THE CARAJAS IRON ORE PROJECT: A COST-BENEFIT ASSESSMENT

BY MARIA BERNADETE G. P. S. GUTIERREZ

Thesis Submitted for the Degree of PhD

University College London

University of London

June, 1991

Abstract

The main aim of this thesis is to provide an extended cost-benefit analysis of the Carajas Iron Ore Project, an integrated mine-railway-port project, located in the eastern part of the Amazon forest, Brazil. This project is a main component of the recent Greater Carajas Programme (Programa Grande Carajas, 1980), which has been conceived to settle an industrialization process in that area led by the processing of the abundant mineral resources found generally in Amazonia. On the other hand, the project's area of influence is characterized by being a dynamic frontier where the rates of migration and settlement have considerably exceeded those in the rest of the country, due to the afflux of people from other parts of Brazil in the search for better life prospects.

At a first stage, a conventional cost-benefit analysis of the project is undertaken. It is found that, on purely economic and financial terms, the project's profitability has been undermined due to the declining world iron ore prices. While the capital cost required to finance the project is on the order of 6%, its present "ex-post" economic rate of return is on the order of 2%.

Following it, the project's interactions with the physical and the social environment are highlighted. Although mitigating measures to the damaging effects of related air and water pollution were taken in the activities of iron ore mining and transport, the Carajas project has, direcly and indirectly, resulted in adverse social and environmental consequences in the broader region of the Greater Carajas Area. Among these, the project has directly contributed to the following devastating ecological and social processes taking place in the region: a)the deforestation induced by the pig-iron smelting industry being settled along the railway corridor and using as input the project's output; b) the

invonlutary resettlement of local populations, especially in the area surrounding the port; c) the increase in the rates of migration to the region through not only the increase in local employment opportunities but also the opening of a up to then inacessible area through the railway component of the project.

At the "ex-ante" appraisal stage, none of the above factors were given serious consideration. As long as the project has resulted in many negative externalities, an attempt is made to reassess the project taking into account its social and environmental effects. In particular, a methodology is developed to estimate the economic costs of the Amazon deforestation in order to partially internalize some of those costs to the joint project Carajas - Pig Iron Smelting Industry. Proceding so, this joint project shows a negative social rate of return.

List of Tables

List of Annexes

List of Figures

Acknowledgements

Directly and indirectly, I have benefitted from many people and institutions which have made possible that this thesis be accomplished.

First of all, I would like to thank Professor David Pearce for his continuous guidance and permanent encouragement, fundamental inputs to the elaboration of this thesis. I wish to thank Dr. David Goodman for the suggestion of the case study, the Carajas Iron Ore Project, a project so representative of the many social and environmental problems affecting the Amazonia. I also would like to express my gratitude to Dr. Anil Markandya for his help in Chapter 5, the estimation of the shadow prices for the Brazilian economy. Moreover, I wish to thank Prof. Dennis Anderson for having made me available fundamental material on the Carajas project.

Dr. Sergio Margullis, who at the time of the research was working for IPEA-RJ and now working for the World Bank, and Dr. Ronaldo Seroa da Motta from IPEA-RJ, have provided me invaluable help in this research., not only through the access to important material but also through helpful discussions. People at BNDES-RJ have allowed me the access to the fundamental data on the Carajas project as well as they have provided important incentive for the line of research being followed.

The permanent friendship and moral support of my family and friends have also been a key input to the elaboration of this thesis. Teresa Sarmiento, Sara Bennett, Carlos Osorio have been always present people in the common difficulties that arise in this kind of undertaking.

Finally, financial support is greatly acknowledged from CNPq all over the period of research and the partial one from BNDES.

Acronyms and Abbreviations

ALBRAS-Aluminio do Brasil (Aluminium Company of Brazil)

ALUMAR-Aluminio do Maranhao(Aluminium Company of Maranhao)

ALUNORTE-Aluminio do Norte (Aluminium Company of the North)

BNDES-Banco Nacional de Desenvolvimento Economico e Social (National Bank for Economic and Social Development)

CIMA- Comissao Interna do Meio Ambiente (Internal Commission for the Environment)

CIOP- Carajas Iron Ore Project (Projeto Ferro Carajas)

CVRD- Companhia Vale do Rio Doce (Rio Doce Valley Company)

FAO- Food and Agriculture Organization

IBGE- Instituto Brasileiro de Geografia e Estatistica (Brazilian Institute of Geography and Statistics)

IISI -International Iron and Steel Institute

PGC - Programa Grande Carajas (Greater Carajas Programme)

PIN- Plano de Integracao Nacional (Plan for National Integration)

PND - Plano Nacional de Desenvolvimento (National Development Plan)

POLOAMAZONIA - Programa de Polos Agropecuarios e Agrominerais da Amazonia (Programme of Agro-Livestock and Agro-Mineral Poles for Amazonia)

SPVEA-Superintendencia do Plano de Valorizacao da Amazonia (Superintendency for the Economic Valorisation of Amazonia)

SUDAM- Superintendencia do Desenvolvimento da Amazonia (Superintendency for the Development of Amazonia)

UNCTAD- United Nations Conference on Trade and Development

Currency Equivalence

Brazilian currency-Cruzeiro(Cr$)

Cr$ 65.5= US$ 1.00 (as in December 1980, the date of base cost estimates)

CHAPTER 1- INTRODUCTION

1.1) Purpose

This thesis aims to provide a social and economic analysis of the Carajas Iron Ore Project (henceforth CIOP), giving special emphasis to its environmental and distributional effects. The Carajas project consists of a mine, integrated to a railroad and a port, covering parts of the states of Para and Maranhao in the north of Brazil(see Figure 2.1, p.20). It was conceived at the beginning of the 1970s and implemented in the early 1980s in a context in which the Brazilian government decided to take measures to develop economic activities in the Amazon region.

