5. MAIN ENVIRONMENTAL CHARACTERISTICS OF THE PARNAÍBA RIVER BASIN

5.1. The Parnaíba River Basin Physical Boundaries

The Parnaíba River Basin is situated between 3°30'S, 10°30'S latitudes and 41°12'W and 46°00'W longitude (approximately). The river represents the political border between the States of Maranhão and Piauí, the latter being totally included within the physical boundaries of the Basin.

In the west and the north, the Basin is separated from Itapicuru and Munin River Basins (MA), the latter more to the North, next to the coast. In the East, the mountain ranges known as Serra de Ibiapaba and Serra Grande separate the Basin (and Piauí territory) from Ceará and Pernambuco States. In the SE and south, the Basin is separated from the São Francisco River Basin (and Pernambuco and Bahia States) by the water divisors represented by the "serras" of Dois Irmãos, Tabatinga and the Mangabeiras Plateau. These boundaries are shown in **Figure 02.**

5.2. Main characteristics of the territory

The 343,000 km² catchment area of the Parnaíba River Basin has proportions similar to any European country. Its main stream lies as the border line between the States of Maranhão and Piauí. It has an estimated total of 1,176 km navigable lengths in various stretches, from an extension of 1,350 km[7].

Some 73.1 % of its surface lies inside the State of Piauí territory, 19.3 % in the State of Maranhão and the remaining 7.6 % in the State of Ceará, in the northwestern boundaries of the semi-arid climatic zone of Northeastern Brazil.

Navigation and river transportation in the Parnaíba River Basin was incipient in the 1950 decade, but construction of new roads and intense use of trucks for long range cargo transportation turned river navigation irrelevant to the Brazilian economy in general, as the government policies reinforced even more the use of automobiles and trucks.

Otherwise, troubles arose intensely from labor laws and policies and navigation was practically abandoned in the Basin.

The construction of the Boa Esperança Power Plant and reservoir in the sixties divided Parnaíba River in two stretches, without any navigation locks which could make possible the moving of cargoes and passengers from one stretch to other, since construction was interrupted just in its beginning due to lack of financial support, associated to unresolved conflicts of interests among different economic sectors.

Nowadays, there is some navigation activity between the city of Tutóia (Maranhão) in the Parnaíba Delta and the city of Parnaíba (Piauí) near the Igarassu River, due mainly to

[7] It is important to note that there are various discrepancies in the total length of the main river. Some say it is more than 1,700 km, according to BAPTISTA, J. G., in: "Geografia do Piauí", but others mention a length less than 1,400 km. For the purposes of this study, the 1,350 km length will be adopted along this report. Similar comments should be pointed out as to basin total area. In this report, the 343,000 km² is considered to be the correct one.

the troublesome Delta flatlands and its complex waterways and canals network that may affect road construction.

5.3. Regional Climate

The climate variations of the Parnaíba River Basin shown in **Figure 03** well characterizes the situation of transition that occurs in this region of Northeast Brazil. One can notice a variation from arid climates towards humid ones in the direction E-W. It also varies from S to N, since rainy seasons in the South occur in Summer, while in the North they delay for the Fall.

According to the **Köppen** climate classification system, which conciliates the observation of rainfalls and temperature, the following climatic types are found:

- **AW** - Rainy Summer and dry Winter, with less than 60 mm in the driest month. The average temperature of the coldest month is over 18°C.
- **AW'** - Rainy season delays for the Fall, keeping the other characteristics of AW.
- **BSWh'** - coldest month with over 18°C. High temperature and strong evaporation in Summer.
- **BSW'h'** - coldest month with over 18°C, very hot, rains delayed to the Fall.

5.4. Rainfalls

Regional rainfall structure is associated to the penetration of Continental Equatorial Mass which moves from Amazônia and from North Atlantic Equatorial Mass which proceeds from North Hemisphere. According to the behavior of these predominant air masses, two systems are defined: *Continental Equatorial* and *Maritime Equatorial*, as shown in **Figure 04**.

In the Maritime Equatorial System, the existing limit in its edges penetrate as far as the highest altitudes so that it can be presented with great instability. It is accompanied by convective clouds which have strong influence in the reduction of solar radiation which reaches the surface, being responsible for the temperature variation observed prior to the rainy season.

The Continental Equatorial System precedes the Maritime and the comparison of **Figures 04** and **06** permits to observe what occurs in the area of study. The biggest overall results are linked to Maritime Equatorial System, varying from 1,600 to 1,000 mm (**Figure 06**). The Continental System is responsible for the overall results ranging from 1,200 mm in the Western portion of the Basin, declining up to 550 mm to the South.

As for the wettest trimester, as the Continental system precedes the Maritime, the far South and Central Part of the Basin have respectively the trimesters Dec./Jan./Feb. and Jan./Feb./Mar. as the wettest. Yet, the Northern part, under the Maritime System, has the trimester Feb./Mar./Apr. as the wettest. **Figure 05** illustrates the partial distribution of these stormy variations.

The occurrence of heavy rainfalls concentrated on a short period, associated to the soil fragility, constitutes an important factor in the erosion process. **Figure 07** presents the

maximum intense 24 hours rainfall distribution. As storms contribute to hydraulic erosion processes, the Lower Canindé and Lower Gurguéia River Basins are likely to suffer higher intensity of erosion, representing important sources of sediments for the siltation observed in the Parnaíba River.

5.5. Hydrography

The Parnaíba River is formed by the confluence of Curriola and Água Quente Rivers, both originating from Serra da Tabatinga, in the so called Sambaíba Formation, at an altitude of 800 m. It is commonly divided into 3 stretches: **Upper**, from the source to Boa Esperança Dam; **Medium** as far the mouth of Poti River, and **Lower**, from this stretch as far as the Ocean.

- **Upper Parnaíba:**

  The upper part of Upper Parnaíba — from its source up to Santa Filomena town — is frequently embedded in tight canyons and resembles a waterfall, and no navigation is possible in this stretch. The average declivity is approximately 0.79 m/km. Yet, in the stretch between Santa Filomena and Uruçuí, the declivity stands for 0.3 m/km. Although there are several falls, navigation is possible as it occurred in the past. Uruçuí lies just upstream Boa Esperança Dam Reservoir.

  The main tributaries of Upper Parnaíba are as follows: Parnaibinha, Medonho, Pedra Furada, Balsas, Curimatá and Pedra do Fogo on the left banks (Maranhão); and Uruçuí Vermelho, Taquara, Riozinho, Volta and Uruçuí Preto, on the right banks (Piauí).

- **Medium Parnaíba:**

  In this stretch the Parnaíba River does not receive any important tributary from Maranhão and the falls are less frequent. The average declivity reaches 0.20 m/km. The Basin is narrow on Maranhão side, but it covers all the land East of Gurguéia River and the South of Poti River and reaches Ceará's territory.

  The main tributaries in this stretch are the Prata, Gurguéia, Itaueira, Canindé, Mulato and Poti Rivers, all of them on the right bank.

- **Lower Parnaíba:**

  This stretch of the river widens considerably, starting with approximately 300 m in the mouth of Poti River, reaches 500 to 600 m in Luzilândia and keeps this width as far as its mouth. The "*coroas*" start to predominate, originating from the widening of the river and sedimentation. The average declivity comes to 0.13 m/km. The falls disappear, except for some sandbanks.

  The islands, due to its widening, become more numerous, as well as lagoons along river banks. Accumulated sandbanks due to intense siltation are frequent, constituting temporary islands.

  Here also the tributaries from Maranhão side are unimportant ones. The main tributaries are the Raiz, Piranhas, Longá and Piranji Rivers, all coming from the East.

From the above mentioned tributaries, it is worth giving special attention to the following ones, due to drainage areas of their watersheds, with respective percentages

referred to the total area of Parnaíba River Basin: Canindé (26.2 %), Poti (16.1%), Gurguéia (9.9%), Longá (8.6%), Balsas (5.8%), Uruçuí Preto (4.7%) and Corrente/Itaueira (2.5%).

5.6. Streamflow and water quality

Average monthly discharges of Parnaíba River from the period of 1967 to 1984 are presented in the table below. Data corresponds to the Veneza Farm Fluviometric Station in Palmeirais town, located about 196 km downstream of Boa Esperança Dam, with a corresponding drainage area of 219,900 km²

Two distinct periods are noted: floods from December to May and droughts from June to November. Flood peaks occur in March and September is the dryest month. Extreme values observed in the period were 4,488 m³/s (Feb/80) and 132 m³/s (Jan/70).

Parnaíba River at Veneza Farm Station (Palmeirais, PI)

Dischrges	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Qm	670	857	976	919	586	361	312	289	285	368	472	538	553
Qdmin	384	470	445	498	362	265	255	241	240	236	345	368	201
Qdmax	1,144	1,429	1,788	1,566	890	475	360	341	350	563	693	828	2,180

Notes:
Qm = Average monthly discharges
Qdmin = Average daily minimum
Qdmax = Average daily maximum
Source: SEAAB (Departamento de Hidrometeorologia)

As for water quality aspects, data were obtained from Fundação CEPRO (Departamento de Meio Ambiente), SEAAB (Departamento de Hidrometeorologia) as well as information on potability supplied by AGESPISA, state owned water supply company.

Information obtained shows that throughout Parnaíba River there are no significant pollution sources which could jeopardize the water quality. There are few installed industries and the biggest ones treat their effluents or avoid discharging them into the river, as it is the case of alcohol plants which use their liquid wastes for fertilization and irrigation of sugar-cane cultivation. These industrial plants are concentrated in Teresina and Parnaíba. Besides, there are other smaller industries of tannage, soap, dairy products, etc.

The main pollution sources are represented by urban wastes due to lack of sanitary sewer systems. The only city with a sewage system is Teresina, but at a rate of only 5% of the population. Wastes are treated in a stabilization pond which nowadays operates beyond its capacity load, with consequent low efficiency.

Poti River, a tributary of right bank of Parnaíba River, which crosses Teresina, is considerably polluted by domestic sewer, due to clandestine disposal in the storm sewers system and/or direct disposal on surface waters and street ditches.

Results of the water analysis undertaken both by DNAEE and AGESPISA show that the presence of Fecal Coliformes have been constant, with very high rates for the *most probable number per 100 milliliters* (mpn/100 ml): in the analyses by AGESPISA the figures have always shown higher than 1,600 (detection limit of the exam) and in the DNAEE analysis rates up to 8,000 have been found. In general these analyses refer to samples collected in the valley towns (from Ribeiro Gonçalves to Luzilândia) where dilution

in surface waters is very effective due to low sewage volumes in comparison to river discharges.

Diluted oxygen rates (DO) always range up to 5 mg/l, and biochemical oxygen demand (BOD_5) rates are in general lower than 2 mg/l, which indicate that Parnaíba River is still capable of absorbing man-made pollution. Nonetheless, it is worth mentioning that last year worries with water pollution arose due to the *cholera* outbreak in Teresina, Luzilândia and other cities of the region.

5.7. Groundwater

Parnaíba River watershed is very promising as regards to groundwater since it lies almost completely in the *Silty Parnaíba Basin*, except for a strap of approximately 60 km wide along the Southeast border and on the coast, the latter being 40 km wide.

It extends over an area of 450,000 km², covering most of Maranhão's and Piauí's territories apart from small portions of Bahia and Ceará. It has almost a circular shape, and is filled with over 300 m of sedimentation in its deepest portion. From bottom upwards, the following formations are found: Serra Grande (50-200 m thick); Cabeças (200-300 m), Piauí (50-200 m) and Poti (200-250m).

Serra Grande and Cabeças formations present confined aquifers, and Poti and Piauí formations present unconfined aquifers, which come up as principal groundwater sources. Extensive recharge area, great thickness and lithological conditions provide Poti-Piauí System reasonable conditions of permeability. Volume estimates of about 600 x 10^9m³ make exploitable capacities of 1.18 x 10^9 m³/year an acceptable rate.

Preliminary existent estimates for the whole sedimentation basin of Parnaíba show that the total outflow of natural discharge is about 2.5 x 10^9 m³/year in the free aquifers and of 5 x 10^9 m³/year in the confined ones.

As for the exploitation potential and geological conditions, it is noted that along Parnaíba River valley and its main tributaries, the aquifers are artesian with potentials above 100 m³/h/10 km², whereas in the plateaus free aquifers of deep waters (50 to 100 m) with the potential at most 20 m³/h/10 km² are found. Intermediary potentials (50 to 100 m³/h/10 km²) are found in shallow aquifers (less than 50m), located along the arrow covering all the East border, central Southeast and the Southwest of the Basin.

On the southeast border of the Basin, where the crystalline rock formations are concentrated, the aquifers are constituted by systems of fissures. In this case, the exploitation potential is quite low, averaging 4 m³/h and at maximum 10 m³/h in the most fractured zones.

5.8. Main geological characteristics

The expressive sediment stratum found in Parnaíba River Basin is formed by several lithologies, containing rocks dated from Lower Paleozoic (Silurian) to upper Mesozoic (Cretaceous).

This sedimentation is linked to the successive transgressions and regressions, combined with subsidence and arching moves held during the Paleozoic, period in which

the most important Brazilian cycles occurred. The crystalline and metamorphic rocks of Precambrian age appear in a narrow strap in the Southeast of Piauí, covering about 20% of total area of Parnaíba River Basin.

It follows a geological sketch of the Basin, according to Projeto RADAM, which is illustrated in Figure 08:

Period	Litho-stratigraphic unit	Lithology
QUATERNARY	Alluvions and dunes	gravel, sand, silt and clay
TERTIARY	Barreiras Formation	pink sandstones, little consolidated, with clay and kaolin
	Serra da Tabatinga Formation	lateritic ferruginous sandstone
CRETACEOUS	Itapecuru Formation	sandstone and red clay stones, laminated
JURASSIC	Orozimbo Formation	black-purplish amygdaloidal basalt
TRIASSIC	Sambaíba Formation	thin and medium sandstone with big crossed stratifications
PERMIAN	Pedra de Fogo Formation	sandstone, siltites and shale with silex calcareous and gypsum bed
CARBONIFEROUS	Piauí Formation	thin sandstone with carbon shales intercalations
DEVONIAN	Longá Formation	dark grey and black shales
	Cabeças Formation	medium to thick sandstone with crossed stratification
	Pimenteiras Formation	shale and grey-purplish siltites with pyritic oolites layers and sandstone on the top
SILURIAN	Serra Grande Formation	thick sandstone with beds of oligomythic conglomerate
ORDOVICIAN	Jaibaras Group	slates, phylites, polimythic conglomerate and black calcareous lenses
PRECAMBRIAN	Salgueiro Group	micaschists, micaceous quartzites and crystalline calcareous beds
	Caraíba Group	granites, migmatized gneisses and quartzite beds
UNDIVIDED PRECAMBRIAN		gneisses, granites, amphibolites and pegmatites

5.9. Relief aspects

The relief of Parnaíba Basin characterizes for the predominance of two peculiar forms: the *plateaus* (high and low), which are tabular surfaces, with profound soils and the *slope areas and the plateau extension* or other elevations forming ondulated surfaces with eroded soils. Figure 09 shows details of the spatial relief distribution in the Basin.

Apart from these two formations stand out: pediplanation surfaces at the low plateau level in the semi-arid region, in the Southest of the Basin, some inter mountain valleys with fertile soils, the region of Campo Maior, the Parnaíba Valley, the fluvial flatlands and terraces, and the coastline.

