the Four Industrial Districts

As described in Section 2-3, a number of assumptions have been made concerning the raw material price and the product selling price, so that the resultant FIRR values have meaning when comparing the four industrial districts in terms of one industry, but cannot be used when comparing different industries at one industrial district. To avoid confusion, therefore, and to make it possible to compare the results mutually on the same basis, the results of Barcarena, Tucurui and Maraba were expressed as a percentage with the results of Sao Luis used as a base of 100.

The obtained results are shown in the following table.

Base Case

	Sao Luis	Barcarena	Tucurui	Maraba
Copper	100 (1)	86.85 (2)	78.14 (4)	84.29 (3)
Fe-Mn	100 (1)	92.37 (2)	75.28 (4)	81.63 (3)
Nickel	100 (1)	94.87 (2)	84.36 (4)	90.44 (3)
Fe-Ni	100 (1)	60.72 (4)	66.67 (3)	89.01 (2)
Tin	100 (1)	86.33 (3)	88.53 (2)	78.30 (4)

Gap Adjusted Case

Copper	100 (1)	93.80 (2)	78.14 (4)	91.29 (3)
Fe-Mn	100 (1)	98.67 (2)	75.28 (4)	88.52 (3)
Nickel	100 (2)	101.4 (1)	84.36 (4)	95.66 (3)
Fe-Ni	100 (1)	65.11 (4)	66.67 (3)	95.50 (2)
Tin	100 (1)	96.09 (2)	88.53 (4)	89.84 (3)

For most industries in the Base Case and the Gap Adjusted Case, Sao Luis is ranked at the top and Barcarena as number two indicating that Tucurui and Maraba, which are located well inland, are inferior in terms of construction and operation costs to the coastal regions.

For the ferro-nickel (Fe-Ni) industry in the Base and Gap Adjusted Cases, Maraba is graded as number two and Barcarena as the lowest, the reason being that the location of Maraba is superior to that of Tucurui and Barcarena. For a transport scale of some 600,000 tons per year, there are no advantages in using the Tocantins Navigation System to the Fe-Ni plants of Tucurui and Barcarena. For the nickel industry, however, Barcarena is ranked second in the Base Case and first in the Gap Adjusted Case, indicating that the Tocantins Navigation System makes Factor A less effective than Factor C for nickel smelting at Barcarena which is far from the mine but requires a transportable quantity of at least one million tons per year.

Tin smelting in Tucurui is number two in the Base Case and the lowest in the Gap Adjusted Case. Tucurui enjoys the most favorable conditions in terms of gap adjustments of the infrastructure at present. In addition, construction costs in the tin smelting are relatively low. Therefore, the construction costs of appurtenant facilities outside the factory i.e., a part of gap adjustment cost, occupy a relatively high proportion in the total construction cost. This situation is more conductive to success of a tin industry in Tucurui than to one in Maraba or Barcarena in the Base Case, but the position of the industry turns down to the substantive order in the Gap Adjusted Case where the situation is relatively the same for each location.

3-3 Conclusion

The comparative advantages of metallurgical industries development in terms of investment efficiency are shown in the Base Case table (Sao Luis registered the highest ranking for all industries). The Gap Adjusted Case table indicates that coastal zones enjoy more beneficial conditions than the inland areas, even after the infrastructural base has been laid for the entry of smelting industries. In both tables, Barcarena recorded the second highest score except for the Fe-Ni industry. One measure that thus may be implemented by Para is to develop the transport infrastructure between the inland areas and Barcarena along the Tocantins River to send mineral ores from the mountain area to Barcarena industrial district.

Because Sao Luis, Barcarena, Tucurui and Maraba are supposed to be developed as bases for social development through industry, and if at least one industry is to be allocated to each industrial district, one combination which has highest total of FIRR values, that is, the greatest total score, can be chosen from all possible combinations.

The most profitable combinations selected from either the Base Case or Gap Adjusted Case are as follows:

Sao Luis	Copper smelter and ferro-manganese smelter
Barcarena	Nickel smelter
Tucurui	Tin smelter
Maraba	Ferro-nickel smelter

This comparative study has been carried out by converting the FIRR values into relative score points, so that the results can be used only for comparison of the range of advantages and the degrees of difference in the investment returns. If the choice is to be made on the basis of some investment criteria (for example, a project having an FIRR value of 10% or less is judged to be unworthy of the investment), these relative terms are insufficient. It is difficult to make the choice with such criteria because at the present time, with mines not having been fully developed, there are too many uncertain factors affecting raw material

prices, with variations in product prices in the market being difficult to forecast. The resultant FIRR values are therefore very difficult to analyze, making firm conclusions difficult. Conversely, these relative terms are used to avoid confusion, and it must be realized that ideas based on an investment criteria such as absolute values of FIRR will not suit the scope of works for the present Study.

Appendix: *Utilization Measures for Sulfuric Acid*

Sulfuric acid of 98% purity suitable for industrial use is a by-product of the copper smelting process. Sulfuric acid has a heavy specific gravity (about 1.84); is a dangerous substance highly corrosive and reactive (especially explosively reactive with water); and is a poisonous and toxic chemical that is very expensive to transport. Considering that it would be preferable to convey or sell sulfric acid by converting it first into other chemicals rather than to transport it as it is, preliminary market research was conducted.

Studies into raw materials and market outlets of sulfuric acid in Brazil reveal that large quantities of the acid are used in the production of fertilizers. The well-known fertilizers produced from sulfric acid are ammonium sulfate and phosphoric acid-based products, and examination centered on the latter because of its large share in the Brazilian market. The survey results suggest that sulfuric acid should be used in the production of ammonium phosphate. Calcium superphosphate is easy to be produced but contains only small quantity of the effective component.

As the first step in this investment planning, sulfuric acid shall be used to produce phosphoric acid from phosphorous ores, and obtained phosphoric acid will be supplied to the southern industrial areas as a raw material in the manufacture of phosphate fertilizers. This will result in great savings because a considerable amount of phosphoric acid is at present being imported.

The second step is the construction of factories to produce phosphate fertilizers when ammonia will be available also in this area; this step can be achieved after laying the foundations for a sufficient share in the market of ammonium phosphates fertilizers by supplying phosphoric acid as the raw material in the interim period.

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