CIOP is a component of a wider project, called the Greater Carajas Programme (GCP- Programa Grande Carajas), created in the early 1980s, and which was aimed at developing Amazonia on an industrial basis as well as through large scale agricultural projects. The 1970s and 1980s were marked by intensive government action to establish economic activities in the Amazon area. It included not only large scale projects undertaken by the government but also a set of fiscal measures to attract both national and foreign capital to that region. Large hydro-power stations, the construction of roads, mining projects as well as a package of fiscal benefits to incentive colonization in the area, were intended to give economic value to a region which contributed just 6% to Brazilian GNP in 1986 (about US$ 15 billion). Moreover, in the specific case of the Carajas Iron Ore Project, a major benefit credited to this project was the generation of foreign exchange: most of its output was to be exported.

CIOP is chosen as a case study for several reasons. First, it is a major investment and therefore raises many issues of "standard" project appraisal- the selection of shadow prices, interest rates and the valuation of output from interlinked investments. CIOP is part of a wide programme of settlement and development. Second, at the time decisions were being made about Carajas, environmental impacts were not given significant weight. In light of the upsurge of world interest in environmental issues, and in the Amazon region in particular, CIOP needs an "ex post" re- evaluation. Third, social impacts have become a further focus of concern and CIOP is associated with a general programme of settlement in the area. An important issue, then, is whether "standard" project appraisal techniques are capable of evaluating major projects with environmental and social impacts, on the scale of CIOP, without modification.

1.2) Approach

A Cost-Benefit Approach (CBA) will be used here as the basic framework to assess the CIOP social and economic profitability. CBA has been widely used in project planning and appraisal. Basically, it seeks to put money values on the benefits and costs of a project using a numeraire for such and then comparing them. Additionally, we look at the distributional consequences and the "sustainability" of CIOP by analysing its resource demands.

Postponing for later a better explanation of the usefulness and the limitations of a CBA approach in the context of project appraisal and planning, something can be said about specific issues in CIOP. As CIOP produces deforestation, and, moreover, it induces a type of growth in the region based in the iron ore mineral processing, we will have to value these environmental costs at a stage when science hasn't been able to answer all the questions about the ecological impacts of deforestation. Moreover, economic science is in an early stage of providing suitable methods to assess the environmental costs of deforestation. So, we will have to use a CBA framework in a cautious way, knowing that we are in a context of limited information and uncertainty. Even if we are not able to value all the CIOP benefits and costs, at least they should be recorded as such, insofar as we can perceive them as being related to the project.

1.3) Sustainanbility

As we shall see, the CIOP's environmental effects, both direct and indirect, cannot be disregarded as being insignificant. Not only the project is located in a fragile ecosystem, the Amazon forest, but also CIOP is highly dependent on the natural resouce base of the area.

The concept of sustainable development has arisen in part to incorporate the concern for the environment as a world social goal. Several attempts have been made to define and operationalize this concept but we are a long way from consensus. Generally speaking, most definitions have emphasized that sustainable patterns of development are associated with non-declining quality of life and the maintenance of natural and man-made capital stocks (Pezzey, 1989, pp12-22). This last aspect raises the issue of substitutability between natural and man-made capital. Basically, what is sought is that the opportunities open to future generations should not decrease over time as a result of the present development patterns taking place throughout the world. Moreover, all the factors that are thought to be related to the development process are, potentially speaking, relevant components in the conceptualization of sustainable development. Although the definition of sustainable development in itself offers a fruitful topic for research, the approach to be followed here in this connection will be very objective.

Essentially, we will be looking at the relationship between CIOP and the natural resource base of the area of its location, as well as the possible environmental effects derived from this relationship. Sustainability, in this context, means uses of the area of forest consistent with the forest remaining, by and large, intact. Such uses might include sustainable logging, forest crops such as fruits and crops, minor products (see Peters et. al., 1989). On the other hand, the CIOP's distributional impacts will be treated under the heading of social impacts.

CHAPTER 2- THE CARAJAS IRON ORE PROJECT (CIOP)

2.1) The Carajas Iron Ore Project in the Perspective of the Greater Carajas Programme.

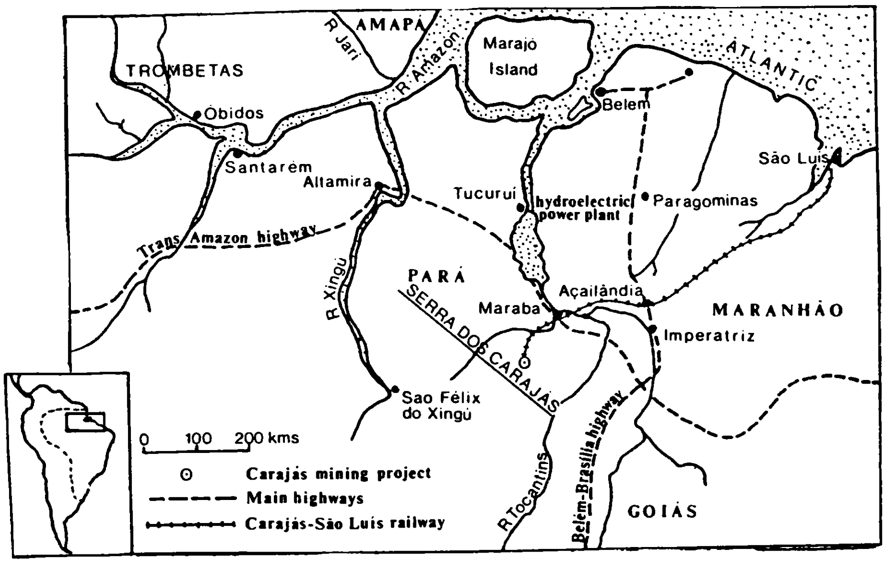
To understand the development goals being aimed at with the undertaking of the CIOP, we have to put it in the perspective of what is called the Greater Carajas Programme (GCP).

GCP is a programme created by the Brazilian government in 1980 and mainly designed to settle an industrialization process in the Amazonian rain forest.[1] The area covered by the programme, the Greater Carajas Area (GCA), corresponds to 11% of the Brazilian territory, extending over a 895,000 km^2 surface area. It includes parts of the states of Para, Maranhao and Goias, being delimited by the Xingu, Parnaiba and Amazonia rivers, and by the 8th parallel (see Figure2.1). In order to fully appreciate the pattern of development being sought in this region through GCP, it is necessary to go backwards over time when the Brazilian government set the policy foundations of this programme.

