CHAPTER 3

NATURAL CONDITIONS

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3.1 Natural Conditions of the State of Pará

3.1.1 Topography

In the State of Pará , there are three different geomorphological regions such as Plain region, Plateau region and Depressions with an altitude ranging from 0 to 100m, 200-500m 500-900m respectively.

Plain regions are present along the Amazonas River (Amazon Plains) and at the northeastern part of the State (Seashore plains). Plateau regions are located at a distance from the banks of the Amazon River (Sedimentary Plateau of the Amazon).The Pará iba Basin Plateau is located near the Maranhão border. Depressions are present at extreme North (Guiana shield) and extreme South of the State (Central Brazil shield).

3.1.2 Geology

There is a great diversity of geological sites ranging from the Archaeozoic period (>2,500 million years ago) to the more recent Holocene period. There are four major geotectonic provinces, which includes Craton Amazonico, Craton São Luis, Mobile Belt from the Late Proterozoic Period, and Phanerozoic Covers.

The most important minerals found in the State are: Iron ore, aluminum, gold, kaolin, lime, tin, copper, lead, zinc, nickel, chromium, phosphate, titanium, salt, gypsite, precious gems (amethyst, topaz, opal, etc.) and rocks used for constructions. Many of these minerals have never been explored.

3.1.3 Soils

The major soil orders in the State of Pará are Oxisols, Ultisols, Alfisols, and Entisols. The major soils in Pará at the great group level in Brazilian classification and the approximate equivalent of the USDA classification and FAO classification are shown below.

Table 3.1-1 Major Soils of the Pará State

Brazilian Great Group	USDA Classification	
	Order	Great Group
Yellow Latosols	Oxisols	Haplorthox
Red-yellow Latosols	Oxisols	Acrothox
Plinthosols	Oxisols	Plinthaquox
Red-yellow Argisols (Podzolic soil)	Ultisols	Tropudults
Red Nitosol (Terra Roxa)	Alfisols	Tropudalfs
Lithic Neosols (Lithosols)	Entisols	Troporthents
Quartz Neosols (Quartz sands)	Entisols	Quartzipsamments
Haplic Gleysols	Entisols	Fluvaquents

Oxisols, which cover an area of approx. 45% of the State, are extremely weathered acidic soils and are typically found on old landforms in humid tropical climates. Ultisols, which cover an area of approx. 40% of the State, are usually acidic soils with low fertility and they might occur on both well and poorly drained landscape conditions. Alfisols which cover an area of approx. 2.7% of the State, have been used mostly for permanent crop production. Entisols cover an area of 6.4% of the state and are mainly under natural vegetation. There are also other soil orders, found in smaller areas. In general, many of the soils in the State are acidic, ill supplied with nutrients and lack of retention capacity.

3.1.4 Climate

There is a high variation in the climate of the State of Pará due to its rainfall, which varies from 1000mm to 4000mm. Rainfall is considered as the main controlling factor in the agricultural production. Although there is no true dry season, there is a pronounced wet season and a less wet season. They occur respectively from December to May and from June to November, but there is a great variation from place to place.

The mean monthly air temperature normally ranges between 24ºC to 28ºC and the variation of mean monthly air temperature is never higher than 5ºC. Seasonal variation in the temperature is relatively small. Using Koppen climatic classification, three sub-types of climates were identified in the Pará State such as Af (no dry season), Am (moderate dry season) and Aw (well defined dry season). In the State of Pará 72% fall under Am, followed by 23.7% of Aw and 4.3% of Af.

It has been observed that the annual hydric deficiency in the State of Pará covers areas where the hydric deficit is non existant with rates from zero to 100 mm to areas, where the hydric deficiency is around 400 to 500 mm. In seasonal terms, the hydric deficiency occurs from June until November with the greatest concentration from August to November.

3.1.5 Hydrology

The State of Pará is rich in water resources. Its huge river network provides the State with many rivers, small lakes and much used natural harbors that ensures the outflow of its products. The most important river in the State of Pará is the Amazon River. It flows northeastward and discharges its waters in the Atlantic Ocean.

The most important tributaries of the Amazon in the State of Pará are – from the left Trombetas, Maicuru, Paru and Jari river. From the right, the tributaries are all clear water rivers – The Tapajos, Xingu and Tocantins where the Tucurui lake and the hydroelectric plant are located. All of these rivers are over a thoushand miles long. Other important rivers in the State of Pará are: Acara, Guamá, Moju, Araguaia and Gurupi.