Heights vary from 400 to 500 meters in the high plateaus, and from 150 to 300 meters in the low plateaus. In the former, the average declivities do not surpass 3% whereas the latter vary between 0 and 8%. On the ondulated surfaces, with heights ranging from 150 to 500 meters, declivities can reach 60% as it is the case of lightly ondulated, ondulated

and mountainous terrains. On the terrain of lighter ondulation, the declivites do not surpass 40%.

5.10. Soils

The soil surveys carried out by Projeto RADAM in the seventies and the EMBRAPA studies provide adequate details for different purposes. The schematic soil distribution is shown in **Figure 10** shows schematic soil distribution.

As for the present environmental study, it is important to point out predominance of the types of soils and their associations in the Parnaíba River Basin, bearing in mind, mainly, the discussions about the intrinsic environmental fragility and tendencies, which eventually could be detected as regards the evolution of land usage. However, the latter aspect goes beyond the scope of the current study and therefore it is not hereby discussed.

From the available data one can see that there is a predominance of latosolic soils with horizon B along the whole Basin. Its distribution covers most of the territory south of parallel 5°S, with small stains in the oriental part of Longá watershed, and practically all the occidental portion of the Basin slope, in Maranhão

Litholic soils come in second place in spatial distribution, and occur extensively along the eastern Basin boundaries and the plateau borders existent in all South and Southwest of the Basin.

The red-yellow podzolic soils occupy important spaces, being the third in extension. It is found all over the Basin, being concentrated in the medium stretch of Balsas River Basin, in medium Parnaíba River and in the Southeast (São Raimundo Nonato and Jaicós). It is also important to mention the expressive occurrence of red-yellow concretioned podzolic soils.

The quartzous sands present relevant spatial importance, mainly for concentrating in the headwaters of Parnaíba, Formiga, Medonho and Balsas Rivers on Maranhão Side, along most of the Uruçuí-Preto River Valley and its headwaters and Gurguéia River lower course. These stains are also distributed along the Parnaíba Valley as far as the Boa Esperança Reservoir region. In the North, quartzous sands are found in considerable extensions above the parallel 5°S up to the Delta region.

It is worth mentioning the occurrence of alluvial soils in the flat and lowlands along Gurguéia River and lower course of Parnaíba River.

The principal characteristics of predominant soils are:

- **Latosoils**: are deep to medium profound soils, highly drained, of texture varying from medium to very clayish in horizon B. They are predominantly alic, occurring also dystrophic and rarely eutrophic.

  They are distributed on the top of plateaus, either low and dissected, a few meters above the swamp levels, or high and with considerable extensions, plain relief with little and soft ondulations.

Although they are soils of low natural fertility, they have an excellent agricultural and live stock potential in the face of plain relief and soft ondulation and adequate physical properties.

- **Podzolic:** The textural soils with horizon B (argilic horizon) integrate this class. Through specific characteristics of this kind of soils, the occurrence of argilic horizon hampers its drainage, and they become saturate quickly in the rainfalls, increasing run off. Thus, they are more easily erodible soils, which worsen with the withdrawal of vegetal coverage.

  They compose big extensions of the Basin, situated principally in the hillsides, also occupying areas of slope and plateau summits, with a relief varying from plain to strongly ondulated. They originate from materials of several geological formations, noting that alic and dystrophic soils are predominantly developed with sandstone while the eutrophic soils can originate from shale, siltites and sandstones of several geological formations.

- **Concretioned soils:** Significant extensions of concretioned soils associated to podzolic and latosoils occur in the Basin, which are characterized by the presence of great quantity of iron concretions, with great limitations to the mechanization. These soils are in general resistant to erosion. However, they can present laminar erosion.

- **Quartzous sands:** they are sandy soils, essentially quartzous, from profound to much profound, excessively chained, without primary minerals, easily decomposable and of very low natural fertility.

  These soils are little used both in the agriculture and livestock due to their being extremely sandy, strongly acid and of very low natural fertility, subjected to erosion processes that originate ravines.

- **Litholic Soils:** poorly developed soils, from shallow to very shallow, possessing a horizon A lying directly over the rock, which makes these soils extremely fragile to human action.

- **Alluvial Soils:** soils poorly developed originating from recent fluvial deposits. They are moderately profound to very profound, and with different textures. In general, they present a high potential for agricultural usage.

5.11. Sedimentation

Studies show that there are several natural and anthropic factors in most of all streamflows of Parnaíba Basin which are responsible for erosion problems and high rates of siltation of riverbeds, mainly in the medium and lower stretches of the main stream.

There is a natural fragility, as regards the production of sediments, due to geological characteristics, where about 80% of the Basin consist of sandstones. Thus, highly sandy soils originate from various places and move into riverbeds.

Soils present in all the upper Parnaíba Valley and Balsas and Uruçuí Preto Rivers are essentially constituted by erodible quartzous sands. These very soils also occur in the lower stretch of Gurguéia River Valley and in significant stains in the Northern portion of Parnaíba River Basin. Other types of soils found in the Basin are subjected to laminar

erosion processes, which are probably associated to the low soil protection provided by typical vegetal formations.

Heavy rainstorms on areas poorly covered with quite thin herbaceous strata, thus permitting raindrops impacts action on soil surfaces, are intensely subjected to erosion processes, mainly on hilly terrains. As one can see in **Figure 07**, the medium stretch of Parnaíba River and lower half of Gurguéia River, Piauí and Canindé Valleys are subjected to a more intense form of this phenomenon.

As for the factors associated to human activities, it is worth mentioning the general practise of deforestation and burning, which expose and weaken the soils, facilitating the wind and rain actions.

Another practise that is responsible for considerable sediment deposit volume on the Parnaíba River bed is the so-called "*cultura de vazante*" (outflow culture, alongside river banks), which consists of deforesting and plunging the adjacent land of the river banks, so that after floods they are immediately cultivated for subsistence purposes, without any modern plantation techniques. This practise leads to an intense erosion process in which the river banks are excavated, increasing the river sedimentation.

In turn, in places where river bed deposits grow, subsequent floods reach higher levels, increasing the erosion again. This loss of previously existent equilibrium, associated to an increase of sedimentation in all the Basin leads to a continuous aggravation of erosive and sedimentation problems. This phenomenon is observed principally in the medium and lower stretches of Parnaíba River. This aspect is of great importance due to the direct interference of the sandbanks on the river navigability.

Intense sediment deposition has recently obstructed a secondary river channel in the Delta region. Maranhão's Araioses area has seen a decrease in rice crops and other outflow cultures due to shortage of water for irrigation purposes. In order to help intercepting sediments and divert them to the main stream, a levee was built in the secondary channel entrance, but the contrary has happened: deposits increased too fast and the channel became completely obstructed in a 1.5 km. Presently, even in wet seasons, discharges from Parnaíba mains stream is zero, and thence salt water reach long distances.

Notwithstanding the social and economic problems that arose from this situation, reclamation of the Araioses area is not programmed for the short term. It is worth of note, however, that there are preliminary studies sponsored by SINFRA aiming at feasible solutions in a local basis.

5.12. Vegetation

The Parnaíba River Basin vegetation has a great physionomic and floristic variety due to differences in climate, soil and topography. However, the predominant vegetal coverage is thorny steppe (*caatinga*) and savanna (*cerrado*), as well as woods and babassupalm trees.

The relief formed by plateaus and mountain ridges compose steep slopes and is covered mainly with steppes and savannas, besides seasonal, decidual and subdecidual forests in the lowlands to the South and North, and riparian forests along river valleys and natural drainage systems.

The steppe does not naturally present high density of trees, bushes and weeds, while in the savannas the burning practises frequently diminish its coverage, similarly to shallow or selective cuts in the seasonal forests. The falling of riparian forests that benefit palm tree expansion, formed principally by babassupalm (*Orbignya martiana*) and *carnaúba (Copernicia prunifera)*, occurring the *buriti* (*Maurita vinifera*), another type of palm tree in the south of the Basin.

This vegetal coverage offers only slight protection to the soils against raindrop impacts, thus originating important erosive processes. This is worsened by wind action, after land clearance for agricultural purposes, notably in the savanna soils. Wind action is a very important erosive agent in Piauí.

To the South, there are incipient processes of desertification and expanding desert areas, due to specific environmental conditions, climate characteristics with drought periods of 6 to 7 months and inadequate agricultural practises. This could become a problem to Parnaíba River Basin, which lies very near of the most problematic areas of desert expansion.

Briefly, **Figures 11** and **12** show morphoclimatic units and distribution of vegetal coverage all over the Basin. Annex B presents details on spatial distribution of the vegetation, with indication of most important species. Predominance of vegetation along the Basin is resumed as follows.

- **North**: dune and sandbank vegetation and mangrove in the Delta, thorny steppe savanna, contact and seasonal subdecidual forest with babassupalm;
- **Center-west**: seasonal subdecidual forest with babassupalm, forest/savanna contact, and savanna;
- **Southwest**: savanna and woodland (or arboreous) savanna (known in Brazil as *cerradão*);
- **Southeast**: savanna, woodland savanna, steppe-savanna contact and thorny steppe;
- **Center-east**: savanna; woodland savanna, steppe/savanna contact and steppe;

While the thorny steppe dominates the eastern portion of Parnaíba River Basin, the savanna occupies its western portion. The seasonal subdecidual forests occur in hills and plateaus covered with thorny steppes. Some species are decidual in dry winter. The formation is defined with many lianas, few epiphytes and upper layers with 15 to 30 m. The seasonal subdecidual forests with babassupalm present great quantities of babassupalm and suffers intense anthropic action. In the drought season, which occurs in winter, the upper layer trees lose their leaves. There are many lianas and few epiphytes, being the layers linked with lianas.

Deforestation and land burning originate secondary vegetation of babassupalm trees and coconut trees. It is found under hot semi-humid climate, in a climate transition region. Its layers are badly defined and the tallest trees reach 30 to 40 m. There are many lianas and epiphytes.

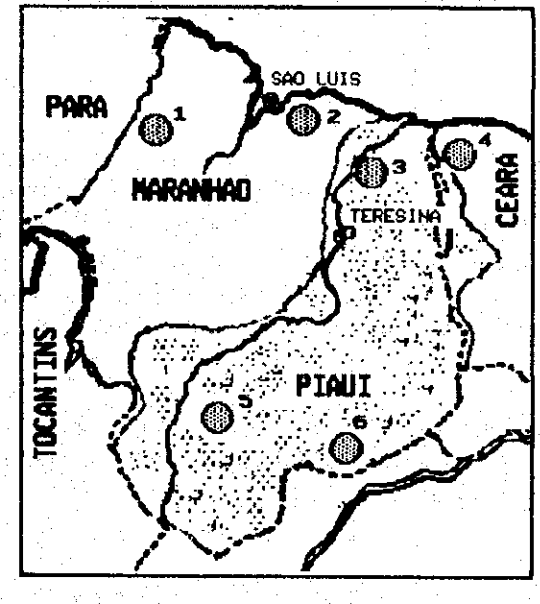
The steppe corresponds to kinds of vegetation from semi-arid climate, varying in structure, height and density. It is distinguished by leafless forest in the drought and thorny trees and bushes, thorny juice plants, herbaceous plants and xerophilous vegetation. The species richness decreases while the aridity increase. It can be divided into thick bushy steppe, which covers most part of semi-arid Northeast, hilly steppes in altitude, with more humidity, defined by more trees and herbaceous individuals.

The savanna is typical of hot semi-humid climate (with 5 to 6 months of drought) and poor soils. It occurs in deep soil plateaus. The vegetation structure varies and generally corresponds to herbaceous - woody formations, with small size trees with profound roots, twisted trunks, average height of 4 to 6 m, with open crowns and coriaceous leaves. In the Center-north of Piauí, the savanna is much different from Central Brazil's, as there are more trees, with straight trunks and bigger caducity, characterizing the transition to subdecidual woods. Approximately 50% of steppe species with smaller leaves are present.

The woodland savanna occurs in areas of better edaphic condition. The vegetation is taller and thicker than the savanna, but lower and less thick than forests, reaching maximum height of 10 to 15 m. The trees are not twisted and herbaceous layer is less thick than in the savannas. In the savanna and steppes it occurs extraction, agriculture and extensive cattle breeding, leading to the natural resources destruction. In forests, there are high and low volumes of timber and babassupalm trees, of low economic value. The steppe covers leveled surface of Precambrian and the savannas occur on Paleo-Mesozoic terrains. Forests occur over leveled surface with more recent silty deposits (Cenozoic and Quaternary) and the reefs occur in big extension of natural pasture.

The seashore dune and sandbank vegetation is affected by the wind, sea and sand dusts, presenting adaptations to salt, high temperature and little quantity of water. The sandbank is less directly influenced, presenting a wide range of bushy and arboreous woody plants, with some common species of steppe and savanna. From the researches, it may be concluded that no endangered species shall be affected by waterworks necessary to navigation development. Nevertheless, future regional development will certainly affect regional flora in a whole basis, if present agricultural practises remain.

Yet, it is important to mention that present knowledge and available information do not allow any conclusions about existence of rare or endangered species among Basin boundaries, but for the purposes of this study, no serious problems can be envisaged. Besides, it is worth mentioning the existence of national parks and biological reservation areas in the region, where these species can be protected and better studied. Locations of these areas are shown schematically below and further details appear in Annex B.



1. Gurupi Biological Reservation*.
2. Lençóis Maranhenses National Park (LM)*.
3. Sete Cidades National Park.
4. Ubajara National Park*.
5. Uruçuí-Una Biological Reservation.
6. Serra da Capivara National Park.

* Representatives of other environments, which are only slightly related to the Parnaíba River Basin: Gurupi is representative of the Amazon rain forests. Ubajara is representative of similar environment, but lies inside Ceará Territory. However, LM is representative of the dune and sandbank vegetation also encountered in the Parnaíba Delta.

It should be noted that the whole Basin is surrounded by areas where most vegetal formations of the Northeast are represented. Besides, other important aspects are contemplated, such as fauna, geological, geomorphologic, archaeological, and mineral water springs

5.13. Aspects of the regional fauna and vanishing wildlife

5.13.1. General considerations

The kinds of different animal groups identified in this study, according to the tables included in this report, originate from 34 municipalities of Piauí and have been selected due to the physiographical characteristics of each region as stated in chapter 3. This has led to a significant sample for this fauna survey in the territory of Piauí.

Most of the animals identified in this study have been focused on the kinds of different classes of Vertebrates whereas several groups of Invertebrates have intentionally been disregarded, although the latter are as important as the former ones as the link for a complex feeding web of numerous ecosystems of Piauí. The goal in this work, however, was to report the significant elements of macro fauna or Invertebrate group which could arise environmental interest in face of the future waterway.

It is important to point out that in the field work carried out during the eighties[8], many groups of terrestrial, fresh water and sea Invertebrates were given the same treatment as Vertebrates, that is, they were captured, stuck, registered, identified and incorporated to the collection of FUFPI DBM. Such data led to the publication of numerous scientific works and reports in Congresses, Symposiums, meetings, including Mastership Essays and Doctorship Thesis, which are listed in Annex A.