[1] GCP was given formal existence through Executive Act No. 1183 of 24.11.80 which instituted the basic tax and financial incentive scheme for investors willing to finance mineral, infrastructural and agroforestry projects in the region. It also created an Interministerial Council, through Decree No. 85387 of the same date, which is responsible for appraising and approving projects funded by the GCP. The Council is directed by an Executive Secretariat and is headed by the Minister of Planning.

Figure 2.1

Area Covered by the Carajas Programme



A firm commitment to occupy Amazonia came with the military government which took power in 1964. There was a feeling that resources were being wasted by leaving idle such a large part of the Brazilian territory, but geopolitical objectives also led the new government to formulate a policy to attract both national and foreign capital to the Amazonian region. According to the military thinking, a geopolitical framework towards Amazonia was deemed suitable to deal with the Brazilian national security. The integration of an economic and military strategy and space would avert internal and external subversion as well as promote the necessary rapid economic development mandatory for neutralizing political challenges from the left.[2] "Operation Amazonia", created in 1966, stood for this new policy towards Amazonia. SUDAM-the Superintendency for the Development of

[2]See Hecht and Cockburn(1990). Chapter six provides excellent material about geopolitics in Amazonia.

Amazonia- was founded in the same year, designed to grant fiscal incentives to attract capital to the region. Furthermore, tax credits and import/export tax exemptions were granted by SUDAM, and subsidised credit was made available for land acquisition. Also multilateral agencies, the IDB-Interamerican Development Bank- and the World Bank, participated in this incentive scheme, financing mainly cattle ranching projects to be developed in large estates.[3] Recently, a number of federal government policies have changed so that to reduce pressure for deforestation. New federal road building in the Amazon has been terminated, although there continues to be road building by local and state governments. The regional incentives scheme, mainly SUDAM incentives, which subsidized large scale cattle ranching has been halted, and the rate of subsidy and the volume of subsidized credit has been reduced. Although these initiatives should be seen in a positive way, we should wait and see how permanent they will be. Moreover, state governments have the freedom to create and give other incentives. So, still a cautious attitude is needed.

According to that strategy, large projects were to be given priority in the name of efficiency, occupation and scale economies. Branford and Glock (1985, p.23) see "Operation Amazonia" as a process of pre-emptive occupation, that is, a holding operation by which it could keep out peasant families and reserve the land for capitalist farming". Hall (1989, p.9) remarks that: "...... by adopting a blatanly latifundio[4]-biased strategy during the 1960s, which subsidised the gradual monopolisation of increasingly large areas of tropical rain-forest for commercial and speculative purposes, the Brazilian State has made violent rural conflict an inevitable feature of life in the Amazon basin ". Many cattle ranching

---

[3]See Hall(1989),pp 6-10.

[4]Latifundio is a large estate holding whose economic exploitation is very limited.

projects were approved to be undertaken by the private sector but few of them reached the state of completion. A study undertaken by Garcia, Gasques and Yokomizo (1986) based on a field survey, found that few ranch owners were seriously interested in developing sustainable beef production and confirmed that many projects were being exploited solely for their fiscal benefits. In visits to projects in Southern Para, the authors discovered that persons with five or six projects approved by SUDAM had received tax credit funds without having ever initiated project implementation. Once the tax credit funds had been fully disbursed, these projects were either sold or abandoned.

The abundant supply of fiscal incentives associated with the lack of control over those livestock projects being financed resulted in great speculation. As Hecht and Cockburn (1990) highlight: "Land in the Amazon became a vehicle for capturing incentives, cheap credits, and itself assumed the form of a speculative instrument and an object of exchange rather than being an input into agriculture. Once again, the dreams of stable agriculture dissipated in gusts of financial extractivism of a sort undreamed of in the region's history".

The 1970s were marked by changes in policies aimed at Amazonian colonisation. In the first period,1970-74, with the First National Development Plan-PND I (Plano Nacional de Desenvolvimento I)- there was an emphasis on road building, small farmers colonisation, besides the maintenance of the stimulus to cattle ranching. Following it, the Second National Development Plan-PND II (Plano Nacional de Desenvolvimento II)-to prevail during the period 1975-79, stressed the importance of providing incentives for large scale export-oriented projects, mainly in the mining sector. A common feature in the two patterns of occupation was an increase in state intervention with a view to intensify the effective occupation of the Amazonian region as well as to relieve social tensions in the region resulting from the confrontation of labourers and squatters, on the one hand, and investors protected by the granting of land titles through SUDAM incentives, on the other hand.

PND I was characterized by directed colonisation by small farmers and an extensive programme of road building. The recognition that Operation Amazonia favoured only the most powerful groups led to the creation of a new programme-National Integration Programme-(Programa de Integracao Nacional- PIN)- whose intent was to shift the ideology of Amazonian occupation away from an " economic" to a " social" perspective.[5] The then Brazilian president, General Emilio Medici, promised to make Amazonia " a land without men for men without land". (Hecht and Cockburn, 1990, p.108). This plan relied on the complementarity of Amazonia and the drought-stricken Northeast. Roads were built linking the Northeast to the Amazonia so that the impoverished Northeasterners could be put on the way to settle in the North.[6] Moreover, it stressed the importance of developing links with the Centre-South not only to provide easy access to Amazonian's raw materials but also to open new markets for southern goods.[7] "Ex-post", that direct settlement programme was considered a complete failure. Objective factors such as poor tropical soils, lack of proper cultivation techniques and absence of entrepreneurial ability or agriculture skills among settlers were cited as explaining the general economic failure of this programme and its promotion of ecological disequilibrium.

With PND II (1975-79), a new pattern of growth in the Amazonian region was planned. Basically, large-scale export oriented projects were

---

[5]Also a major factor explaining this new emphasis was the drought in the Northeast in the beginning of the 1970s.

[6] Mainly the Trans-Amazon highway and the Perimetral Norte.The latter was planned at that time but never built.