3.1.6 Vegetation

These are the main forest formations found among the varieties available in the State of Pará (Source: Environmental Guide of the State of Pará).

a. Upland Forest – It is known for its great heterogeneity and for being located above the areas of inundation. This forest can be formed by the Dense forest, Open forest and the Semi-deciduous forest.
b. Igapo Forest (Oxbow forest) - This formation is found in permanently inundated areas. The presence of prop roots, exposed roots and respiratory roots are common, which emerge from and arch into the ground. The composition is hetereogeneous .
c. Cerrado - Open woodland of short-stature, twisted and thick bark trees caused by bioclamtic conditions such as a well defined dry period.
d. Fields - Areas under the influence of the sea or rivers with problems of hydromorphism (soil with excess of water) . They are found along the Baixo Amazonas Region (Mid-Amazon) and at the Eastern part of the Marajó Island.
e. Sea Coast Formation. - Represented by mangroves. It is characterized by the salinity of the water and by the decomposition of silty sediments.

3.2 Natural Conditions of the Study Area

When comparing the natural conditions of the Study Area, the Marabá munipality, which covers about 76% of the Study Area, has slightly different natural conditions in comparison with the other four municipalities, which together cover the remaining 24% of the Study Area. Therefore, the Marabá Municipality and the other four municipalities are discussed sePará tely in the following sections.

3.2.1 Topography

In the Study Area, the topography is a critical factor, which limits the use of land for agriculture purpose especially, the topography of the Marabá municipality, which presents a large variation in its altitudes with maximum heights around 700 meters,the highest altitudes in Southeast Pará . Because of the steep slope, erosion and mechanization are the major problems in this area. Although the topography of the other four municipalities is not as high as that of Marabá , the relief is rather dynamic presenting hilly areas, plateaus and low land areas (varzeas).

3.2.2 Geology

The geological structure of the Marabá municipality is complex, composed of rocks from Precambrian period of Xingu Complex (granite, granulite, migmatite, etc.); Tocantins Group (schist, gnaisses, quartz, etc.), ferro formations, Rio Fresco formation with Membro Azul (ferromagnesian stratified clayey rocks, silititos, clay and sandstone).

In the other four municipalities, the geology is represented mainly by Precambrian rocks belonging to the Tocantins Group (schists, gneisses, quartz). Purely sedimentary natural rocks are found from the Paleozoic period represented by Pimenteiras Formation (clayish rocks and dark silititos) and Fire Rocks Formation (sandstone, silititos, clayey rocks and limestone); and Masozoic period represented by Sambaiba Formation (thin and medium sandstone) and the Cenozoic period represented by the lithotipos of the Barreiras Formation and from the recent Quaternary in some spots of the Tocantins River.

3.2.3 Soils and Land Capability Classification

(1) Soils

The most predominant soils in the Marabá Municipality are the red-yellow Argisols (Podzolic soil) of clay texture, dystrophic Lithic Neosols (Lithosols), dystrophic red-yellow Latosols of medium texture and clayey texture and dystrophic Quartz Neosols (Quartz sands). The red-yellow Argisols and the red-yellow Latosols present good physical properties, but they still need to be properly fertilized to yield good production. These two soils are found mainly on slight undulated and strongly undulated relief. The dystrophic Quartz Neosols (Quartz sands) are found on plain and slightly undulated relief. Distrophic Gleysols and distrophic Cambisols are also present in associations.

The most predominant soils in the other four municipalities are red-yellow Argisols (Podzolic soil), dystrophic Quartz Neosols (Quartz sands) and dystrophic Lithic Neosols. Red-yellow Argisols are present in the western part of São Joao do Araguaia and São Domingos do Araguaia, most part of Brejo Grande do Araguaia and western part of Palastina do Pará . Quartz Neosols are present in the eastern part of São Joao do Araguaia and São Domingos do Araguaia, and in the western part of Brejo Grande do Araguaia. Lithic Neosols are present mainly in Palastina do Pará . Dystrophic red-yellow Latosols and dystrophic Haplic Gleysols are also present in associations.

(2) Land Capability Classification

The land capability classification map of the Study Area (RADAM – Radar da Amazônia) is shown in Fig.3.2-1. The symbols (IIc, IIIa etc.) mentioned in map are in accordance with the definitions of Land capabilityclassification of RADAM as mentioned in Table 3.2-1.