It has also to be added that, as for the health problems in Piauí, the transmitting insects and vectors of ethiological agents of the most significant diseases found in the Northeast, besides the registers regarding the poisonous kinds of the Artropodous group prone to cause quite serious accidents due to the specific toxic production such as scorpions, spiders, "***potós***" (a bug, *Paederus columbinus*), centipedes, etc., are mentioned and identified. Brief comments on deseases are presented elsewhere.

5.13.2. Fisheries

According to old fishermen of the region, Parnaíba River and some tributaries represented excellent fisheries for fish trade some thirty years ago. Mean and big fishes were captured near the Parnaíba and Poti Rivers confluence. Nevertheless, according to DNOCS researches of the 1977-1979 period, commercial fishes of mean and big proportions were not captured anymore after Boa Esperança Dam construction and reservoir impoundment. Productivity rates (kg/man.year) decreased in 50% in a period of 23 years, from 1955 to 1978.

Most of Parnaíba River fishes are migrating species and need to travel to upstream stretches for reproduction purposes, but the Boa Esperança Dam represents a barrier to migration, differently from tributaries of downstream stretches.

[8] See Chapter 3.

Increasing deforestation and frequent vegetation burning for agriculture, river sedimentation, water pollution besides Boa Esperança Dam construction are factors that may be pointed as responsible for environmental changes, which in turn respond for a decreasing fish population. Besides, it is also necessary to note that physical and chemical conditions of Parnaíba River water do not favor fish life, due to high turbidity and to pH values under 6.8 and less.

The following fishes are endemic in the Basin: *Potamotrygon signata* (arraia)[9], *Loricaria pyauhyensis* (acari), *Pimelodella parnahybae* (xué), *Moenkhausia sanctafilomenae* (piabinha), *Hemiodus parnaguae* (voador) and *Loricariichthys tipus* (cari).

Fish trade in Teresina is done with fishes that are imported from Pará, Maranhão and Bahia. Only a slight percentage, not evaluated for this study, comes from Boa Esperança Reservoir. According to the Guadalupe based Boa Esperança Reservoir fishermen association (*Associação dos Pescadores da Represa de Boa Esperança*), fish population of the reservoir has also decreased since 1974, according to DNOCS data. Big and mean size fishes are rare. Although the association has 120 members, only 64 practise fishing as their economic main activity.

Most frequent species found in the Boas Esperança Reservoir are *Curimatus cyprinoides, Prochilodus lacustris, Astyanax bimaculatus, Serrasalmus rhombeus, Pimelodus maculatus, Pimelodella parnahybae, Geophagus surinamensis, Sarotherodon niloticus* (artificially introduced), *Plasgioscion squamossimus* and a fresh water ray, *Potamotrygon signata.*

In the Parnaíba Delta, human activities affect the marshlands and mangroves, due to rice culture in some places, thus affecting natural conditions with not well evaluated consequences to fish population. It is important to note that alongside river banks there are temporary and permanent small lakes, lagoons and ponds that are necessary for fish reproduction. It is well understood that increasing human activity and deforestation along river banks affect these ponds and interfere in vital cycles, thus also contributing for fish population decrease. As a conclusion, it may be said that present environmental conditions of Parnaíba Basin do not favor fishing as an economic activity.

5.13.3. Results

5.13.3.1. *General aspects*

The fauna survey, carried out in several State regions, in which typical kinds from Piauí's differentiated physiographical areas were looked into, brought a very promising result, of 573 taxons species altogether, most of them consisting of Vertebrate classes, added by Crustaceans and Sea Mollusks, which arise commercial interest and can be a source of revenue to the State.

Small and medium size animals were identified, and in arid and semi-arid regions fauna typically consists of parklands and savannas, and of animals with nocturnal habits. In the humid and sub humid areas the dominant species are represented by marsupials and edentates, significantly poor as regards apes, compared with the Northern and Central-Western regions of Brazil.

[9] See glossary in Annex C.

The results of the survey are registered in 10 tables (see Annex C) that compose the animal range of Piauí. They are listed from the most to the least developed ones. In other words, each group is listed in taxonomic sequence, including the classes, orders, families, genus and species, with their correspondent numbers and whenever possible, the popular denomination known in the surveyed area.

From the available data on animals, the following information can be obtained:

1. Mammals: 75 species, in 36 genus, belonging to 27 families, placed in 7 orders.
2. Birds: 147 species, in 127 genus, belonging to 47 families, placed in 19 orders.
3. Reptiles: 45 species, in 39 genus, belonging to 13 families, placed in 3 orders.
4. Amphibian-anurous: 15 species, in 7 genus, belonging to 4 families, placed in the Anurous order
5. Fresh-water Fishes (OSTEICTIES): 57 species, in 50 genus, belonging to 20 families, placed in 5 orders.
6. Fresh-water Rays (BATOIDS): a sole endemic specie from the Parnaíba River and some major tributaries: *Potamotrygon signata*;
7. Sea Fish (OSTEICTIES): 162 species, in 118 genus, belonging to 50 families, placed in 14 orders.
8. Sharks and Rays (CONDRICTIES- SELACHIOUS and BATOIDS): 25 species, in 25 genus, belonging to 13 families, placed in 2 orders.
9. Sea Crustaceans: 34 species, in 20 genus, belonging to 10 families, placed in one order of 3 sub orders.
10. Fresh-water Crustaceans: 2 species, in 2 genus, belonging to 2 families, placed in one sole order.

5.13.3.2. ***Endangered and rare species***

Endangered species (according to IBAMA) are marked in the tables with "*E" and are listed below:

- **Mammals**: guariba (*Alouatta belzebu*: Primates, cebidæ); macaco-prego (*Cebus apella*: Primates, cebidaæ); saguí (*Callitrix jacchus*: Primates, calitrichidaæ); tatu-bola (*Tolypeutes Tricinctus*: Edentates, dasipodideæ); guará (*Chrysocyon brachyurus*: Carnivores, canideæ); lontra (*Lutra enudris*: Carnivores, mustelideæ); maracajá-açu (*Felis pardalis mitis*: Carnivores, felideæ); maracajá-pintado (*Felis tigrina tigrina*: Carnivores, felideæ); onça-pintada (*Panthera onca*: Carnivores, felideæ);
- **Birds**: guará (*Eudocimus ruber*: Ciconiiforms, treschiornitideæ); asa-de-sabre (*Campylopterus largipennis*: Apodiforms, trochilideæ); Arara-azul-grande (*Anodorhynchus hyacinthinus*: Psitaciforms, psitacideæ); bico-virado (*Megaxenops parnaguae*: Passeriforms, furnariideæ);
- **Reptiles**: tartaruga-lisa (*Chelonia mydas*: Chelonian, cheloniideæ); tartaruga-de-pente (*Eritmochelys imbricata*: Chelonian, cheloniideæ); tartaruga-gigante (*Caretta caretta*: Chelonian, cheloniideæ); jibóia (*Boa constrictor constrictor*: Scaled Ophidian, boideæ).

The tables do not show various species that suffered with hunting pressures. Although their numbers were high in the past, present occurrences and observations in Piauí are very rare and they almost vanished from the region. Among these, it is worth mentioning the following:

- **Mammals**: tatu-canastra (*Priodontes giganteus*: Edentates, dasipodideæ); tamanduá-bandeira (*Mymercophaga tridactyla*: Edentates, mimercofgideæ); capivara (*Hydrochoerus hydrochoerus*: Rodents, hidroqueridaæ); paca (*Agouti paca*: Rodents, agutideæ); anta (*Tapirus terrestris*: Perissodactyl, tapiridaæ); veado-campeiro (*Ozotocerus bezoarticus*: Artiodactyl, cervideæ); guaxinim (*Procyon cancrivorus*: Carnivores, procionideæ); suçuarana (*Felis concolor*: Carnivores, felideæ);

- **Birds**: ema (*Rhea americana*, Rheiforms, rheideæ); urubu-rei (*Sarcorramphus papa*: Falconiforms, catartideæ); papagaio-do-mangue (*Amazona amazonica*: Psitaciforms, psitacideæ); arara-vermelha (*Ara chloroptera*: Psitaciforms, psitacideæ); araponga-de-barbelas (*Procnias averano*: Passeriforms, cotingideæ).

5.13.3.3. *Geographical distribution*

National parks and biological reservation areas presented in Annex B are representative of the various ecosystem found along Parnaíba River Basin and hence brief comments are enough for the purposes of this study.

Sete Cidades National Park shelters fauna representatives that may be found in different ecosystems beyond savanna and steppe. Some elements have ample geographic distribution. Examples of these are the veado-mateiro (*Mazama americana*), which does not appear in Annex C, which tables are based on researches done in other places; mocó (*Kerodon rupestris*), a typical steppe rodent, and the iguana (*Iguana iguana*), also found in Amazônia. Many other species are found, such as carnivores, rodents and others, besides a list of 83 birds.

Serra da Capivara National Park is a typical representative of the steppe ecosystems. Inside its limits it can be found: *Felis* sp; *Felis pardalis*, *Dasypus* sp., *Agouti paca*, *Keredon rupestris* and *Dasyprocta* sp., among many others. Examples of birds are *Cariama cristata*, *Milvago chimachima* and *Herpetotheres cachinnans*, besides a great number of Passeriforms. Examples of reptiles are snakes: *Bothrops spp.* and *Crotalus durissus*, and some iguanas.

In Uruçuí-Una Biological Reservation there are representatives of both savanna and steppe ecosystems. Most of its species can be found in a wide area inside Parnaíba Basin boundaries.

Fauna of the Lençóis Maranhenses National Park is representative of those found in the Parnaíba Delta and Caju Island. For the birds, it is an important "supporting" point for migrating birds in their trips between the Americas. Most of the reptiles, sea fishes, sharks and rays presented in Annex C tables were collected in Caju Island and can be found also along the Maranhão seashore.

Occurrences of palm tree forests predominate along Lower Parnaíba River valley between Teresina and Parnaíba. Due to their small flora diversity, vertebrates quantities are

reduced as compared to other regions. Numbers below are those pointed out in the Annex C tables and indicate presence of specific animals in these forests:

- Mammals: 3, 4, 22. 227, 28, 31, 40, 52, 43, 54, 55, 56, 57, 63, 66 and 70;
- Birds: 100, 104, 108, 139, 142, 162, 179, 180, 196, 197, 211 and 212;
- Reptiles: 232, 235, 240, 245, 253, 255 and 258;
- Anurous: 270 and 282.

5.13.3.4. *Health problems*

Besides specific ecological conditions, poverty, subdevelopment and social conditions are factors that make some tropical diseases endemic in Maranhão and Piauí. Examples of these are briefly commented below, due to their importance in Piauí. It is worth of note that these deseases are also correlated to the regional fauna.

Disease	Causative agent	Vector	Method of infection	Reservoir
Leishmaniasis*	*Leishmania donovani*	Mosquito: *Lutzomyia longipalpis* (Psicodideæ)	Bite	Dogs, Man
Chagas' disease	*Trypanosoma cruzi*	Bugs: *Triatoma brasiliensis, Triatoma maculata, Panstrongylus megistus* and related species	Fecal contamination of bite	Rodents, dogs, cats, bats, marsupials, armadillos
Malaria	*Plasmodium vivax, P. falciparum and P. malariæ*	Mosquitoes: *Anopheles darlingi, A. aquasalis*	Bite	Man, monkeys (?)
Yellow fever	*Virus*	Mosquito: *Aëdes ægypti*	Bite	Man, monkeys (?)
Dengue	*Virus*	Mosquito: *Aëdes ægypti*	Bite	Man
Cholera **	*Vibrio choleræ*	Housefly (*Musca domestica*)	Contamination of food and water	Man

* 300 registered cases in Teresina and 35 in Timon from January to August, 1993.
** There are serious problems due to bad sanitary conditions

Serious health problems can arise from bites of scorpions, spiders, centipedes (*Scolopendra viridicornis*), great ants (22 mm size) of the specie *Paraponera clavata*, and from venomous snakes, such as *Micrurus ibiboca* , *Botrhops* sp., *Crotalus* sp., etc.

5.13.4. Final comments

Fauna representatives are widely spread in the whole territory, in different ecosystems. There are some rare species and various endangered species.

The national park and biological reservation areas contain in their limits enough space for preservation purposes and are very well representative of the surrounding ecosystems. The Southwest still have conditions to support wildlife in good conditions, due to the yet sparse human presence.

A changing environment always poses problems to wildlife, and this is the case of Parnaíba River Basin, which suffers from inadequate agricultural practises, deforestation and bad land usage. Environmental changes are coming too fast and serious problems are being imposed to local fauna.

However, the researches show that no endangered species shall be affected by waterworks necessary to navigation development. Nevertheless, future regional development will certainly affect regional fauna in a whole basis, if present agricultural

practises remain. Even modern techniques of land usage will affect the macro fauna, but for the present and the purposes of this study, no serious problems can be envisaged.

5.14. Main socioeconomic aspects in face of environmental problems

5.14.1 Influence area of the future waterway

5.14.1.1. *General considerations*

As for the description of the main environmental characteristics of the socioeconomic aspects a spatial demarcation was used, different from the one used for the natural system — ***the watershed*** —, being this demarcation supported by the urban spatial structure and respective areas of influence of urban centers, in order to characterize a potential influence area of the future waterway, considering Balsas and Parnaíba River.

Thus, the so-called influence area covers 9 *homogeneous micro regions* (as defined by IBGE: MRHs) of Maranhão and 9 MRHs of Piauí[10]. For the purposes of this study, this area could be subdivided in 3 big segments: North, Center and South, each one incorporating territorial segments of both States.

As it can be observed in **Figure 13**, there are territorial segments which follow a diverging polarization structure, whose principal tendency is to attract the flow from valley areas along Parnaíba River towards urban centers *outside* the Basin as it can be sketched in **Figure 14**. Such aspect can be emphasized by 3 spatial segments discriminated below, with special attention to the Balsas region.

5.14.1.2. ***The Balsas territorial segment***

The influence area of Balsas town consists of Maranhão's MRHs *Porto Franco, Gerais de Balsas* and *Chapada das Mangabeiras*, to the South and Southeast. This region is polarized by Imperatriz and São Luís.

Piauí's South and Southwest portions are being attracted outward by Balsas, due to the quick development of Balsas region, the lack of road infra-structure and their weak links to the North Central Piauí, as well as the *Corredor Carajás* attractiveness regarding grain production. Planned and underway road construction tend to reinforce these factors considerably, as the road network heads for *Corredor Carajás*:

- A bridge under construction over the Parnaíba River in Ribeiro Gonçalves, will allow a direct connection of PI-030 and BR-324[11] highway with Balsas town;
- A small bridge over Parnaíba River in Tasso Fragoso can facilitate the Maranhão dolomitic calcareous entrance into Piauí and the sending of grain (mainly soy) towards Balsas;
- Conclusion of PI-254, linking the BR-135 stretch between Monte Alegre of Piauí and Gilbués with Santa Filomena thus linking Alto Parnaíba and Balsas through MA-330.

[10] **Maranhão**: Baixo Parnaíba, Chapadinha, Codó, Coelho Neto, Caxias, Chapada do Alto Itapecurú, Porto Franco, Gerais de Balsas e Chapada das Mangabeiras.
Piauí: Baixo Parnaíba Piauiense, Litoral Piauiense, Teresina, Médio Parnaíba Piauiense, Alto Parnaíba Piauiense, Bertolínia, Floriano, Alto Médio Gurguéia e Chapadas do Extremo Sul Piauiense.