[7]See Hall(1989), pp 10-18.

conceived to improve the balance of payments: mainly mineral extraction and processing as well as livestock, forestry and agricultural projects. Some factors are relevant to explain this policy switch: the need to earn foreign exchange in a context of growing external debt; frustration with the livestock development phase to generate foreign exchange; rejection of the "social colonisation" model of small-farmer settlement in favour of agribusiness and mining; pressure from the largest iron ore producer company in Brazil, Companhia Vale do Rio Doce-CVRD- to switch production of iron and steel from the state of Minas Gerais to Amazonia; the move to greater centralisation in Brasilia.[8]

The novel feature of this last plan compared to the previous ones was the emphasis placed on expanding the mineral sector of Amazonia. Already in 1974, the POLOAMAZONIA programme was created, aiming at developing fifteen major growth poles, of which Carajas was one. Investigations indicated that a large proportion of the reserves of some minerals was in the Carajas mountains: 53% of iron ore, 25% of manganese, 73% of copper, 12% of nickel, 60% of bauxite, 20% of tin.

GCP was conceived in this context: mining projects and the subsequent industrialization were to take a leading role in the growth process of Amazonia. Basically, GCP was constituted by major investments in mineral extraction and processing sectors and the necessary infrastructure to make them feasible. The integrated nature of the investments belonging to GCP is explained by the lack of any kind of previous infrastructural facilities in the region. A key element for GCP's undertaking, for instance, was abundant cheap electrical energy supply through the Tucurui project (see Figure 2.1), which would allow the conversion of metals and minerals. Certainly, CIOP was very important in

---

[8]See Hall(1989),pp 18-33 about the whole II PND phase; Hecht and Cockburn(1990), pp113-122.

determining and justifying GCP, as revealed by the leading role taken by CVRD in the promotion of the latter. GCP also includes agricultural, livestock and forestry projects. Over a 10 year period, 1981-90, the costs of GCP were projected to total US$ 61.7 billion[9], composed as in Table 2.1.

[9]This value excludes the financing for the Tucurui hydro-power that generates electricity for GCP projects.

Table 2.1

Planned Investments and Associated Infrastructure within the GCP- 1981/1990-

1981 estimates- 1981US$ billion

Sector	US$ billion
Mineral and metallurgy projects	28.1
Forestry	1.3
Agriculture	8.1
Livestock	1.7
Infrastructure	
Mineral and metallurgy projects	6.8
Agriculture/Livestock/Forestry	13.3
Others	2.4
TOTAL	61.7

Source:CVRD (1981)

The breakdown of the mineral and metallurgy projects component is provided in Table 2.2.

Table 2.2

1981 Estimates for GCP's Mineral and Metallurgy Projects -US$ 1981

Product	Production capacity	Investment	Yearly Revenue (expected)
	1000 tonnes	US$ million	US$ million
Copper	1220	1500	660
Sulphuric acid	470	(1)	25
Gold	6500(2)	(1)	85
Aluminium	1740	6090	3130
Alumina	7480	4050	600
Bauxite	18780	1420	(3)
Nickel ore	50	1120	300
Iron manganese	500	500	200
Tin concentrate	2	10	15
Pig iron	3500	630	440
Sinter	5000	260	150
Coke	2000	400	280
Steel products	10000	10200	2500
Metallic Silicon	30	50	40
TOTAL		28130	9175

(1) Copper subproduct

(2) In kilos

(3) Captive production

Source: CVRD(1981)

GCP total investment costs represented 23% of the Brazilian GNP in 1981 (US$ 265 billion). The expected benefits exceeded the sum of revenues to be obtained: the industrialization of the region in itself was considered a major positive contribution of GCP to the region. Large areas covered by forests and in which only forestry extractive activities and subsistence agriculture were practised were to be transformed into a highly industrialized area led by the development of mineral and metallurgic projects. Moreover, another important dimension to be considered in the GCP's conception was the acceleration of the regional development process that would follow as a result of GCP. As Margullis (1990) points out, this statement is expresssed in the CVRD (1981) document: " The development resulting from the settlement of the GCP's projects will be the embryo of complementary activities to be located in the Eastern Amazonia in a future time.....The infrastructure made available by CIOP and its component of electric energy supply from Tucurui will result in a very positive social and economic impact on the region's economy, thus contributing to its integration to the national economy"

Presently, GCP has four main elements: a) CIOP; b) the iron-ore processing along the railway corridor; c) two aluminium plants at Barcarena (near the city of Belem) and in the city of Sao Luis); d) the Tucurui hydroelectric dam (see Figure 2.1). The first of these projects to be conceived was CIOP and one can say that this project was very important in determining the GCP's design. Since the very beginning, it was evident that to secure technical and financial success for CIOP, it was necessary to adopt an integrated approach, in which not only transport but also electricity generation was provided.

The Tucurui hydroelectric scheme plays a vital role in making possible the industrial growth being sought with GCP, through the large and cheap provision of electricity for those projects demanding high amounts of power. The Tucurui hydropower project on the Tocantins river, some 200 km north of the Carajas mining complex, was inaugurated in November 1984 at an estimated cost of US$ 4 billion. Its twelve turbines will eventually generate a total of 8,000 MW. Its electricity generation supplies the aluminium companies of ALBRAS-ALUNORTE at Barcarena and ALUMAR at Sao-Luis- which together will consume between one third and one half of Tucurui's total output- as well as the Carajas iron ore mine pig-iron smelters and other plants along the Carajas-Sao Luis railway. Certainly, these projects wouldn't have been attractive to both domestic and foreign investors without Tucurui subsidized electricity supply.

The most recent GCP's report (PGC,1988) indicates that the GCP's Executive Secretariat has approved[10] 27 projects in the Para state, 29 projects in the Maranhao state, and one in the Goias state, what has meant an employment generation of 105,000 jobs up to that time. Table 2.3 presents the the composition of the approved and implemented projects under GCP .

[10]Approved projects include implemented projects as well as those to be implemented shortly.

Table 2.3

GCP Approved and Implemented Projects

(October 1988)

	Approved	Implemented
Aluminium and Alumina	3	3
Pig Iron	13	4
Iron Alloys	4	4
Metallic Silicon	1	1
Agroindustry	9	4
Cattle Ranching	8	6
Mining	4	2
Lumbering	3	1
Others*	9	4
TOTAL	54	29

Source:PGC (1988)

* It consists of the following projects: Electrical energy(1), cement(2), wrappings(2), aviculture(1), fertilizers(1), margarine/soap(1), and sulphur(1).