Table 3.2-1 Definition of Land Capability Classification (RADAM)

Symbol	Land Capability Classification
Primitive management system	
IIa	Regular for short cycle and long cycle crops
IIc	Regular for long cycle and restricted for short cycle crops
IIIa	Restricted for short cycle and long cycle crops
IIIb	Restricted for short cycle and Inapt for long cycle crops
IIIc	Restricted for long cycle and inapt for short cycle crops
IVa	Inapt for long and short cycle and adequate for extensive pasture
IVb	Inapt for agriculture or extensive pasture
Developed management system (no irrigation)	
Ib	Good for long cycle and regular for short cycle crops
IIa	Regular for short cycle and long cycle crops
IIb	Regular for short cycle and restricted for long cycle crops
IIc	Regular for long cycle and restricted for short cycle crops
IId	Regular for short cycle and inapt for long cycle crops
IIIa	Restricted for short cycle and long cycle crops
IIIc	Restricted for long cycle and inapt for short cycle crops
IVa	Inapt for long and short cycle and adequate for extensive pasture
IVb	Inapt for agriculture or extensive pasture

Ref : Projeto RADAM (Radar da Amazônia), Ministério das Minas e Energia

As it can be seen from the figure, no area falls under the I or Iia classification , which means that there is no area with regular aptitude for both short cycle and long cycle crops. However, there are small parts of the Study Area in Marabá , Brejo Grande do Araguaia, and Palestina do Pará , which fall under the classification of IIc, which means that these areas have regular aptitude for long cycle crops and restricted aptitude for short cycle crops. The area which falls under this category is 1,500 sq.km (7.3%).

Most of the area in the Study area fall within the category of IIIa, which means that these areas have restricted use for both short cycle and long cycle agriculture , but can be used for cattle grazing. The area which falls under this category is approx. 14,000 sq.km (71.9%). The areas with a classification of IIIc have restricted aptitude for perennial crops and is unsuitable for seasonal crops. Only cattle grazing is possible in these areas. The area which falls under this category is approx. 900 sq.km (4.6%).

There are also some small areas in the four municipalities except Brejo Grande do Araguaia, which has an area under the land capability class of IVb. This area is not suitable for agriculture or cattle grazing. Only silviculture is possible in this area. The area which falls under this category is 3,082.1 sq.km (15.4%).

The percentage and area of the Study Area which falls under each category are shown below:

Table 3.2-2 Area under Each Land Capability Classification

Category	Area, km^2	Percentage
IIc	1,448.6	7.3
IIIa	14,362.6	71.9
IIIb	154.1	0.8
IIIc	924.6	4.6
IVb	3,082.1	15.4
Total	19,972.0	100.0

The land capability classification made in the micro region of Marabá by RADAM and PRIMAZ (Program of Integration of Minerals in the Municipalities of Amazonia) indicates different agricultural aptitudes, which is probably due to the difference of the map scales. In the RADAM report, where the map is prepared at a scale of 1:1,000,000, most of the areas are classified as areas restricted to short cycle and long cycle agriculture crops. However, there are also some small patches of areas especially at the settlement areas, where subsistence agriculture (cassava, rice, corn etc.) is carried out with some limitations. If more technologies such as fertilizer application, weed control and mechanization are applied, then there will be a higher agricultural production in these areas, although the economical feasibility still needs to be confirmed. Based on these considerations, PRIMAZ (Amazon Municipalities Integration Program) , where the map is prepared at a scale of 1: 250,000, classified these areas as areas, which has regular aptitude for agriculture with application of medium technology and good aptitude for agriculture with high technology. Agroforestry, especially cultivation of fruit crops is suitable for these areas and should contribute substantially to the recuperation of these areas.

3.2.4 Climate

Except for a minor variation, the climatic conditions of the municipalities are similar; Excepting Marabá, all other four municipalities are considered to have the same climatic conditions.

The municipality of Marabá lies within the transition border from Aw to Am in the Koppen classification. The average annual temperature is 26^{o}C. The average annual maximum temperature is 31.0 ^{o}C, and the mean annual minimum temperature is 22.0 ^{o}C. Rainfall reaches around 1500-2,000 mm/year. The rain season is from December until May and the driest months are from June until November. Relative humidity is high oscillating between the rainy and dry season from 73% to 93%. Monthly mean temperature and rainfall of Marabá is shown below.