[11] BR stands for federal roads, PI and MA for state roads.

It is also a significant aspect that Cia. Vale do Rio Doce (state owned greatest Brazilian mining company) strongly supports grain trading in Uruçui (PI).

The political movement in favor of the subdivision of Piauí aiming at forming the State of Gurguéia also represents the feelings of producers and the political elite of the South of Piauí region, which would be separated from the politically dominating North-Central Piauí, in order to make possible the same kind of economy of Central Brazil's Savannas.

Despite these considerations, Balsas town and its tributary segments were included in the potential influence area of the waterway, as an eventual extension of it through Balsas River, which would constitute a powerful appealing factor, thus offering an alternative for transportation with competitive costs, totally or partially changing the current tendency.

5.14.1.3. *The Far South Piauí region segment*

MRHs *Alto-Médio Gurguéia* and *Chapadas do Extremo Sul Piauiense* are polarized by Floriano town — with special attention to the importance of BR-135 road and state roads linked to it — but do not keep significant relations with the urban centers of Parnaíba River upper course. The traditional polarization of Floriano may possibly revert due to the attractiveness of Barreiras town, regional center of Bahia Savanna, and Balsas.

Presently, for the region's grain producers, these are the commercial main centers for their production flow, being Balsas (300 km) nearer than Barreiras (500 km). Part of soy crop goes the other way round to milling centers of Fortaleza, CE, via Picos, PI. Likewise the previous idea this region seems to be part of the potential influence area of the future waterway.

5.14.1.4. *The Teresina region segment*

In the medium and lower course of Parnaíba River it can be observed a dubious relation of polarization between Teresina/Timon and Caxias, MA and its area of influence. Bearing in mind the presence of railway and roads crossing the Itapecuru Valley and a possible cargo inter modality in Teresina, the territorial segment of MRHs *Codó*, *Coelho Neto* and *Caxias* adds to the area of influence of the waterway.

5.14.2. Discussions

Thus, the potential influence area of the waterway extends beyond Piauí's and Maranhão's State borders, reaching almost two thirds of Piauí's territory, part of eastern Maranhão and portions of Northern Bahia, with a roughly triangular form as it can be seen schematically in **Figure 15**.

The significance of this area in the context of both Piauí and Maranhão in relation to their principal portions inside its imaginary boundaries can be visualized in some basic census information (see Annex D of this report) which are discussed below.

In 1991, the total resident population was about 3,000,000, representing almost 40% of both State populations (25.8% in Maranhão and 66.4% in Piauí), with urban growth rate of 55.9%, which reached 79.4% in the Piauí's portion and 39.3% in Maranhão's.

The northern and central portions of the area included most of such total population, 81.3% of total population and 85.4% of urban population. The industrial, commercial and service holding segment were strongly concentrated in these portions, being the south portion marginal to them.

As for the agricultural and cattle breeding activities, the 1985 data from Economic Census shows their distribution. The area of influence covers a total of 265,601 agricultural and cattle breeding or vegetal exploitation, amounting to 11,545,744 hectares, standing for 42.2% of the sum of areas of those establishments in both States.

They were responsible for 32.6% of the agricultural and cattle breeding production rate in both States (36.4% with permanent farm lands and 35.3% with temporary farm lands), besides 31.1% of ox cattle and 35.5% raw rice crop. The South portion, with low occupation density, stands for 54.6% of total area of establishments, but with much inferior proportions in the agricultural and cattle breeding performance.

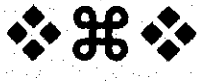
5.14.3 Considerations regarding fishing activities

Present fishing practise in inland waters, from the socioeconomic point of view, is only on the subsistence level and linked to informal economy when practised near the biggest urban nucleus. Owing to almost absolute lack of secondary information[12], the analysis of this activity was based on field observations and on interviews with fishermen and their colonies leaders and also on considerations discussed elsewhere in this report.

In general, information and data obtained show the existence of no intense fishing effort, which develops on amateur basis. During drought periods this effort is more reduced with the migration of most of professional fishermen — that is, those whose principal economic activity is the fishery — to other activities of subsistence.

In domestic economies, it is frequent to find the combination of fishing and a small subsistence agriculture, various service holding activities. There seems to be very few people dedicated only to fishing activities in a whole year basis. They are found mainly in Boa Esperança Reservoir (with embarkation ports in Guadalupe and Uruçuí), in stretches of Parnaíba River near Teresina - Timon (including the fisheries along Poti River and embarkation points in both cities) and in the lake regions (lower course Parnaíba), specially in Luzilândia.

A preliminary and rough estimate in *this* study points out the existence of about 500 workers, whose principal economic activity during rainy season is the fishery. Approximately two thirds concentrate in the previously mentioned places, the others being distributed in other valley urban nucleus. Thus, it can be seen that from the economic and environmental points of view, fishing activities have no importance in the present context of the whole Parnaíba River Basin.



[12] Freshwater fishing activities in Piauí are rarely mentioned or referred in the bibliography and data analyzed. Only references to fishing activities in Boa Esperança Reservoir and Parnaguá Lake were found, as well as to fish breeding in artificial ponds.

6. ENVIRONMENTAL PROBLEMS ASSOCIATED TO LAND USAGE AND DEFORESTATION

6.1. General considerations

The traditional model of agriculture and cattle breeding activities adopted in Parnaíba River Basin are predatory to the environment, once they are based on obsolete techniques of deforestation and without any modern technology. Soils become exhausted due to its over utilization and the practise of burning the vegetation. Such a model represents also a constant move to incorporating new virgin areas and abandoning the old ones simply because there is so much available land.

Comments presented in this chapter introduce to more detailed and specific discussions for impact assessment purposes and justify some countermeasures that are proposed in this report in view of the Navigation Development Plan, as seen in the following chapters.

6.2 Relevant aspects for the environmental analysis

6.2.1. Economic activities

The potential influence area of the Parnaíba waterway, as well as the remaining territories of Piauí and Maranhão, is traditionally characterized by the obsolete productive sector and poverty of most of the population. The region is highly dependent on the importation of industrialized goods, due to lack of local industrial development: Piauí's importation between 1974 and 1975, for example, reaching 4 times the export rates, amounts to about 40% of state net gross product (NGP)[13].

The tertiary activities are responsible for a bigger amount of NGP, centered in service holding activities and commerce, being severely affected by the vegetal extraction crisis (*carnaúba* and *babassupalm* tree) which could not bear the similar product competition, disseminated in the fifties onwards.

The primary sector was historically characterized by the predominance of extensive cattle breeding in constant expansion, combined with a fragile policulture practised within the cattle breeding space — the large landed estates — by a great number of landless farm workers.

This policulture, developed in small establishments, aimed at the self subsistence of direct producers and was practised with obsolete techniques. Only cultures such as rice, corn, beans and manioc for subsistence were practised, besides cotton cultures, with small market surplus.

The abundance of lands and the relative isolation of the region allowed this economic and sociopolitical system to reproduce and expand for a long time, which increased the predominance of local commercial capital.

[13] This is a very important aspect as related to environmental analysis and impact survey, as it indicates that the future port of Luís Correa tends to be the main entrance of industrial products and goods to Piauí. The waterway could, therefore, contribute to a significant amount of environmental problems and risks, due mainly to transportation of dangerous cargoes.

The integration of the area to Brazilian and Northeastern economy started in the fifties, but it made the local production basis still weaker because of its low competitive power, reinforcing the dependency relations to more developed centers and intensifying the process of rural-urban migration.

The industrial sector remained less important and turned to traditional and little capital-demanding activities (food products, clothing, leather, fur, furniture, etc.). Thus, tertiary activities predominated, mainly banking and financial, communication, transport and welfare services, besides commercial activities. This process coincides with intense urban development and civil construction expansion.

The primary activities, specially the agriculture, remained scattered, atomized and without any organizational or modernization skill. They continued being practised by small landless producers, and by small land owners — the former paying rent to the cattle breeders, *the whole conjuncture being highly vulnerable to the climatic conditions*. Still in 1980, around 80% of peasants worked on agriculture, essentially on the self-subsistence level. Around 60% of producers were landless and stood for approximately 40% of agricultural production.

Farming techniques remained obsolete, and due to abundance of lands, there was a constant expansion of occupied areas, the older pieces of land being abandoned due to exhaustion, over utilization and the predatory practises. Therefore, there was a constant deterioration of country life condition, keeping the productive sector to self consumption and with low market surplus.

The low soil fertility and its high degree of acidity, irregular rainfalls, absence of agricultural policies, high concentration of land ownership — unused areas and small areas exhausted by over utilization — and poverty for great part of the rural population point out to an extremely important aspect in this environmental assessment, which means that land usage is a non conservative and non self sustained practise.

6.2.2. Public projects and investments

Since 1970, external decisions and resources — Federal Government and World Bank (BIRD) — have made possible the modernization of agricultural and cattle breeding due to public irrigation projects and financial support to tenant farmers and small and medium rural entrepreneurs The big private projects were supported by fiscal incentives and subsidiary credits. The modernization attempts of small and medium food production can be mentioned (*Pólo Nordeste, PDRI Vale do Parnaíba and PAPP*) and are also factors correlated to modernization attempts.

The results achieved by the public irrigation projects sponsored by DNOCS and DNOS, today under the responsibility of SENIR suffered basically local impacts, as the biggest projects are still in the implantation phase (*Tabuleiros Litorâneos*, *Platôs de Guadalupe*, *São Bernardo* and *Piracuruca*). The oldest ones, *Lagoas do Piauí*, *Caldeirão*, *Gurguéia* and *Vale do Fidalgo*, amount to approximately 3,000 hectares of already implanted irrigated areas, the total effectively in operation today being much inferior as can be seen in Annex D.

Yet, the impact of private projects is more evident, not only as regards the irrigated perimeters and agroindustries but also concerning the big agricultural and cattle breeding projects in dry areas. In the Central and Northern areas agroindustrial nucleuses based on

irrigated cultures were implanted, especially for sugar-cane and rice. As well as that numerous small and medium irrigated perimeters which turned to the production of rice, cotton, fruit, are present in small scale in the South, particularly in Gurguéia and Uruçuí Valleys.

The big agricultural, cattle breeding and forest projects, carried out specially in the southern savannas, are turning this segment into the biggest nucleus of grain production in Occidental Northeast, which has wide potential for expansion due to over 10,000,000 hectares of available unexplored savannas.

6.2.3. The migration to the cities: a common problem

A modernization attempt was made for the small production in an area covering mainly 28 Piauí municipalities along Parnaíba River, between Luis Correia and Amarante. The results obtained so far have been of little importance, due to factors directly derived from wide political and economic dominance by great landowners and by traditionally commercial capital. The actions taken through programs aiming at this goal — infra-structural work and acquisition of lands — seem to have benefited more directly the latifundia, and was incapable of impeding the disintegration of traditional small production.

The large amount of establishments explored by landless — tenants, partners and occupants —, as well as the growing soil exhaustion and the fragmentation and decrease of average area of these settlements, are partially responsible factors, in the last 2 decades, for the migration to the principal regional and external urban centers, their intense urbanization and growing of slums.

This set of factors and processes significantly contributes to the loss of importance of small farmers and to increase the producer's instability in relation with the land, and strongly contributes to the intensification of migration flow of most vulnerable rural populations Thus, the urbanization rate, which in Piauí stood for around 20% in 1980, jumped to over 51% in 1991, with an average yearly growth rate above 7,0%, the same happening in Maranhão although in lesser scale.

Migrating people tend to concentrate in most developed centers — Teresina, Parnaíba, Picos, Floriano and Caxias — which also concentrated biggest increase of industrial, commercial and service holding activities. The Piauí's mentioned cities respond for almost 90% of total trading tax (*ICMS*) collection.

Although these cities became industrialized, mainly Teresina, they remained as commercial and political centers, and therefore unemployment levels are far beyond demand for jobs. Thus, underemployment and informal economy show considerable expansion.

6.3. The traditional ways

Historically land usage revealed a progressive tendency towards increasing losses of topsoil of extensive portions of the Basin, due to natural conditions of fragility, which are intrinsic to the environment, as well as to progressive deforestation without any control nor any official reclamation policy. The annual burnings for pasture renewal tend to considerably weaken the soils, thus conditioning new erosion processes, which are intensified in the wet seasons.

This totally inadequate form of land usage is also present in areas of more irregular relief as well as in the plateaus, where one can observe timber extraction and vegetal coal production activity. During heavy storms, there are great tendency of ravine formation on sloped areas.

Even though the intensive agricultural practises are leading to the modernization of the cattle breeding and agriculture, they are not free from serious environmentally aggressive actions. Due to their scale in a large territory — one must have in mind that the whole watershed area is much bigger than most of European countries —, the use of heavy equipment, pesticides in general and chemical fertilizers associated or not to irrigation projects, they have a high potential of environmental degradation in the form of water and soil pollution, deforestation, *savannization* of forested areas and siltation of river beds.

Thus, incoming progress to the region may bring a very bad situation to the already deteriorating environment, that can even quickly surpass the predatory practise of traditional agricultural model.

The great agricultural and livestock projects are just "*modern*" as regards great production rates, use of equipment and goods, entrepreneurial planning and profit calculation.

The willingness to maximize these rates, never aiming to environmental conservation and protection as are the regional political and cultural tendencies, lead to renewal traditional predatory practises, such as deforestation, burning and soil exhaustion. This is reinforced, again, by the existence of large quantities of unexplored land reserves and by official policies of fiscal and credit incentives[14].

6.4. New possibilities of expansion

With current factors of attractiveness, one can expect to the near future strong expansion of bovine cattle breeding, rice, corn, cotton and soybeans production in Southwestern Piauí and Southeastern Maranhão, which will make possible significant production surplus through a progressive incorporation of new areas by big projects.

Thus, the Southern portion of the Parnaíba Basin, despite important restrictive factors becomes the most promising area for agricultural expansion. It is important to mention that upper stretches of Gurguéia, Parnaíba and Balsas Rivers are being talked of in these discussions, as a guidance to impact survey and examination of future problems that may arise from development of this region, in order to consider possible consequences to the navigation plan.

[14] Due to such policies and reduced land prices in comparative terms, there is a proportionally small participation of individual resources in face of the total amount of investments. So this form of agricultural and cattle breeding practices combining the "*modern*" and the "*traditional*" seeks a quick return of investment and private funds, regardless of heavy environmental damage due to total lack or absence of conservation policies and inspection, even though the Brazilian laws concerning environment are modern and restrictive in some aspects.

7. IMPACT SURVEY AND EVALUATION IN CORRELATION TO PROPOSED RIVER TRAINING WORKS AND OTHER HYDRAULIC WORKS

7.1. Basic discussions

This part of the report discusses the possible environmental impacts which could originate from the necessary works to be executed for the waterway implementation. The "*matrix-step*" method used is based on what is discussed elsewhere in this report.

With the basic concept that it refers to a navigation plan of regional coverage, the correlation between the necessary actions (*causes*) to its implantation and the relevant environmental attributes were established.

These correlations take shape in an impact matrix, in which the environmental impacts (*effects*) that can occur as a consequence of the project actions in its different implantation phases are detected. Furthermore, these impacts are described and discussed for each action identified as potentially impact bearing.