Investment costs already spent in the above projects have totalled US$ 13.8 billion, of which US$ 9 billion (65.5 %) has been allocated to infrastructure projects (hydropower stations, railway transport, and the port). 17.8% of these resources has been channelled to Para, 16.9% to Maranhao and 0.4% to Goias. External loans are responsible for financing 41.6% of these costs, while domestic sources have financed the remainder.

Production figures for 1988 are: 30 million tonnes of iron ore; 0.60 million tonnes of alumina; 0.41 million tonnes of aluminium; 0.22 million tonnes of pig-iron (PGC,1988). However, these low production figures hide the fact that production targets to be achieved in the 1990s decade will, if they are achieved, transform the region into a highly industrialized area to be led by the mineral and metallurgic sectors. Production targets being achieved or not will depend on a host of interactive factors that will determine the final outcome. The government's commitment to the GCP success, the evolution of international markets, the expected profitability of those projects to both domestic and foreign investors, the evolution of the Brazilian environmental policy towards the Amazon forest are, probably, among such factors. Table 2.4 shows planned levels of activity.

Table 2.4

Actual and Projected Mineral and Metallurgic Production in Comparison to Originally Planned Production Targets in 1980(1000 tonnes per year)

	Actual Production (1988) (1)	GCP Approved Projects (2)	CVRD/1981 for 2000 (3)	GCP/CVRD for 2000 (4)
Iron Ore	30,000	35,000	35,000	35,000
Pig Iron	229	2,832	3,500	4,200
Steel	-	3,500	10,000	3,500
Alumina	600	3,800	7,840	3,800
Aluminium	405	700	1,740	700
Manganese	-	800	-	800
Iron Alloys	-	320	550	670
Bauxite	-	100	18,780	100
Metallic Silicon	32	32	30	32

Source: PGC(1988)

CVRD stands for Companhia Vale do Rio Doce, the responsible company for CIOP

The Carajas Iron Ore Project was conceived in the beginning of the 1970s. It consists of a mining project in the eastern Amazonian state of Para, integrated to a port at Ponta da Madeira in the northern state of Maranhao through a 890 km interconnecting railroad line. The Brazilian state-owned enterprise, Companhia Vale do Rio Doce (CVRD), was to own and operate the 3.8 billion dollars project at 1981 prices, besides partly financing it and, on the other hand, receiving resources from BNDES (the Brazilian development bank-Banco Nacional de Desenvolvimento Economico e Social), the World Bank, among other sources of financing.

The iron ore mineral reserves are supposed to be some 18 billion tonnes in the Greater Carajas region. CIOP reached an annual production level of 30 million tonnes in 1988. Most of the production is exported. At the time of the project conception this was thought to be a major social benefit to the economy, due to the persistent balance of payments deficits prevailing in the late 1970s and early 1980s in Brazil.

CIOP included the settlement of 5 urban areas along the railroad and another close to the mine. Further details about it will be given in Section 2.2 .

2.2) Physical Description of the Carajas Iron Ore Project.

The Carajas iron ore deposits are situated about 550 km south of Belem in the Greater Carajas region. It covers an approximate area of about 4,000 km^2 at an average altitude of 650 m above sea level. The vegetation found in the region is characterized as continuous equatorial rainforests except on top of the plateaus where clearings occur, indicating outcropping iron formation.

The conception of the system as an integrated one (mine, beneficiation plant, railroad, port and urban areas) was intended to fulfill two main interrelated objectives. The first was to provide the necessary infrastructure services so that the project would benefit from scale economies, making its output competitive in world markets. The second objective was to increase the reliability of the project, in the sense of securing all the relevant stages of the production process. In what follows, a brief description of the project components is provided.

The Mine:

The iron ore deposits are situated in the south of the Para state. More precisely, most of the iron ore reserves in the Carajas region are located in two sectors of the Serra dos Carajas - Serra Norte and Serra Sul-(Carajas Mountains) which are separated by 35 km. Preliminary investigations indicate the existence of 17.8 billion tonnes of high-grade, low-phosphorous iron ore. Both the quality of the iron ore and the magnitude of its deposits make the Carajas region one of the most important iron ore areas in the world. Table 2.5 shows the magnitude and the quality of the iron ore, according to the results of a extensive exploration programme in the period1969-1972.

Table 2.5

Brazil-Iron Ore Reserves in Serra dos Carajas

(billion tonnes)

Deposit		Reserves Measured	Indicated	Inferred	Total	Grade % Fe	P	Si02	A1203
Serra Norte									
	N1	0.28	0.12	0.45	0.85	66.41	0.05	1.12	1.17
	N5	0.34	0.12	1.12	1.58	66.18	0.05	0.88	1.07
	N4W	-	0.63	1.10	1.73	65.75	0.04	1.25	1.33
	N4E	1.28	0.06	0.02	1.36	66.13	0.04	1.00	1.05
	Others	0.04	0.03	0.49	0.56	65.35	-	-	-
	Sub-total	1.94	0.96	3.18	6.08	65.86	-	-	-
Serra Sul									
	S11	0.30	1.27	8.76	10.33	66.33	0.04	1.26	0.83
	Others	-	-	0.60	0.60	66.08	-	-	-
	Sub-total	0.30	1.27	9.36	10.93	66.32	-	-	-
Serra Leste		0.20	0.12	0.10	0.42	65.90	-	-	-
Serra de Sao Felix		0.08	0.07	0.22	0.37	62.82	-	-	-
Total		2.52	2.42	12.86	17.80	66.08	-	-	-

Source:CVRD

N1, N5, N4W, N4E, S11 refer to iron ore deposits located in the two sectors of the Serra dos Carajas-Serra Norte and Serra Sul.