Table 3.2-3 Monthly Mean Temperature and Rainfall of Marabá

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct.	Nov.	Dec.
25.8	24.3	25.8	26.2	26.5	26.4	26.3	26.8	26.9	26.7	26.4	25.9
308.9	326.9	349.4	267.1	81.3	24.3	13.1	19.0	47.7	106.7	123.8	227.4

Most of the Study Area, especially the 4 four municipalities and the eastern part of Marabá have a high hydric deficiency of 400-500 mm. Therefore, irrigation is essential for agriculture cultivation during the dry season.

3.2.5 Hydrology of the Study Area

The most important water resource in the Marabá Municipality is the Itacaiunas river on the left bank of the Tocantins river on whose mouth the town of Marabá is located . Its main tributaries from the right are the rivers: Madeira, Pará uapebas; From the left the tributaries are: Aquiri and Tapirapé The presence of the Tocantins river is also important and its main tributaries are Tauarizinho river and Flecheira river.

The municipality of São João do Araguaia is represented by the low Araguaia River near its mouth and a small portion of the Tocantins river. The main rivers in São Domingos do Araguaia are Tauarizinho, Uba and Veados, which are the tributaries of Tocantins river. The hydrographic network of the municipality of Brejo Grande do Araguaia is represented by a section of the Araguaia river, near where it flows into the Tocantins river. In Palestina do Pará , Rio Araguaia is the most important river, serving as limit between the municipality and the state of Tocantins. The other important river in the municipality is the Gameleira River.

3.2.6 Vegetation of The Study Area

The vegetation of the Marabá Municipality is very diversified. However, the predominance is the submontana dense forest, which is also known as rain forest, in the flat topography to the Sub-region of the plain flattened surface of Serra dos Carajás, to the North of the municipality and to the sub-region of the dissected surface of the Araguaia to the southeast. At the bottom of the Serra, Mixed Open Forest (Cocal with the predominance of babacu) is found and in a smaller scale the Broadleaf Open Forest (Cipoal), except in the western side, which is covered

by the submontana dense forest in the irregular subregion relief of the flattened surface of the medium Xingu-Iriri River.

Most of the four municipalities are covered by the broadleafed equatorial forest represented by the following subtypes: The submontana dense forest in plain relief (the largest area) and the mixed open forest (cocal). To the banks of the Araguaia and Tocantins Rivers, there are some areas with alluvial forest, mainly on the terraces and river islands. In several different areas,there are large portions of cleared areas where the forests has been cut for pasture and cattle grazing. This has led to the appearance of a secondary forest (capoeiras) in different stages of regeneration.

3.3 Specific Natural Characteristics of the Study Area

The Study Area, which lies in the southeastern State of Pará has a distint natural characteristics, especially in terms of topography, soil and climate, which altogether have a significant influence on the land capability potential and limitations for various activities such as agriculture, pasture and silviculture. The natural conditions of Marabá munipality, which covers about 76% of the Study Area, have a slightly different natural conditions in comparison with other four municipalities, especially the topography, which reaches an altitude of around 700m in the western part of Marabá.

The specific natural characteristics of the Study Area are as follows:

a. The Study Area has a diversified relief presenting hilly areas, plateaus and lowland areas (varzeas) along some of the tributaries of Tocantins and Araguaia rivers. Topography is one of the critical factors in the Study Area, which limits the capability of land for agriculture purpose.

b. The most predominant soils are the red yellow Argissols (Podzolic soil), red yellow Latosols, Lithic Neosols (Lithosols) and Quartz Neosols (Quartz Sands). These are extremely weathered acidic soils with a granulated soil structure. Except for the nutrients cycled in organic matter, the soils are very low in nutrients and therefore a careful fertilization is necessary.

c. Except for small parts of the Study Area in Marabá , Brejo Grande do Araguaia, and Palastina do Pará , most of the area has restricted aptitude for traditional agriculture and therefore technical application and improved cultivation management practices such as adaptation of suitable varieties, application of fertilizers, irrigation etc. are essential for higher agicultural production.

d. According to Koppen classification, the area is situated between the transition area from Aw to Am. . The average annual temperature is 26^{o}C with an average annual maximum and minimum temperatures of 31^{o}C and 22^{o}C respectively. Relative humidity is high, oscillating between 73% and 93%.

e. The rainy season starts from December and ends in May and the dry season is from June to November. Rain fall is around 1,500 to 2,000mm/year. Most of the Study Area

has a hydric deficiency between 400mm and 500mm, demanding the use of irrigation during the dry season.

f. The Study Area is included in the river basins of Itacaiunas river, Araguaia river and Tocantins river and their tributaries. Several other smaller rivers such as the Gameleira, Tapirapé, Vermelho, Cinzento, Preto etc. are also part of this river basin.

g. The vegetation in the Study Area is composed of Submontana Dense forest in plain relief (the largest area) and Mixed Open Forest (cocal). The alluvial forests are found along the banks of Araguaia, Tocantins and some river islands. In several different areas of the Study Area, there are large portions of cleared forests that have been open for pasture and cattle grazing. It has led to the appearance of a secondary forest (capoeiras) in different stages of regeneration.