Having in mind what is expected, the present assessment was discussed in a workshop held on October 13th, 1993, previously setting up the environmental factors relevant to the analysis and the important environmental impact bearing actions.

Based on available information for the present study, the following actions were considered, which actually represent grouping of several others. These groupings were aimed at facilitating and in the light of a much simple matrix building, as it is shown later.

This worked as a form of surveying and systematizing for identification, evaluation and discussion of environmental impacts. *Only those considered relevant or important were detailed.*

7.2 Impact generating actions

- **Demarcation, location and construction of working sites.**

  It consists of necessary work for the preparation of working sites in various places along the future waterway in order to give logistic and operational support to the spur dikes construction in the three sites initially chosen (Teresina, União and Buriti dos Lopes) as well as in other places (not yet chosen) which will in the future count on specific works for the improvement of the waterway.

  It will involve the execution of small land moves, construction of storage shed and material and tools deposits and lodgings for the workers, and then, its effective occupation (and utilization) by the workers, machines and equipment.

- **Accesses to specific sites construction.**

  Here, it is considered the work of path and service alley openings which will be necessary for the timber cutting, borrowing and moving of construction material in general, access to working sites near the river, as well as those necessary to the operational logistic of construction works.

- **Hiring and employment of labor force**

  This action will take place during the construction stages foreseen for the waterway. Even though they are developed in different periods, not predictable at the moment, there will always be worker hiring as an action which could provoke environmental impacts.

  The amount of workers present in the working sites at any moment represent balance between hiring and dismissals, which normally occur in a large scale work. This balance is kept positive until half way the construction, when the hiring rhythm surpasses the leaving. Due to specific characteristics of the project, the required labor force for the construction should be quite specialized, with only a small recruiting of non-specialized workers being likely to occur.

  Analyzing the timing aspects of this action, the event of labor force demobilization should be considered when construction works finish.

- **River banks excavations and dredging**

  This action includes all kinds of excavations that are executed on the river banks and/or riverbeds for the waterway implementation, covering the spur dikes initial works as well as the others that will be undertaken in the future, including those destined to improve the conditions of anchoring and embarkation moving at the existing ports as the ones to be built. As an important impact cause, any dredging work that may be carried out in the waterway implantation area is considered.

- **Wood acquisition for spur dikes construction.**

  It refers to the utilization of wood piles for the configuration of projected dikes, as well as other bank contention work that could be necessary for the improvement of the waterway, either through implantation of spur dikes or through the construction of moles and anchorage bridges and any other work that may be necessary.

- **Navigation implementation and development.**

  This action considers the set of events which will take place throughout different specific activities, of regional or only local interest, bearing in mind the recovery of navigation activities in Parnaíba Basin, including eventual introduction of improvements in the ports and anchorages, the eventual conclusion and consequent operation of Boa Esperança navigation locks, besides specific aspects of barge traffic along the rivers.

  The discussions here are based on available studies on Luis Correia Port , which show that liquid granaries (fuel) could represent in the future the highest departure cargo potential in this port. These granaries are expected to serve as return cargoes of boats or barges coming from upper Parnaíba River.

- **Further navigation development**

  This action is here considered, but in fact its effects can only be evaluated and discussed within a wider and more comprehensible conceptual perspective, which considers the navigation effects in the regional context, and not only within the boundaries of Parnaíba Basin, but in a general context of the waterway influence area.

  For this reason, the discussions on this action are object of Chapter 8 of this report. The analysis of impacts held show that, in this particular case, these impacts should be discussed together with the eventual measures that should be taken at government level

having in mind the hypothesis of introduction of regional environment control as a governmental planning tool.

7.3. Relevant environmental attributes

- **Surface water quality**

  This factor considers the physical, chemical and biological characteristics of water, its current and potential uses, the natural discharge variations, the streamflows, as well as the morphological characteristics of rivers, lakes and lagoons.

- **Erosion and siltation**

  It is considered the process by which the soil particles are split and transported to other sites by water and wind action.

  The erosion occurs as a result of the change in the soil usage and vegetal coverage, thus leading to considerations about loss of fertile surface soil layers and the siltation increase of the riverbeds. Eventually, the degradation of certain areas resulting from erosive processes should also be considered.

- **Potential land usage**

  As an essential natural resource for the natural or induced activities, the soil presents usage potentiality according to its characteristics, such as industrial, commercial, residential, agricultural, controlled forest and natural forest usage.

  For the present analysis, physical and chemical proprieties of soil and any kind of change that may occur in the surface layers are considered.

- **Vegetation**

  It refers to populations, species and kinds of vegetation including discussions on the natural inheritance represented by forests, steppes and savannas.

- **Fauna**

  It refers to populations, species and kinds of vertebrate and invertebrate animals that preferably live in terrestrial environments.

- **Fisheries**

  It refers to the populations, species and kinds of fishes found in rivers, lagoons and sea.

- **Fishing activities**

  In this study, the activity was considered apart from other biological and economic aspects for being directly related the aquatic environment, which can suffer modifications due to the navigation. In this case, the economic value of fishes is considered.

- **Regional Economy**

  It refers to the development of primary, secondary or tertiary economic activities in regional context, associated to the navigation development plan. Eventual variations in the employment levels are also considered.

- **Local Economy**

  This environmental factor is regarded with the development aspects of economic activities in general, as well as the local commerce and service activities that can develop near the waterway improvement places and the towns located along the waterway. Parallel to this, associated to employment, this environmental factor tries to characterize the levels and distribution of personal income.

- **Life style and culture**

  The life style and the social relations refer to the habits and sociocultural aspects of the communities as well as the relationships among individuals in the community. Also, psycho social aspects linked to the interpretation that the community can develop about the project are considered.

- **General infra-structure**

  This factor refers to the conditions of basic social service offer, the degree of attendance of social demands and the quality of these services.

- **Public Health**

  This factor synthesizes public health conditions linked to local characteristics and to the project, in the aspects regarding surface water quality.

- **Political Aspects**

  Here the political aspects related to movement and mobilization of civil society, political parties, and forms of public representation as well as institutional aspects related to necessary intervention of different public spheres of power, numerous organs, agencies and mechanisms of governmental action are referred.

- **Public finance**

  The public finance reflects the degree and evolution alternations of both revenue and expenditure, by distinct spheres of the government, particularly in municipality context, which are changed by new generating factors of taxation or by new government action imposition.

- **Tourism**

  This factor refers to tourism aspects which can eventually be affected by the waterway, due to the eventual attraction of the outside visitors of the Parnaíba Basin region and the area of influence of waterway and the consequent development of activities correlated to tourism.

7.4. Impact detection

The simplified matrix for impact survey was drawn on the basis of the above assumptions. Discussions held in the October 13th internal workshop resulted in the detection of impacts as shown in the matrix. Descriptions and discussions of these impacts are presented in the subsequent items.

RELEVANT ENVIRONMENTAL ATRIBBUTES	IMPACT GENERATING ACTIONS	1 Demarcation, location and construction of working sites	2 Accesses to specific sites construction	3 Employment of labor force	4 River banks excavations and dredging	5 Wood acquisition for spur dikes construction	6 Navigation implementation and development	7 Further navigation development	TOTALS PER FACTOR
1	Water quality	x	x	x	x		x	x	6
2	Erosion and siltation processes	x	x		x			x	4
3	Land potential usage				x			x	2
4	Vegetation		x	x	x	x		x	5
5	Fauna		x	x				x	3
6	Fisheries				x		x	x	3
7	Fishing activities		x	x	x		x	x	5
8	Regional economy						x		1
9	Local economy	x		x			x		3
10	Life style and cultural aspects			x			x	x	3
11	General infrastructure		x				x		2
12	Public health			x					1
13	Political aspects						x		1
14	Public finances						x		1
15	Tourism						x		1
	TOTALS PER ACTION	3	6	7	6	1	10	8	41

7.5. Description of impacts for each generating action

In the following items, brief descriptions of the impacts detected are presented for *each* possible cause of impact: the impact generating actions. Although the environmental attributes are not specifically mentioned, it may be noted that descriptions and comments are correlated to the matrix above. In some few cases, there is more than one impact for an action, but evidence of this arises by itself.

7.5.1. Demarcation, location and construction of working sites

- There can be alterations of little importance and significance in the water quality of nearby sites, due to the presence of wastewater, garbage and siltation.
- Erosive processes, which normally occur, will be intensified in the working sites. However, there will be only local significance.
- There will be local production outlet demands, to supply the working sites with construction material and food.

7.5.2. Accesses to specific sites construction

- Small alterations in water quality, which can be polluted in the access and little water courses crossing sites. These effects will be associated to erosive processes, mainly in the rainy seasons.
- Erosive processes along these accesses in the steeper declivity sites, as well as near the water courses.
- Loss of vegetation along the accesses and alleys.
- Insignificant alterations of "habitats" due to vegetation clearance for access construction, borrowing areas and sediment depositions sites.
- One could consider a slight incentive to fishing activities which could derive from new facilities provided by new accesses.
- Road infra-structure enlargement, considering that the new accesses can be transformed eventually in new roads that assist the nearby inhabitants.

7.5.3. Employment of labor force

- Surface water pollution by the presence of sanitary sewerage and garbage disposal. As it was commented previously, however, the public water supply will not be jeopardized or affected.
- The vegetation near the working sites can be harmed in an uncontrolled way, by indiscriminate cutting, accidental or intentional burning and fires, essentially due to the presence of workers in the working sites. The problems pointed out here, however, will be restricted to the working sites.
- Similarly, fauna can suffer hunting pressures, apart from other problems associated to vegetation loss.
- Hiring can eventually recruit task force among people that otherwise could be devoted to fishing practised near the biggest urban centers, such as Teresina. Yet, man power demands for dike construction is negligible if compared to available potential workers
- The presence of workers will provoke monetary circulation increase in the neighborhood and the demand of goods and services. These effects will be temporary, as long as construction lasts.
- Alterations in habits and customs of working sites nearby inhabitants.
- Possibility of contagious disease dissemination.

7.5.4. River banks excavations and dredging

- Temporary alterations of surface water quality owing to possible fuel and lubricants leakage, to the presence and movement of the heavy machine and vehicles, and significant turbidity increase near the places affected by the works.
- If it is not possible (or intended) to use river bed sand for construction purposes, the opening of borrowing areas may cause some erosion and consequent sedimentation. Also, any steep terrain near working sites may be affected by erosion.
- With the alterations in the river flow conditions due to any contraction works in the river, there will be solid material removal (sand) from these places and its consequent

shifting to new areas, being likely to widen some downstream sand banks as well as to form new ones, mainly in the lower course of Parnaíba River.

- As for the dredging execution if any is planned, there may be located processes of siltation, unless there are cares or controls of the dredged material disposal in selected sites.
- The eventual excavation for the opening of borrowing areas outside the river bed, as well as the use of marginal areas for disposal of dredged material will result in the alteration or local loss of soil usage potential for productive activities. This aspect, however, has little global significance, being only local and even so depends on the volume of work.
- There will be vegetation losses in the excavation sites and/or material disposal sites.
- Due to riverbed alterations, there will be decrease of primary productivity and consequent reduction of food for the fishes nearby. This aspect is only important in case of eventual destruction of marginal lakes (or residual lagoons). Nevertheless, in a wider context of Parnaíba River Basin, this effect would be negligible.
- Consequently, there may be some temporary reduction in the fishing activity. As in the region this activity is little developed (in a subsistence level), without economic importance to the region, any reduction of it carries only local significance, forcing the eventual fishermen to move to other sites of the river. Again, in the Basin context, *these effects are negligible.*

7.5.5. Wood acquisition for spur dike construction

- There may be scattered losses, of difficult assessment, in forest areas, for the acquisition of wood in adequate dimensions and quantities. This does not mean, however, that the use of wood in the dikes can result in deforestation problems, in face of the small quantity (of dikes) and its locations. So for the purposes of this study, this effect is also negligible, but some care should be taken if in the future the quantity of contraction or river works increase significantly.

7.5.6. Navigation implementation and development

- Risk of spreading water pollution strains owing to accidental leakage of fuels and/or dangerous cargoes, which should be likely to affect the water intakes for public supply and irrigation and also marginal lagoons. However, the quantification of these risks will only be possible when there is correct prediction of the waterway traffic volume and of the types of cargo that will be transported, principally downstream - upstream bound.
- Water pollution in small scale, due to the normal leakage of fuels and lubricants from river boats (in general). To the scale of the problem that can be envisaged, this problem is negligible.
- Eventual occurrence of fish slaughter and/or jeopardizing of marginal lagoons (considered spawning places), due to accidental leakage of fuel and/or dangerous cargoes.
- With the eventual conclusion and operation of Boa Esperança navigation locks there may occur migrations in small scale of rheophilyc fishes from the downstream stretches to the interior of Boa Esperança Reservoir, and then to upstream stretches of Parnaíba River and tributaries.

- Port and harbor facilities improvements may affect the local economies, which can become dynamic, linked to the waterway use.
- Recovering or reclamation of the waterway will permit the recovery of important cultural values and flourishing of a traditional culture of the region, as well as the achievement of old aspirations of the population of Piauí, mainly from the valley, which in the past was dependent on the waterway.
- Increase in cultural and commercial exchange among the valley communities with the navigation implementation.

7.6. Comments

It is worth of note that no significant impacts that could endanger the present environmental conditions of the Basin or even of the Parnaíba River can be envisaged, if one considers its total extension and present planned construction activities for navigation implementation.

During construction of spur dikes in only three sites as planned, only slight modifications will occur and limited to working sites. Considerations on problems that could extrapolate their limits are due to point out only impact *possibilities*. However, most impacts detected in this chapter are totally irrelevant if considered in the Parnaíba River context.

It is important to note that flora, fauna and fisheries will not suffer any serious damages from spur dike construction and correlated activities. One could say that navigation activities by themselves will not provoke any environmental problems or damages. Unless one considers that important works and construction activities would be planned for the near future, but this is not the case.

This leads to other import conclusions, in order that the Navigational Development Plan must be considered in its global and regional context, including activities such as river bed modifications, canalization and river bank stabilization works, narrowing of shallow places, transportation of cargoes and persons along the rivers, dam construction, navigation locks building, etc. For the present, only accidents with dangerous cargoes can be envisaged as relevant cause of impact to water quality and thence to fisheries.

8. IMPACT ASSESSMENT OF THE NAVIGATIONAL DEVELOPMENT PLAN AND OTHER EXISTING PLANS AND PROJECTS

8.1. General considerations

In this chapter, general problems that can affect the whole region of Parnaíba River Basin, due to the future development of the region are tackled. This development, in turn, can be the result of the waterway implementation.

On the other hand, as it is discussed in Chapter 6, many environmental problems are observed today in the region because of obsolete techniques and old fashioned land exploitation, with constant burning and deforestation. This means that the present problems can aggravate, as long as the waterway can revert several migration flows, bringing bigger population contingencies to the region.

Apart from any prospective scenario that could be outlined to the navigation development, some more general environmental problems are bound to occur and will demand the government attention for the introduction of adequate policies to stimulate the environment control at a regional level, as regards conservationist practices and self supported development.

This becomes extremely important, since studies show that there are particular areas in the region with particular environmental fragilities, unable to bear an inadequate management.