As can be seen from Table 2.5, there are many high quality iron ore deposits. The present project has involved the exploitation of the N4-E deposit. It was selected due to the easy access to the railroad and to its abundant reserves. This deposit is 4.2 km long with an average width of 300 m and a maximum depth of 285 m below the surface. The mine is an open pit with a waste-to-ore ratio by weight of 1:2. A standard shovel/truck mining system is used. Benches are 15m high and drilling is done by two rotary drills. Given the characteristics of the iron ore in this deposit, only 25% of the ore has to be blasted using explosives based on ammonium nitrate. The waste rock is hauled to waste dumps and the ore is transported an average of 100 m from the mine to the beneficiation plant.

Beneficiation

Due to its characteristics, the iron ore available in Carajas area doesn't need to be concentrate, and so only the operation of crushing to reduce the ore to sinter feed and natural pellet is necessary. Beneficiation activities consists of three stages of crushing and screening, one stage of rod milling, a recovery stage with screw classifiers and cyclones and a last stage of dewatering the products. Beneficiated products are transported through belt conveyors to the stockpile area with a capacity of 1.6 million tonnes. Tailings are pumped to two tailing ponds, where wet screening is applied in order to avoid clogging of the screen desks. Recirculation of some process water is allowed by tailing thickeners. Make-up process water is pumped to the plant from the tailings ponds where effluents are treated and spillway water is cleaned.

All facilities (offices, laboratories, maintenance workshops and warehouses) are common to the mine and to the beneficiation plant.

The Railroad

The railroad which was especially built for the project is 890 km in length and links the mine to the port at Ponta da Madeira. There are 4 stations along the track and 36 crossing loops, each 2,300 m long. A Central Traffic Control system and an Automatic Train Control were installed to be operated in the Sao Luis terminal.

The railroad follows the way of the cities of Santa Ines (km 200- km 0 being Ponta da Madeira), Imperatriz and Maraba (km 737). From km 0 to Santa Ines city, the topography is low, with many small rivers, swampy in some parts and with medium forest elsewhere. The other part of the railroad (from km 200 to Carajas) crosses through jungle with large and dense timber. Along the line, there are small villages : Santa Cruz (km 282), Calis (km 385), Pequia(km 514), Cara(km 634), and Parauapuebas (see Figure 2.2). There are 63 bridges, the only major bridge being that which crosses the Tocantins river at Maraba with a total length of about 2.3 km.

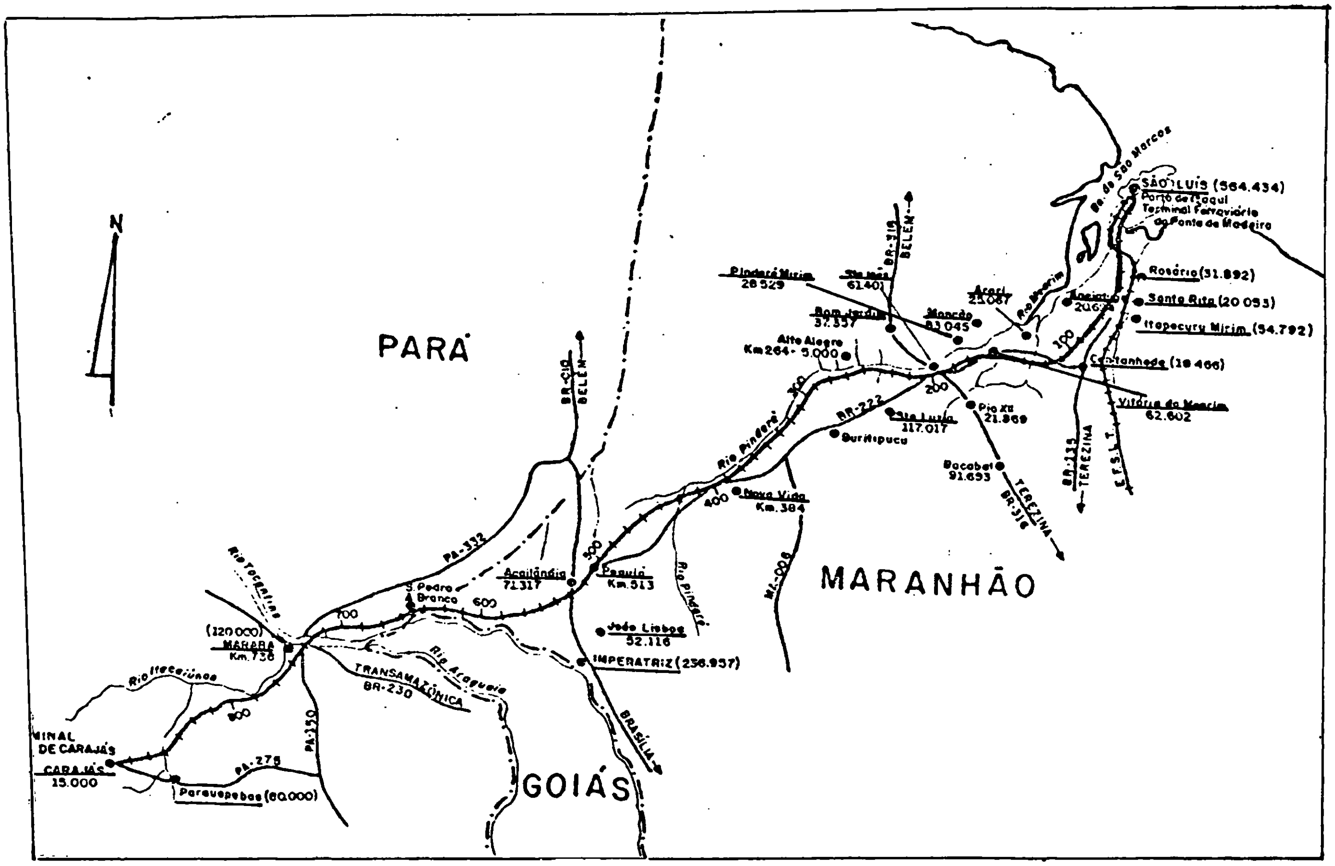
The system is operated by a train which has 160 iron ore wagons with an ore load of 15,680 tons hauled by three 3,000 HP diesel electric locomotives. There are eight ore trains per day in each direction.

