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 consumption 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.

<u>H-a site class:</u> 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.

<u>H-b site class:</u> 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.

<u>S-a site class:</u> 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:

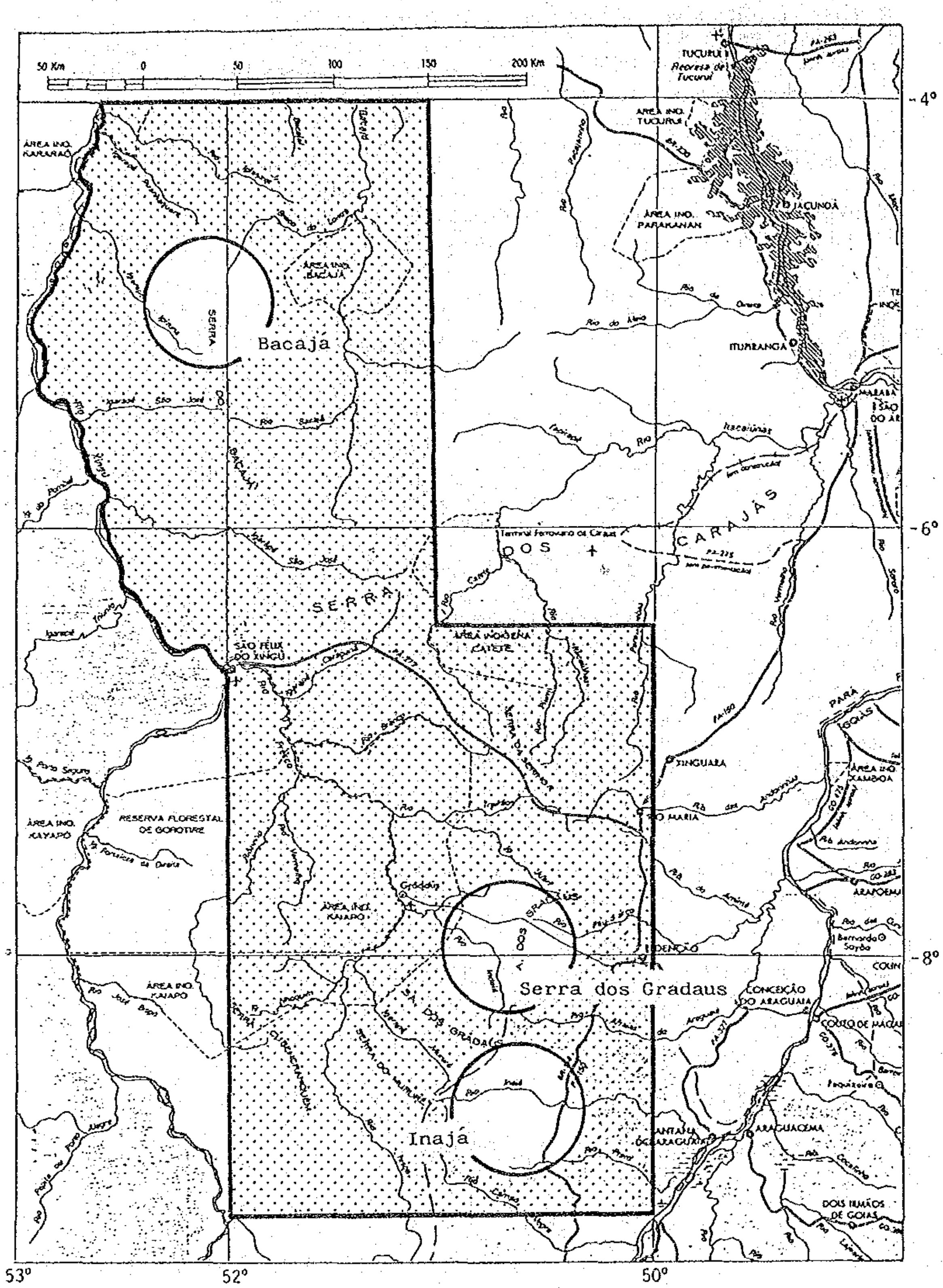
- Mineral exploration in the Area is at the stage of reconnaissance and regional geological survey.
- Grao Para Group and Rio Fresco Formation as well as the granite and ultrabasic bodies that intrude into the former two geologic units, provide for the major geological environment for mineral resources 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 pipe-lines, 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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