The discussion to the environmental impacts, therefore, pointed out some specific problems that may arise from future operation of the waterway, which by their nature and magnitude should be commented separately, as follows.

The navigation development can spread the human occupation in marginal areas along Parnaíba River and its main tributaries, both in urban nucleus and in the valleys, in all the Basin and in the plateaus, mainly in the Southwest of Piauí and Southeast of Maranhão with the widening and acceleration of deforestation processes, with consequent weakening of valleys, edges and slopes of the plateaus.

The widening of road network for the local flow can induce sedimentation problems to natural drainage systems and can induce burning as land preparation practice in broader proportions than done presently.

8.2. Impacts due to further navigation development

In a more specific analysis, discussions based on the impact matrix pointed out the following possible impacts, some of which with positive effects:

- The future waterway represents a new way for the flow of agriculture and livestock from Southwest Piauí and Southeast of Maranhão, and will eventually enable to stimulate the use of areas which presently are still unexplored due to lack of infra-structure.

- Introduction, in a medium and long run, of new habits in the region, due to the attraction of population from other states provided by the waterway and new areas of economic exploitation.
- The implantation of the waterway and the development of navigation facilities can transform Parnaíba River and its tributaries into a structural way of regional integration, enabling to polarize grain production areas situated in the North of Bahia, Tocantins as well as Southeast of Maranhão. As for this aspect, see specific comments in Chapters 5 and 6.
- Consequently, there will be a better political integration between the South and Southwest Piauí areas and North-Central Piauí, ensuring a better political unity for the whole of Piauí State.
- The production increase that can be stimulated by the waterway will bring bigger tax revenue, improving the public financial situation.
- There may be a regional tourism due to the new transportation facility provided by the waterway, taking advantage of the tourism potential of Parnaíba River and its tributaries.

8.3 Effects on the area of influence of the waterway

It is worth discussing also some important aspects that will affect the area of influence of the future waterway, as defined in Chapter 5 and shown in Figures 14 and 15.

- Waterway operation will increase the degree of attractiveness of the borderline areas of Parnaíba and Balsas River in Southwest Piauí and Southeast of Maranhão, as well as, in a smaller scale, the far South of both States. There are millions of hectares of suitable soils (despite the drawbacks already mentioned elsewhere) for a considerable agriculture and livestock development.
- Thus, the occupation of these areas can be quickly intensified by the agricultural and cattle breeding activities, contributing for the development of the whole area of influence. It is of particular importance the possibility of development of agroindustry and transformation industry in the biggest cities of North-Central segment (Teresina region segment), as well as commerce and services.
- The existence of a production flow access of the whole area of influence at competitive costs is a second aspect to be pointed out at a regional level as an economic increase factor.
- As a potential development that can be caused by the project, the question of fragility of the small landless producers' situation stands out. The land appreciation due to the waterway proximity may intensify the rural exodus, swelling the bigger cities. On the other hand, the attraction of opposite flows to the South — big, small and medium entrepreneurs as well as the workers associated to them — originating from different places, specially from the South of the Country, can bring significant changes in the traditional culture of the local population.
- The navigation development plan and the waterway by itself could induce a change of policies concerning road planning, which presently is partially directed to "*Corredor Carajás*". This change — it is possible to happen — can direct new road implantation plans considering the intensification of the

waterway traffic. The waterway itself will constitute an overturn of the present primacy of road system in the region.

- Political strengthening of both Piauí and Maranhão (which constitute the *"Western Northeast"*) as a whole due to the existence of one more structural way and exportation corridor, capable of influencing segments of Central Brazil in the future.
- Increase of fiscal revenue, permitting to the State Governments of Maranhão and Piauí better budgets for public investment and welfare service improvement.

8.4. Comments

Direct effects on the natural environment will not depend on activities associated to development of navigation only, which by itself can only cause problems due to accidents, as commented in Chapter 7.

This is important to discuss, in order to show that the consequences of the implementation of Navigation Plan will be the most important causes of impact generation., due to spreading of economic activities in regional basis. This is the most important question to be discussed in this report, in order that it is the whole Parnaíba River Basin that will suffer the consequences of waterway recovery. The main streams will only be affected by works along river banks, dike and dam construction, conclusion and operation of Boa Esperança navigation locks, construction of other navigation locks, etc.

If any development plan is to be established, it must be analyzed in a regional basis. Besides, planners and project proponents must take into account Brazilian environmental legislation[15], in order that any new project that may adversely affect the environment shall be analyzed for licensing purposes. This include all of the above mentioned works and structures.

[15] See details in Chapter 10.

9. PROPOSALS OF COUNTERMEASURES

9.1 General considerations

Bearing in mind the carried out study and the discussions summed up in Chapters 7 and 8, this Chapter 9 aims at the recommendations and countermeasures regarding the environmental problems detected in the impact survey.

Proposals are presented in two principal groups, and are referred to the potential impacts detected in the matrix shown in Chapter 7, and the recommendations cover from specific problems to general ones, both types being related to Navigation Development Plan.

1. Specific countermeasures linked to the implementation process of the waterway and its future operation.
2. General and comprehensive recommendations that refer to problems of the Parnaíba River Basin and the potential area of influence of the waterway as a whole.

The specific recommendations are geared more directly to the Navigation Development Plan proponents, pointing out the aspects to which special cares should be taken, apart from more detailed studies and surveys that will be necessary for further actions.

Thus, general recommendations are aimed at being targeted to state governments of Piauí and Maranhão and their respective municipalities, in order that the main reason of so doing is to show that it is desirable and possible to promote regional development based on environmental planning and conservation policies.

9.2 Specific countermeasures

The recommendations presented in this item refer directly to the Chapter 7 matrix. The countermeasures are considered necessary to anticipate potential environmental alterations resulting from the foreseen actions for the project.

Countermeasures thus proposed and discussed below envisage the preventive aspects of planning. For *each* action, it is recommended:

Demarcation, location and construction of working sites:

- To implant the working sites in places already altered and preferably in places where new accesses are not necessary;
- To provide the working sites with a minimum of sanitary installations (septic tanks) for adequate disposal of wastewater.

Accesses to specific sites construction:

- To provide the construction of culverts or pontoons in order that any ditch, channel or streamflow can be obstructed;
- To foresee erosion control measures in steep slope terrain;

- To avoid paths and works in which important vegetal formations could be affected; cutting of trees should be avoided whenever possible;

Employment of labor force:

- To hire preferably local workers.

River banks excavations and dredging:

- To choose appropriate sites for the excavated and/or dredged material disposal, in order to avoid fauna and flora damage and eventual usage of productive areas;
- Assess the possibility of reusing excavated/dredged material in civil construction or in the own project such as preparation of soil-cement if great quantities are to be involved;
- Take specific care so that the actions do not affect any marginal (residual) lakes, due to their high importance for fisheries;

Wood acquisition for spur dikes construction:

- Preferably wood should originate from reforestation projects, if available in the vicinity (for example: eucalyptus);
- In case natural wood is necessary, previous authorization should be obtained at the competent environmental organ (*IBAMA*);

Navigation implementation and development:

- Establishment of security rules for the loading and transporting cargoes, as well as inspection of very dangerous cargo transportation;
- Establishment of procedure rules in case of accidents, counting on the civil defense mobilization and other entities if any risk to the population is foreseen;
- If and when Boa Esperança navigation lock is completely built, studies should be done aiming to check the effects of possible fish migration into the reservoir, in the spawning period.

Further navigation development:

- Waterway administration or management should be planned together with States of Piauí and Maranhão and AHINOR representatives, in order to establish a global plan aiming to future actions and regional development.

  This is important for preventing some problems that may arise from such development, as it is discussed elsewhere in this report (see Chapters 6, 7 and 8 and item 5.14 of Chapter 5).

- Also, it is recommended that any further actions involving contraction works, spur dikes construction, riverbed banks removal, dredging works or even conclusion of Boa Esperança navigation locks or any other construction jobs along the rivers that should arise from the Navigation Development Plan be submitted to environmental authorities of both States of Piauí and Maranhão, due to legal prerequisites that must be followed.

- The CONAMA Resolution nº 01/86 points out the legal obligation of environmental impact assessment studies prior to any construction program if projects have any possibility of altering environmental characteristics of any kind. Nevertheless, the State authorities should be heard by AHINOR, their representatives and the other Parnaíba waterway entrepreneurs in order to demonstrate projects characteristics in details such as to permit firm decisions and orientation for licensing purposes.

9.3. General recommendations

The extensive recommendations consider the implementation of general policies of the Basin as well as sector policies and local programs. The implementation of an environmental policy that directs all the economic sectors actions and activities of the project influence area is of special relevance.

The natural resources administration, specially water resources, should be coordinated so that the determinations of the plan as regards the Basin are respected but at municipal level the consideration of each region peculiarities should be guaranteed.

Considering the actions that will follow as consequences of the implementation of the Parnaíba River Basin Navigation Development Plan and the discussions presented in this report, it becomes highly desirable that the adoption of techniques, principles and procedures of environmental analysis as current practice in directing the regional development action becomes a reality.

Thus, it is advisable to fix planning attitudes which enable to predict well in advance the social, political, economic and environmental problems that can affect decisions regarding investments in infra-structure and economic activities.

Such proposition can be achieved if the global planning is based on an environmental analysis, considering the usage and the appropriation of natural and environmental resources of the territory, ecological balance, and the socio-environmental conditionings of the area of interest.

As for these considerations, it should be added the peculiarities of each project to be analyzed, due to its technical and conceptual characteristics, direct and indirect effects over the population, its global impacts to the environment generating potential and feasible environmental control plans.

The environmental analysis should be initiated through extensive diagnosis that should recognize, identify and map the potentialities and restrictions of use and appropriation of environmental resources of the Basin, and continued by the study of environmental attributes which make possible the definition of the different levels of environmental fragility of the territory, as it was *preliminary* done in this present study.

Low degree fragility establishes specific restrictive conditions for the development of certain economic activities.

However, it is necessary to associate to the analysis the other social, economic and political factors, aiming to identify other less evident aspects from strictly environmental

point of view, but which can become relevant in case they are investigated integrating the social, political and environmental aspects.

9.4. Planning for the future

Based on the above mentioned discussions, it will be possible to:

- direct and discipline the occupation of the territory in order to create possible conditions to keep or restore the environmental own regenerative ability;
- make the necessary investments in infra-structure more profitable with the return provided by rational use of natural resources;
- set up new forms of exploitation adequate to the characteristics of different regions of the Parnaíba Basin, without opposing the material and economic development of their population.
- create conditions so that the development and exploitation projects of water resources can attract real benefits for the region, allowing its harmonious development.

In order to achieve these objectives, the following actions should be taken into account in any development plan for the region:

a. Carry out a survey of plans, programs and projects in the different institutions of the region to obtain essential elements of compatibility between its objectives and environmental preservation, aiming to an integrated water resources planning policy.

b. Establishment of consortium with public and private institutions aiming at environment conservation with rational use of natural resources plans that lead to the improvement of the population's life standard.

c. Implementation of training courses for land laborers, employing appropriate and modern methods to the improvement of their crops together with soil and water conservation techniques.

d. Technical assistance program to farmers interested in conservationist practices, providing adequate information, and attendance as well as other necessary elements for their accomplishment.

e. Development of reforestation projects and plans for fragile ecosystems, such as desertification nucleus (Gilbués) and plateaus steep borders.

f. Conclusion of Boa Esperança navigation locks aiming at the restoration of navigation. Secondarily, a plan to permit access of downstream migrating fishes to the lake in appropriate seasons, in order to facilitate biological reproduction in better conditions.

g. Study aiming at a small watershed land usage and protection plan, in order to control erosion and pollution.

h. Parnaíba River water pollution control program adopting water quality standards and a plan that includes, among other measures, wastewater collection,

treatment and disposal systems for domestic and industrial sources, at least in the main cities of the Basin. In this program, subprograms should be necessarily included, related to:

i. A plan for a piscicultura station in Boa Esperança Reservoir should be thought of in order to develop fisheries in the lake. This should be done with economically important species of the same Basin, adapted to lake environment

j. In view of the serious problems related to land usage pointed out in the study, it is recommended that alternative forms of land management for agricultural purposes be adopted considering the following:

- development of varieties resistant to prolonged droughts, both for cropping and pastures;
- recovery and reclamation of vegetation along river margins, springs, borders and steep tabular slopes, as well as re-establishment of native forests, or their protection where remnants of natural coverage can be found;
- decrease of burning frequency;
- incentive to use areas of better agricultural potential where irrigation and soil conditions are more favorable;
- adoption of soil conservation practices, including the use of water and wind erosion control techniques,
- establishment of crop rotation and resting systems, in order to achieve better conditions to reestablish physical and chemical soil characteristics;

k. In view of bigger risks of a more fragile situation of small traditional food producers, especially the landless workers, due to possible land appreciation along the river banks and in territorial segments in Southwest of Piauí and Southeast of Maranhão, it is advisable to restart, revise and intensify the implementation of support programs in order to oppose to the probable tendency of rural-urban migration intensification.

10. LEGISLATION

10.1. General considerations

Brazilian law regarding environmental aspects is very complex, but capable of covering different aspects and needs to various types of projects and enterprises, and hence capable of providing adequate environmental protection means all over the country.

As stated in the 1st paragraph of its Article 255, the Brazilian Constitution (promulgated on October 10th, 1988) obliges any proponent to environmental impact assessment (EIA) studies prior to any project or enterprise construction or implantation, when it is capable of significantly altering the environment.

It is of utmost importance in the Brazilian legal context concerning the environment that the environmental licensing procedures are not restrictive or imperative to any enterprises or projects, if they are adequate in terms of harmonious integration to the environment. The laws state, however, that any project capable of significant damage or modification to the environment must be newly planned, revised, modified, relocated or, in extreme cases, abandoned.

Any proponent of project, public or private, must take into account that the environment is to be preserved, even with increasing costs to the project. This means that impact assessment shall be done in most cases (unless otherwise stated by competent authority), and the public has the right to be heard and to give opinions in public audiences, as the public interest must always be preserved.

These comments serve as introduction to a brief presentation of Brazilian laws and recommendations that might be of interest to the proponents of the Parnaíba River Basin Navigation Development Plan. There isn't the intention here to present any analyses of the legislation, but to point out some relevant aspects that can in the near future affect planning decisions related to waterway or even to navigation policy.

10.2. National Environmental Policy

According to the law nº 6,938 of August 8th, 1981, regulated on June 6th, 1990, it is defined the Brazilian National Environmental Policy, in which, among others, it is mentioned the EIA as an instrument for implementing that Policy.

Also, according to the regulation of this Policy, it is said that any project capable of significant modifications to the environment must be licensed by State environmental authorities, *without any prejudice of other licenses that may be asked for by other authorities*. It is also mandatory that any norms, procedures and rules fixed by State or Municipal authorities be followed up in view of possible environmental damage that may arise from project actions.

10.3. CONAMA Resolution nº 01/86

CONAMA, the Brazilian National Counsel on Environment (*Conselho Nacional do Meio Ambiente*) established one of the most important regulations on impact assessment by its resolution as of January 23rd, 1986: it gives various definitions on rules, principles and

procedures for impact assessment studies of any project that might bring any modification to the environment to be submitted to State authorities for licensing purposes .