The Port

The new port, located in Sao Marcos Bay, is 10 km southeast of the city of Sao Luis, in the Maranhao state. The system allows 35 million tonnes per year to be received from the railroad wagons and loaded into ships. There is a single berth, whose occupancy rate averages 64%.

Figure 2.2

Cities Crossed by the Carajas Railway



Infrastructure Induced By The Project:

Urbanization

In the attempt to fulfill the basic needs of the working population, the Carajas project was conceived to include the settlement of a new town(Carajas) as well as the urbanization of previously existing small cities along the railway.

At the CIOP's completion, it became evident that the infrastructure planned was insufficient to meet the demands of a growing migrant population.

The new town created by the project, Carajas, is situated on a plateau at an altitude of 640 meters and about 12 km from the mine. This little town was built within CVRD's concession and was planned to provide housing for CVRD employees, infrastructure, community facilities, commercial and recreational areas. At the CIOP's appraisal, it was estimated that 2,044 workers would be needed by 1988 at the level of CIOP production of 35 million tonnes. Moreover, eight locations along the corridor were selected to provide railway maintenance. These locations are (see Figure 2.2): Parauapebas (27 km from the Carajas Township); Maraba; Rosario; Vitoria do Mearim; Santa Ines; Nova Vida; Pequia; Km 650 (from the port). Housing facilities were plannned to accomodate CVRD workers.

CVRD initially designed the urban development component expecting a population of 5,000 at Parauapebas by 1988, but this estimate was after revised upwards to 10,000. The remaining seven locations were to be provided with about 280 housing units and community facilities. At the port of Sao Luis, CVRD had to relocate some 700 squatter families to a new town. CVRD prepared a land use and zoning plan for the area around the port at Sao Luis to ensure squatter groups were kept away from the area.

"Ex-post", the Carajas township conception proved to be adequate to the local needs. A whole package of community facilities as well as the sufficient provision of services made this town a good example of planning. CVRD's employees enjoy a quite reasonable living standard. The city is completely under the CVRD's control and its growth is completely determined by the company. The situation in Parauapebas, however, contrasts sharply with that of the Carajas town. Project-related urban investments at Parauapebas have been considered far from sufficient to meet the growing shelter and service needs of the rapidly expanding population in this town and its satellite, Rio Verde. In 1988, the estimated population at Parauapebas/Rio Verde was of the order of 45,000-50,000 inhabitants, far above the 10,000 original estimate at the CIOP appraisal's time in the early 1980s. The growth of Parauapebas/Rio Verde is explained basically by the following factors: a) official settlement programmes near the Carajas project; b) extensive gold and other mineral prospecting in the vicinity; c) spontaneous establishment of small farms and ranches in the area. All of these activities as well as the migration to that area were made possible by the road infrastructure installed in connection with CIOP.

Such divergence between estimates and actual figures in the population size of Parauapebas/Rio Verde has brought to the region a host of problems associated with inadequate infrastructure, poor housing, health problems and poverty. The situation in the other seven locations proved to be minimally adequate for the purposes of housing CVRD's employees.

Electric Power:

CIOP included the installation of an electrical substation at the mine site, a 180 km-230 KV transmission line from the already existing substation in Maraba to Carajas and a 230 KV line along the railway from Maraba to Sao Luis to supply communities along the railroad and the port at Sao Luis.

However, the large scale industrial development envisaged in GCP, as suggested before, had as a pre-requisite the cheap and abundant supply of electrical energy. The Tucurui hydropower project on the Tocantins river, some 200 km north of the Carajas mine, was basically conceived as the source of supply of electrical power to GCP: to the aluminium companies of Albras-Alunorte at Barcarena and Alumar at Sao Luis as well as to the Carajas iron ore mine[11] and the expanding cities and towns along the corridor.

The Tucurui project consists of a concrete gravity dam containing a power plant, a spillway, a navigation lock and an earthfill dam across the left bank. Its average height is 77.5 m. The costs of Tucurui have so far reached US$ 4 billion and its twelve turbines will at its completion generate a total of 8,000 MW. This project, inaugurated in 1984, presently generates about 3,333 MW. A number of major social and environmental problems have been associated with this project: the displacement of about 35,000 people by the dam and reservoir (an area of 2,500 km^2), the flooding of the forest, an increase in endemic diseases, the effects on flora and fauna, the spread of water weeds,

[11]In 1988, only 1% of the electricity generation in Tucurui was consumed by CIOP.

among others.[12] Although in 1988 just 1% of the electricity generated in Tucurui was destined to supply CIOP, the whole GCP's conception, in particular the pig iron industry, depends heavily on the Tucurui undertaking. So, ideally speaking, part of Tucurui's environmental and social costs should be assigned to CIOP and the pig iron industry.

Other Infrastructural Developments

These include a water supply system for mining activities and the Carajas township as well as reconstruction and pavement of 170 km of roads connecting Carajas with Maraba. Also, an airport was built inside CVRD's concession near the mine site, having a 2,000 m runway capable of accomodating commercial jet aircraft.

[12]The reader interested in the environmental effects of the Tucurui project should consult Goodland(1987) and INPA(1982).

2.3) The Expected Regional Impact of the Carajas Iron Ore Project

As CIOP is situated in the larger development efforts of the Greater Carajas Programme, significant regional effects were expected as a consequence of the project at the appraisal stage. As the development of the region was highly dependent on the existence of basic infrastructure, and the CIOP conception had two important infrastructure components (the railway and the port), one of the major benefits of the project was thought to be its regional impacts.

In addition to the iron ore operation, several other projects will be using the Carajas transportation infrastructure in the medium run. These projects include: a) the pig iron smelting industry being settled along the railway corridor; b) a copper concentrate venture for which CVRD has completed exploration; c) several tin projects under implementation by Brazilian private firms; d) a bauxite project at Paragominas; e) the mechanized exploitation of gold at Serra Pelada. All those projects belong to GCP but they are still being implemented. Moreover, passenger transportation is also provided by CVRD due to local populations pressure.