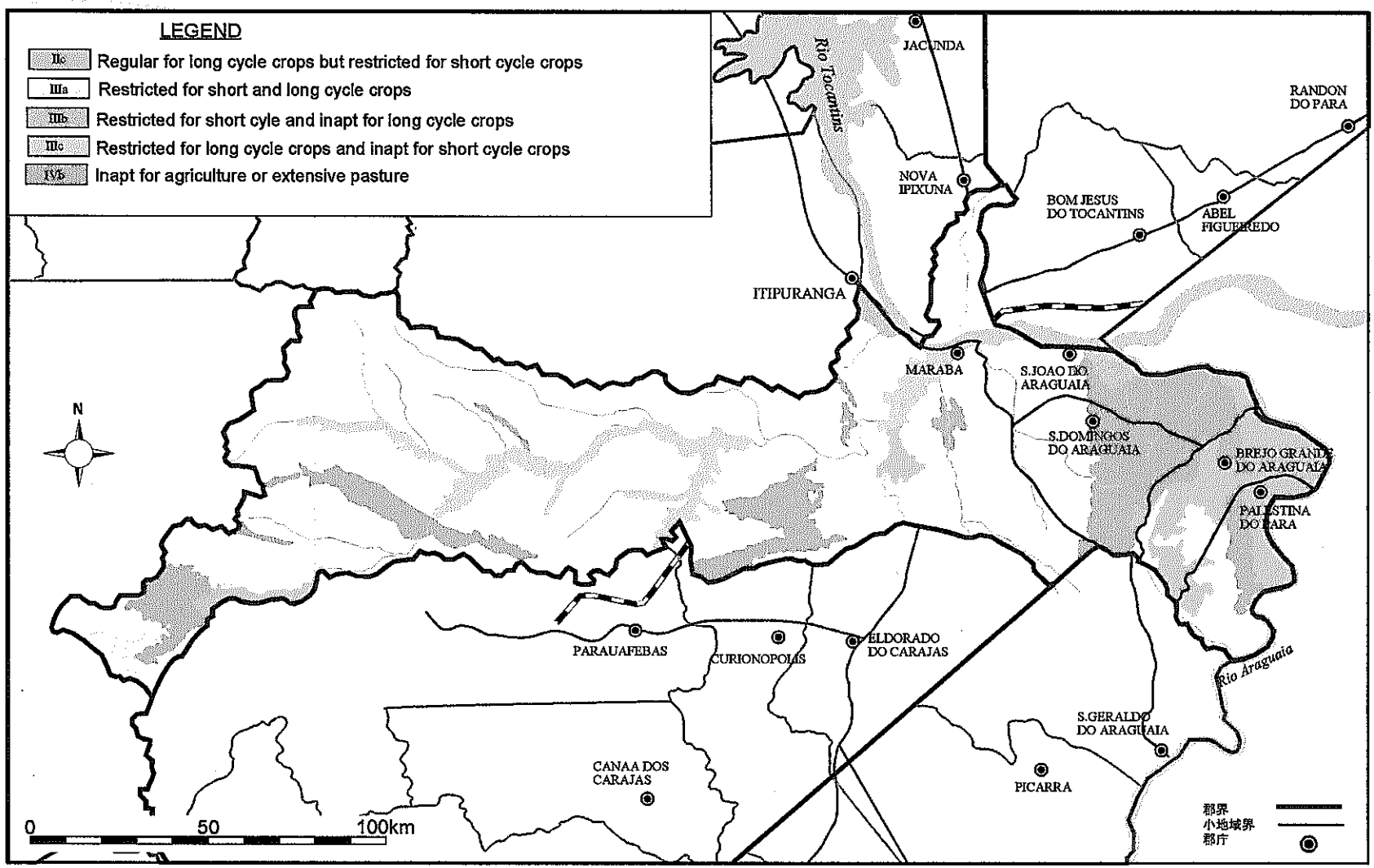

Fig.3.2-1 Map of Land Capability Classification of the Study Area