In this resolution, there are definitions and orientations as for procedures that must be followed on EIA, which must be presented in the form of a report on environmental impact (*RIMA: Relatório de Impacto Ambiental*), in which a detailed assessment has to be explained to the authorities and to the public.

The EIA must contemplate all project technical, technological and locacional alternatives, confronting them to the non-implementation hypothesis. Information to be included in the RIMA must be presented in comprehensible ways to be accessible to the public, which may participate on decisions that may affect public or even private interests.

There are many cases in which there follows public audiences to discuss peculiarities of project or environmental impact of its actions. Then, it is possible that final decisions about project characteristics may be taken, involving modifications or even abandonment of the project proposal.

According to this important resolution, most of projects that involve water resources management may be subject to licensing previously to any decision on construction or even preparing for construction. So, most of Federal, State or private enterprises are subject to previous evaluations, as part of feasibility studies, in order to obtain adequate licenses for implementation. The responsibility for preparing environmental assessment lies on the proponent, as part of its overall planning.

10.4. Public hearings

Public hearings are part of the environmental global assessment and evaluations of proposed enterprises or projects. They were previously established in CONAMA's n° 01/86 resolution and are regulated by a July, 1990 CONAMA resolution and various Brazilian States have specific norms and procedures for public hearings.

They represent the opportunity for the public evaluate and be assured that all relevant issues have been considered in the decisions to be followed.

The regulation of public hearings state that they must be held in order to discuss the EIA and its RIMA, and will occur whenever required by a number of 50 or more citizens, or the Public Ministry or the State authority. If required, but not held for any reason, the environmental licensing will not have any legal value.

10.5. Forests and fauna

In Article 23 of the Brazilian Constitution, it is stated that the Nation, the States, the Municipalities and the Federal District shall protect forests, fauna and flora.

Brazilian Forest Code (Law n° 4,771 of September 15th, 1965) considers all forests and other vegetal formations goods of common interest to all Brazilian citizens. Nevertheless, the rights of property are subject to restrictions fixed by law and by this code, in order that inadequate exploitation or actions that are against law determinations are considered as bad property usage.

10.6. Aspects of forest conservation and preservation

Forest Code was modified in July 18th, 1989 by the Law nº 7,803, which states that forests and other natural vegetal formations have the "status" of being of permanently preserved whenever they are found along shorelines and margins of rivers, lakes, lagoons, man-made lakes, around ponds, springs, etc., in extensions and widths defined by the law, according to dimensions of the watercourse or lake and on top of hills, mountains, steep terrain, slopes with more than 45° of declivity, on sand banks along mangroves and swamplands and in heights over 1,800 m, for any kind of vegetation.

Besides these determinations, one must take into account the September, 1985 CONAMA's Resolution nº 04/85, which determines that these vegetal formations when located along shorelines are considered to be ecological reserves with widths varying in accordance to dimensions of the lakes, rivers or streamflows.

10.7. Aquatic fauna

Presently, fisheries are under law protection in accordance to IBAMA regulations of which most important ones are those correlated to damming projects or any modifications that may be imposed to water courses by any means. In such cases, proposals for aquatic fauna protection and conservation must be submitted previously.

10.8. Wildlife

Wildlife fauna lies under Law nº 5,197 (March 1st, 1967) protection, which establishes that all free living animal, at any age or developing stage, as well as their places of rest, nests and/or breeding places are State property, and their hunting or imprisonment are strictly prohibited, unless specific authorization is given for animal *captivity* and imprisonment.

10.9. Surface water resources

Brazilian water resources in general are public property (public dominion) and cannot suffer any kind of international restriction. Brazilian Constitution define as Nation's patrimony any lake, river or streamflow inside Nation property boundaries, or which extends to more than one State, or serve as boundary between Brazil and any other country, or even which extends to or come from any other country, as well as lowlands along river margins, shorelines along rivers, lakes and seas, and hydraulic power for energy production.

It is defined that the Nation is responsible for the exploration of energy supply and distribution and hydraulic power exploration directly or through authorization or concession.

As for water quality aspects, CONAMA's Resolution nº 20/86 establishes classification for water bodies in accordance to predominant uses, related to water supply, aquatic fauna protection, leisure, irrigation, navigation, landscaping, agriculture and animal watering. Also, there are water quality standards determined for different cases and types of water usage, through which restrictions related to pollution control are fixed.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PACIFIC CONSULTANTS INTERNATIONAL

THE FEASIBILITY STUDY ON THE NAVIGATION OF THE PARNAÍBA RIVER BASIN

PARNAÍBA RIVER BASIN ENVIRONMENTAL STUDIES

ANNEX: TABLES, GENERAL DATA, PHOTOS AND MAPS

November, 1993

A. LIST OF AVAILABLE DATA AND INFORMATION

Important remark: in general, documents are available at OCTA office. When this is not the case, indication of places of origin are given as follows:

* - OCTA office
1 - Fundação IBGE São Paulo branch and library
2 - Library of the Instituto de Geografia e História (USP)
3 - Library of Instituto de Biociências (USP)
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9. Bibliography on fauna

Important remark: the bibliography presented below indicates a necessarily large list of data, due to the methodological approach usually adopted for fauna studies. Required data are available in different places and institutions, but mainly in the IBILCE - UNESP library and Professor Vizotto's files. The specimens listed elsewhere in this report (see annex) were identified in field observations and secondary data based on the bibliography

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B. VEGETATION

1. Vegetation distribution

Vegetation distribution in the Parnaíba River Basin is associated to the different physical and geographical aspects as follows:

- **Peripheral elevations:**

  They are the peripheral mountain ridges, ranging heights of 1,000 m. Examples of these are the plateaus (*chapadas*) of Ibiapaba, Bom Jesus do Gurguéia and das Mangabeiras. They surround the Basin represent Basin boundaries to the South, Southeast and Southwest. Savanna dominion predominates in South and Southwest, while in the Southeast there are transition between savanna and steppe.

- **Interior elevations:**

  With heights between 300 m and 600 m, they have flat relief on top and steep sloped areas along the borders ("cuestas"). They predominate along the central portions of the Basin, with savanna dominion in the South and West, contacts between savanna and steppe in the East and steppe dominion in the Southeast.

- **Inter mountain depressions:**

  They are low flatlands situated among the interior elevations, and are subject to temporary flooding. Typical vegetation are the riparian forests and palm forests with babassupalm trees, *carnaúba* and *buriti*, which sometimes form mixed forests. There are subdecidual forests in the South.

- **Pediplanation surfaces:**

  Heights less than 200 m, along the center and northern portions of the Basin. Main formations are represented by mixed subdecidual forests, with babassupalm trees and *carnaúba*.

- **Coastal flatlands:**

  The northern portion, including the Parnaíba Delta. Formations are mangroves and dune and sandbank vegetation.

2. Some regional flora representative species

- **Subdeciduous forest:**

  Cedrela fissilis (Meliaceae);
  Cenostigma macrophyllum, Senna ensiformis, Hymeaea courbaril, Peliogyne confertifolia (Leguminosae);

- **Deciduous forest (Woodland savanna or thick savanna):**

  Pterodon polygalaeflorus, Platypodium elegans, Anadenanthera macrocarpa, Poeppigia procera (Leguminosae);
  Astronium fraxinifolium (Anacardiaceae);

- **Riparian forests:**

  Mouriria guianensis (Melostomataceae);
  Tapirira guianensis (Anacardiaceae);
  Cynometra bauhinifolia, Hymenaea courbaril, Copaifera langsdorffii (Leguminosae);

- **Palm forests:**

  Copernicia prunifera, Mauritia vinifera, Orbignia martiana (Palmae);

- **Savanna:**

  Salvertia convalliodora, Qualea grandiflora (Vochysiaceae);
  Tabebuia caraiba, Zeyhera digitalis (Bignoniaceae);
  Bowdichia virgilioides, Sclerobium aureum, Acosmium dasycarpum (Leguminosae);
  Cariocar coriaceum (Caryocaraceae);
  Magonia glabrata (Sapindaceae);

- **Steppe:**

  Bursera leptophloeos (Burseraceae);
  Mimosa acustipula, Calliandra depauperata, Caesalpina pyramidalis, Ceasalpina microphylla (Leguminosae);
  Astronium urundeuva (Anacardiaceae);
  Cerus jamacaru, Pilocereus glaucescens (Cactaceae);

- **Sandbank vegetation:**

  Copaifera coriacea, Piptadenia obliqua, Peltogyne confertiflora (Leguminosae);
  Manilkara triflora (Sapotaceae);
  Ouratea cuspidata (Ochnaceae)
  Anacardium microcarpum (Anacardiaceae);

- **Dune vegetation:**

  Ipomoea pes-caprae, Ipomoea asarifolia (Convolvulaceae);
  Indigofera microcarpa, Chamaechrista tetraphylla, Chamaechrista flexuosa (Leguminosae);

- **Mangroves:**

  Rhizophora mangle (Rhizophoraceae);
  Avicennia schaverianna (Verbenaceae);
  Laguncularia racemosa, Conocarpus erecta (Combretaceae).

3. Brief information about preservation areas

3.1. Sete Cidades National Park

With an area of 6,221 hectares and a 40 km total perimeter, Sete Cidades National Park is destined to protect geological and geomorphologic important aspects, besides some permanent springs and water fountains in a region which is characterized by intense droughts and temporary water courses. It is located in the geographic coordinates of Latitude 04° 03'S and 04°09'S and Longitude 41°40'W and 41°46'W.

Due to geological conditions, the predominant sandstone facilitate formation of free and confined aquifer, thus permitting the existence of permanent springs that origin some permanent streams.

Typical vegetal formations are representative of both savanna and steppe. Vegetation features show that inside park limits the savanna predominates, but it is intermixed with woodland savanna, open or isolated tree savanna and riparian forest. Due to farming activities near the park limits, frequent fires occur in drought periods (June to November).

Examples of typical savanna species that encountered are *Curatella americana*, *Platonia insignis*, *Byrsonima crassifolia*, *Qualea grandiflora*, among others. Specific communities may be found, such as wet fields with gramineous plants (e.g., *Aristida*, *Eragrostris* sp) and unexpected aquatic ones, with individuals of *Drosera sinsifolia* (an interesting insectivorous plant), besides *Nymplaea* sp and *Montrichardia* sp.

From a flora point of view, it is worth mentioning the presence of steppe representatives, such as *Zizyphus joazeiro*, groups of *Astronium urundeuva*, *Bromelia laciniosa* and *Piloceus gounellei*, besides decidual forest elements, such as *Tecoma serratifolia* and *Cecropia cinerea*. No more babassupalm trees are found, probably due to intense exploitation, but *Mauritia flexuosa*, *Corpenica cerifera* and *Astrocaryum* sp can be encountered.

Present fauna that occur in the park is represented by elements that occur in other ecosystems and is not exclusive of the savanna nor the steppe.

3.2. Serra da Capivara National Park

This park was created by a Federal decree in 1979 in order to protect valuable and remarkable prehistoric sites It is located in the São Raimundo Nonato region, which is well known by its prehistoric stone paintings. Its coordinates are: Latitude 8°30'S - 8°50'S and Longitude 42°20'W - 42°45'W. Total area is 97,933 hectares with a 300 km perimeter.

The Sambaíba geological formation predominates. The region presents a very flat relief in heights of 500 m to 600 m, with a very monotonous landscape. Inside park limits there are thick latosoil layers on the plateaus and sandy soils derived from sandstone along vales. Generally, they have little organic matter contents cannot retain much water.

This park is the only Brazilian conservation unit that contain a significant sample of the steppe ecosystem (*caatinga*). Vegetation is typical of the closed thorntree steppe, with specimens of *Astronium urundeuva* and *Schnopsis brasiliensis* as representatives of its arboreal stratum. The shrub stratum is dominated by *Mimosa acustipula* and *Leocerus squamosus*. The lower stratum contains specimens that occur in any type of (Brazilian) steppe, such as *Bromelia laciniosa*, *Pilocereus gounelli* and *Caesalpina microphylla*.

3.3. Lençóis Maranhenses National Park

Although situated far from the Parnaíba Delta, it is worth presenting information about this park, because it preserves a unique ecosystem, represented by dunes, seashore sandbanks and mangroves. The State of Maranhão coast lies in the *Litoral de Rias e Lençóis Maranhenses* morphostructural unit, which corresponds to the Holocene sediments and is

characterized by sandy and estuarine formations. At the mouth of Piriá River there is a transition between two distinct areas: to the West the estuaries are predominant, while to the East prevail the sandy formations known as *Lençóis Maranhenses*, embodying the Parnaíba Delta.

The seashore is very shallow, with sand-ridges or shoals that emerge at low tides, but with also the presence of high dunes, sandbanks, small lagoons and islands, rare mangroves and very large river mouths. Total park area contains only alluvial recent deposits, formed by gravel, sand and unconsolidated clay. Dunes are found in distances of 50 km from the coast line. They present high mobility due to wind action, but there are also fixed dunes.

Typical vegetation inside park limits is representative also of that of the Parnaíba Delta. Mangroves contain *Rhizophora mangle*, which can reach heights up to 12 m, *Laguncularia racemosa*, *Avicenia tomentosa* and *Avicenia nitida*. Different kinds of animals can be observed in the park, such as some sea tortoises, migrating birds, fishes, crustaceans, mollusks and mammals.

3.4. Uruçuí-Una Biological Reservation

This reservation area has a total 135,000 hectares area. Located in the South, with geographic coordinates o Latitude 8°37'S - 9°10'S and Longitude 44°55'W - 45°30'W, it is representative of the plateau relief.

Atop the big tablelands, the vegetation formations are typically from savanna and steppe dominions, which are well represented. Along valleys, although most rivers are intermittent, there are riparian forests with palm trees. The escarpments may have heights of 80 m and are constituted mainly of sandstone. Fauna is also well represented in this reservation, in which fauna researches were done as commented elsewhere in this report.

C. PIAUÍ FAUNA INVENTORY

Data about the Parnaíba River Basin fauna are organized in the following tables:

1. Mammals: 75 species, in 36 genus, belonging to 27 families, placed in 7 orders.
2. Birds: 147 species, in 127 genus, belonging to 47 families, placed in 19 orders.
3. Reptiles: 45 species, in 39 genus, belonging to 13 families, placed in 3 orders.
4. Amphibian-anurous: 15 species, in 7 genus, belonging to 4 families, placed in the Anurous order
5. Fresh-water Fishes (OSTEICTIES): 57 species, in 50 genus, belonging to 20 families, placed in 5 orders.
6. Fresh-water Rays (BATOIDS): a sole endemic specie from the Parnaíba River and some major tributaries: *Potamotrygon signata*;
7. Sea Fish (OSTEICTIES): 162 species, in 118 genus, belonging to 50 families, placed in 14 orders.
8. Sea Sharks and Rays (CONDRICTIES- SELACHIOUS and BATOIDS): 25 species, in 25 genus, belonging to 13 families, placed in 2 orders.
9. Sea Crustaceans: 34 species, in 20 genus, belonging to 10 families, placed in one order of 3 sub orders.
10. Fresh-water Crustaceans: 2 species, in 2 genus, belonging to 2 families, placed in one sole order.

See a small glossary on Brazilian fauna at the end of this annex.

Endangered species are signaled with *E.

TABLE Nº 1: MAMMALS

ORDER	FAMILY	GENUS	SPECIES	Nº	POPULAR TERMINOLOGY
MARSUPIALS	DIDELFIDEÆ	Caluromys	*C. phylander*	1	Cuíca
		Marmosa	*M. cinerea*	2	Cuíca
			M. murina	3	Cuíca
		Didelphis	*D. Marsupialis*	4	Mucura
PRIMATES	CEBIDEÆ	Alouatta	*A. belzebu*	5	Guariba *E
		Cebus	*C. apella libidinosus*	6	Macaco-prego *E
	CALITRICHIDÆ	Callithrix	*C. Jacchus*	7	Sauí or Sagui *E
EDENTATES	MIMERCOFAGIDEÆ	Tamandua	*T. tetradactyla*	8	Tamanduá-mambira
	DASIPODIDEÆ	Euphractus	*E. sexcinctus setosus*	9	Tatu-peba
		Cabassous	*C. unicinctus*	10	Tatu-china
		Tolypeutes	*T. Tricinctus*	11	Tatu-bola *E
		Dasypus	*D. novemcinctus*	12	Tatu-verdadeiro
CARNIVORES	CANIDEÆ	Dusicyom	*D. vetulus*	13	Raposa
			D. (Cerdocyon) thous	14	Cachorro-do-mato
		Chrysocyon	*C. brachyurus*	15	Guará *E
	PROCIONIDEÆ	Nasua	*N. nasua nasua*	16	Coati
	MUSTELIDEÆ	Galictis	*G. cuja Furax*	17	Furão
		Conepatus	*C. chilensis amazonicus*	18	Maritataca
		Lutra	*L. enudris*	19	Lontra *E
	FELIDEÆ	Felis	*F. pardalis mitis*	20	Maracajá-açu *E
			F. tigrina tigrina	21	Maracajá pintado *E
		Panthera	*P. onca*	22	Onça pintada *E
ARTIODACTYL (SUIFORMS)	TAIASSUIDEÆ	Tayassu	*T. pecari*	23	Queixada
			T. t. tajacu	24	Caititu
ARTIODACTYL (RUMINANT)	CERVIDEÆ	Mazama	*M.govazoubira spnciliar*	25	Veado-catingueiro
			M. rufina nana	26	Veado-garapu
RODENTS (HISTRICO-MORPHOUS)	DASIPROCTIDEÆ	Dasyprocta	*D. aguti aguti*	27	Cotia
	CAVIIDEÆ	Galea	*G. spixli spixxi*	28	Preá
		Kerodon	*K. rupestris*	29	Mocó
	ECHIMIIDEÆ	Cercomys	*C. cunicularis larentiu*	30	Punaré ou Rabudo
CHIROPTERS	EMBALONURIDEÆ	Rhynchonycteris	*R. naso*	31	Morcego-insetívoro
		Saccopteryx	*S. bilineata*	32	Morcego-insetívoro
		Peropteryx	*P. macrotis macrotis*	33	Morcego-insetívoro
	NOCTILIONIDEÆ	Noctilio	*N. alviventris albivent*	34	Morcego-insetívoro
			N. leporinus leporinus	35	Morcego-pescador
	MORMOOPIDEÆ	Pteronotus	*P. gymnonotus*	36	Morcego-insetívoro
			O. parnellii rubiginosi	37	Morcego-insetívoro
			P.personatus personatus	38	Morcego-insetívoro
	FILOSTOMIDEÆ (FILOSTOMINEÆ)	Phyllostomus	*P. discolor discolor*	39	Morcego-insetívoro
			P. hastatus	40	Morcego-insetívoro
		Trachops	*T. cirrhosus cirrhosus*	41	Morcego-insetívoro
		Micronycteris	*M. hirsuta*	42	Morcego-insetívoro
			M. megalotis megaloti	43	Morcego-insetívero
			M. minuta	44	Morcego-insetívoro
		Lonchorhina	*L. aurita*	45	Morcego-insetívoro
		Tonatia	*T. sylvicola*	46	Morcego
		Mimon	*M. crenulatum*	47	Morcego
	FILOSTOMIDEÆ (GLOSSOFAGINEÆ)	Glossophaga	*G. soricina soricina*	48	Morcego-do-néctar
		Lonchophylla	*L. aurita*	49	Morcego
			L. mordax mordax	50	Morcego
		Anoura	*A. geoffroyi geoffroyi*	51	Morcego

(Continue next page)

TABLE Nº 1: MAMMALS *(continued)*

ORDER	FAMILY	GENUS	SPECIES	Nº	POPULAR TERMINOLOGY
CHIROPTERS	FILOSTOMIDEÆ (CAROLINEÆ)	Carollia	*C. p. perspicillata*	52	Morcego
	FILOSTOMIDEÆ (ESTENO-DERMATINEÆ)	Sturnira	*S. l. lilium*	53	Morcego
		Vampyrops	*V. lineatus*	54	Morcego
		Artibeus	*A. cinereus*	55	Morcego
			A. jamaicensis	56	Morcego-de-frutas
			A. l. lituratus	57	Morcego-de-frutas
	FILOSTOMIDEÆ (DESMODONTINEÆ)	Desmodus	*D. r. rotundus*	58	Morcego-hematófago
		Diaemus	*D. Youngii*	59	Morcego-hematófago
		Diphylla	*D. e. ecaudata*	60	Morcego-hematófago
	NATALIDEÆ	Natallus	*N.Stramineus natalensis*	61	Morcego-insetívoro
	FURIPTERIDEÆ	Furipterus	*F. horrens*	62	Morcego-insetívoro
	VESPERTILIONIDEÆ	Myotis	*M. nigricans*	63	Morcego-insetívoro
		Eptesicus	*E. b. brasiliensis*	64	Morcego-insetívoro
		Rhogeessa	*R. sp*	65	Morcego-insetívoro
		Lasiurus	*L. ega*	66	Morcego-insetívoro
	MOLOSSIDEÆ	Tadarida	*T. laticaudata europs*	67	Morcego-insetívoro
			T. molossa	68	Morcego-insetívoro
		Molossops	*M. planirostris*	69	Morcego-insetívoro
			M. t. temminckii	70	Morcego-insetívoro
		Molossus	*M. ater ater*	71	Morcego-insetívoro
			M. molossus crassicau	72	Morcego-insetívoro
		Neoplatymops	*N.mattogrossensis*	73	Morcego-insetívoro
		Eumops	*E. perotis*	74	Morcego-insetívoro
			E. sp	75	Morcego-insetívoro

TABLE Nº 2: BIRDS

ORDER	FAMILY	GENUS	SPECIES	Nº	POPULAR TERMINOLOGY
TINAMIFORMS	TINAMIDEÆ	Crypturellus	*C. noctivagus*	76	Zabelê or Jaó
			C. parvirostris	77	Inhambú-pé-vermelh
		Bothura	*N. boraquira*	78	Codorna-do-nordeste
		Rhynchotus	*R. rufescens*	79	Perdiz
PELECANIFORMS	ANHINGIDEÆ	Anhinga	*A. anhinga*	80	Biguá-tinga
CICONIIFORMS	ARDEIDEÆ	Ardea	*A. Cocoi*	81	Socó-grande
		Casmeródius	*C. albus*	82	Garça-branca-grande
		Egretta	*E. thula thula*	83	Garça-branca-pequen
		Florida	*F. caerulea*	84	Garça-morena
		Butorides	*B. Striatus*	85	Socozinho
		Hydranassa	*H. tricolor*	86	Garça-do-mangue
		Bulbucus	*B. ibis*	87	Garça-boieira
		Jabiru	*J. Mycteria*	88	Jaburu
	TRESCHIORNITIDEÆ	Theristicus	*T. caudatus*	89	Curiaca
		Eudocimus	*E. ruber*	90	Guará *E
PELECANIFORMS	TRESCHIORNITIDEÆ	Ajaia	*A. Ajaja*	91	Colhereiro
ANSERIFORMS	ANHIMIDEÆ	Anhima	*A. cornuta*	92	Anhuma
	ANATIDEÆ	Dendrocygena	*D. bicolor*	93	Marreca-caneleira
		Oxyura	*O. dominica*	94	Bico-roxo
		Cairina	*C. moschata*	95	Pato-do-mato
FALCONIFORMS	CATARTIDEÆ	Coragyps	*C. atratus*	96	Urubu-comum
		Cathartes	*C. aura*	97	Gereba
			C. burrovianus	98	Urubu-cabeça-amarel
	ACCIPITRIDEÆ	Ictinea	*I. plumbea*	99	Gavião-pombo
		Buteo	*B. magnirostris*	100	Gavião-carijó
		Busarellus	*B. migricollis*	101	Gavião-panema
		Buteogallus	*B. aequinotialis*	102	Caranguejeiro
			B. urubitinga	103	Gavião-preto, cancã
	FALCONIDEÆ	Falco	*F. sparverius*	104	Gavião quiri-quiri
			F. rufigularis	105	Cauré
		Daptrius	*D. americanus*	106	Gralhão
		Herpetotheres	*H. cachinnans*	107	Acauã
		Milvago	*M. chimachima*	108	Caracaraí
		Polyborus	*P. plancus*	109	Caracará
GALIFORMS	CRACIDEÆ	Penelope	*P. superciliaris*	110	Jacupemba
		Ortalis	*O. superciliaris*	111	Aracuã
GRUIFORMS	RALIDEÆ	Aramides	*A. cajanea*	112	Três-potes
			A. mangle	113	Saracura-do-mangue
			A. ypecaha	114	Saracuraçu
		Gallinula	*G. chloropus*	115	Jaçanã-galo
		Porphyrula	*P. martinica*	116	Jaçanã-d'água
	CARIAMIDEÆ	Cariama	*C. cristata*	117	Seriema
CARADRIIFORMS	JACANIDEÆ	Jacana	*J. jacana*	118	Piaçoca
	ESCOLOPACIDEÆ	Charadrius	*C. collaris*	119	Batuíra-de-coleira
		Vanellus	*V. chilensis*	120	Téu-téu
		Actitis	*A. macularia*	121	Maçarico-pintado
CARADRIIFORMS (LARI)	LARIDEÆ	Sterna	*S. hirundinacea*	122	Trinta-réis
			S. dougalli	123	Andorinha-do-mar
		Rynchops	*R. nigra*	124	Talha-mar
COLUMBIFORMS	COLUMBIDEÆ	Columba	*C. picazuro*	125	Pombão, Asa-branca
		Columbina	*C. picui*	126	Rolinha branca
			C. talpacoti	127	Rolinha-caldo-de-feijã
		Leptotila	*L. verreauxi*	128	Juriti
		Zenaida	*Z. auriculata*	129	Avoante
		Scarda Fella	*s. squamata*	130	Fogo-apagou

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TABLE Nº 2: BIRDS *(continued)*

ORDER	FAMILY	GENUS	SPECIES	Nº	POPULAR TERMINOLOGY
APODIFORMS	APODIDEÆ	Chaetura	*C. andrei*	131	Andorinhão-do-temporal
		Reinarda	*R. squamata*	132	Andorinhão-de-cauda
		Streptoprocne	*S. biscutata*	133	Taperuçu
	TROCHILIDEÆ	Campylopterus	*C. largipennis*	134	Asa-de-sabre *E
		Eupetomena	*E. macroura*	135	Beija-flor-tesoura
PSITACIFORMS	PSITACIDEÆ	Aratinga	*A. aurea*	136	Periquito-rei
			A. cactorum	137	Periquito-da-caatinga
			A. nobilis	138	Maracanã-nobre
			A. solstitialis	139	Jandaia
		Anodorhynchus	*A. hyacinthinus*	140	Arara-azul-grande *E
		Forpus	*F.xanthopterygius*	141	Tuim
		Brotogeris	*B. versicolurus*	142	Periquito-chiriri
		Pionus	*P. maximiliani*	143	Maitaca-bronzeada
		Amazona	*A. aestiva*	144	Papagaio verdadeiro
CAPRIMULGIFORMS	CAPRIMULGIDEÆ	Nyctiprogne	*N. leucopyga*	145	Cacurau-barrado
		Nyctidromus	*N. albicollis*	146	Amanhã-eu-vou
		Caprimulgus	*C. hirundinaceus*	147	Bacurauzinho-da-caatinga
TROGONIFORMS	TROGONIDEÆ	Trogon	*T. curucui*	148	Surucuá
CORACIIFORMS	ALCEDINIDEÆ	Ceryle	*C. torquata*	149	Martim-pescador-grande
	MOMOTIDEÆ	Momotus	*M. momota*	150	Udu, Juruva
ESTRIGIFORMS	TITONIDEÆ	Tyto	*T. alba tuidara*	151	Suindara
	ESTRIGIDEÆ	Otus	*O. choliba decussatus*	152	Corujinha-de-orelha
		Bubo	*B. virginianus*	153	Corujão-orelhudo
		Pulsatrix	*P. perspicillata*	154	Murucututu
PICIFORMS	GALBULIDEÆ	Galbula	*G. ruficauda*	155	Bico-de-agulha
		Brachygalba	*B. lugubris*	156	Ariramba
	BUCONIDEÆ	Nystalus	*N. maculatus*	157	João-bobo
	RAMFASTIDEÆ	Ramphastus	*R. toco*	158	Tucano-açu
	PICIDEÆ	Colaptes	*C. campestris*	159	Pica-pau chanhã
			C. melanochloros	160	Pica-pau-carijó
		Campephilus	*C. melanoleucos*	161	Pica-pau-topetovermelho
		Dryocopus	*D. lineatus*	162	Pica-pau
		Picumnus	*P. pygmaeus*	163	Pica-pau-anão
		Veniliornis	*V. passerinus*	164	Pica-pau-anão
PASSERIFORMS	RINOCRIPTIDEÆ	Melanopareia	*M. torquata*	165	Tapaculo-de-colarinho
	DENDROCOLAPTIDEÆ	Dendrocolaptes	*D. platyrostris*	166	Arapaçu-grande
		Lepidocolaptes	*L. angustirostris*	167	Arapaçu-do-cerrado
		Xiphocolaptes	*X. Falcirostris*	168	Arapaçu-do-nordeste
	FURNARIIDEÆ	Furnarius	*F. leucopus assimilis*	169	Maria-de-barro
		Gyalophylax	*G. hallmayri*	170	João-chique-chique
		Certhiaxis	*C. cinnamonea*	171	Curutiê
		Cranioleuca	*C. vulpina*	172	Arredio-do-rio
		Phacellodomus	*P. rufifrons*	173	João-de-pau, crispim
		Pseudoseisura	*P. cristata*	174	Casaca-de-couro
		Megaxenops	*M. parnaguae*	175	Bico-virado *E
	FORMICARIIDEÆ	Formicivora	*F. melanogaster*	176	Papa-formiga-pardo
			F. rufa	177	Papa-formiga-vermelho
		Thamnophilus	*T. doliatus*	178	Choca-barrada
			T. torquatus	179	Choca-asa-vermelha
		Myrmochilus	*M.strigilatus*	180	Piu-piu
		Herpsilochmus	*H. pectoralis*	181	Chorozinho
			H. pileatus	182	Chorozinho-topete-preto
	COTINGIDEÆ	Tityra	*T. cayana*	183	Anambé
			T. semifasciata	184	Anambé
		Procnias	*P. averano*	185	Araponga-do-nordeste

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