Over the longer run CIOP is expected to indirectly stimulate development of the more important towns in the region into significant commercial and industrial centers. In particular, the following towns are recognised to have their growth rates positively affected by CIOP:
a) Carajas led by the iron ore extraction; b) Sao Felix do Xingu led by the extraction and processing of tin concentrate; c) Maraba; d) Tucurui; e) Barcarena and Paragominas led by alumina and aluminium; f) Sao Luis/ Ponta da Madeira. In addition, the cities along the railway corridor where the pig iron smelters are to be located also fall in this category of

cities positively affected by CIOP: as it stands, these are Acailandia and Maraba.

Other major regional benefits associated to CIOP are considered the opening up of a remote but resource rich area of the Amazon. Also, the acceleration of migration towards the region as well as the employment generation that would follow as the before mentioned investments materialize was also considered a social benefit for the country. Finally, the project was expected to play a key role in accelerating the economic growth of the region and to begin the process of planning and controlling the growth of a territory vast and rich in mineral resources, whose exploitation would bring foreign exchange generation to the country.

2.4) The Carajas Iron Ore Project and Industrialization: The Pig Iron Industry

A major indirect consequence of CIOP will be its impact on the industrial development in the region. The most direct reflection of this linkage is the pig iron industry which depend not only on the transportation provided by CIOP but also on its output, the iron ore. Presently, four pig iron smelters are already in operation (two each in Maraba and Acailandia) and further nine projects have already been approved by the GCP to be located along the rail corridor. All these projects qualify for fiscal incentives under GCP. In the absence of CIOP, none of these thirteen industries could be installed along the rail corridor.

If these thirteen industries are installed as presently planned, they would produce more than 1.3 million tonnes of pig iron a year and would provide about 5,000 permanent direct jobs. Six of these smelters would be located in Acailandia, five in Santa Ines and two in Maraba. These metallurgical industries and others similar in nature that are expected to be established in the future -manganese, copper and other minerals- will generate a substantial amount of indirect employment. This last will be the result of the production of non-mineral input supplies such as, for instance, charcoal, the provision of transportation and other services, and the increased demand for locally produced goods and services on the part of those directly and indirectly employed by these activities and their families.

The mineral processing industries allowed by CIOP through the components of transport and the iron ore in itself are likely to have significant and multiplier effects in terms of employment and income in the area under influence of the project, which as a first order approximation could be considered as the cities crossed by the Carajas railway. Most of this employment generation will be concentrated in cities and towns, especially Maraba, Acailandia, Santa Ines, Rosario and Sao Luis, from which it can be concluded that another important impact of CIOP will be the impulse for urban growth in the region. Thus, one of the conclusions that emerge is that CIOP will be an important indirect source of industrial and urban growth in Eastern Amazonia.

CHAPTER 3- THE CARAJAS IRON ORE PROJECT'S FINANCIAL ANALYSIS

3.1) Ex Ante: Original Appraisal

In the economic analysis of Carajas project, only the financial aspects were considered, that is, those for which there is a market expression. That is, costs were identified as those associated with cash outflows and benefits as cash inflows. The sum of input costs (fixed and variable) was taken as a measure of the total costs of the project and the benefits were limited to those associated with its financial revenue. No adjustments were made to correct possible distortions in market prices, taken to reflect the true value of goods and services to the economy.

Before entering into the prospective financial analysis that was undertaken at the time (1981) of the CIOP's evaluation by the official financing agencies, it is worth describing the projected iron ore market trends in order to better understand the pricing assumptions in the analysis. Moreover, given that CVRD is a company which operates in the world market, it is useful to suggest the strategy being taken by CVRD with the CIOP undertaking.

The operation of the iron ore market depends mainly on what happens in the steel market as well as the expected market behaviour of the iron ore supply. At the beginning of the 1980 decade, the prospects for the iron ore market in the 1980s were not good. With the two oil shocks in the 1970s, it was expected that the steel world production would suffer a downward trend. Large steel producers, such as Japan, Western Europe and United States of America were expected to increase their production at a pace following close to their historical rates of growth.

Developing countries, on the other hand, were expected to perform better than developed countries. As part of their development process and the effort to decrease the gap between the underdeveloped and the developed world, the expected rates of growth in the steel market of developing countries was supposed to be significantly higher.

Table 3.1 shows the expected rates of growth in the world steel market in 1980.

Table 3.1

Expected World Steel Production in 1981-1985/90

	Steel Production (10^6 t)			Growth Rates (% p.y.)	
	1979*	1985	1990	1979/85	1985/90
(1)Developed Countries	430,3	496,1	558,6	2,4	2,4
(2)Developing Countries	100,4	150,7	201,7	7,0	6,0
(3) Eastern Europe	214,6	263,8	313,3	3,5	3,5

Source:BNDES(1980)

(1) Western Europe, North America(USA and Canada), Japan and Oceania

(2)Latin America, Africa, Middle East countries and Asia excluding Japan.

(3)URSS, Czechoslovaki, Eastern Germany, Poland, Romania, Hungary and Bulgaria.

*Realized

A point that, at the time of the CIOP's appraisal, contributed to the formation of optimistic expectations was the projected increase in the demand for transoceanic trade of iron ore. The progressive depletion of developed countries' reserves shifted iron ore production to developing countries, as can be sen in Table 3.2. Moreover, the technological progress in the steel industry made more rigourous the iron ore requirements.

Table 3.2

Iron Exports by Country(million tonnes) and as % of Total Iron Ore Trade

	1965	%	1970	%	1975	%	1978	%
Australia	0.20	0.13	41.38	16.72	75.60	25.63	75.34	28.43
Brazil	11.3	7.45	25.39	10.26	68.77	23.31	66.0	24.9
India	11.0	7.26	20.10	8.12	19.75	6.69	20.9	7.89
Sweden	24.5	16.16	28.17	11.39	18.9	6.41	23.3	8.79
Liberia	15.7	10.36	22.56	9.12	18.78	6.37	18.0	6.79
Canada	16.7	11.02	21.86	8.84	21.48	7.28	13.0	4.90
South Africa	2.20	1.45	3.13	1.27	3.85	1.31	14.0	5.28
Venezuela	17.10	11.28	20.10	8.12	20.8	7.05	12.7	4.79
Mauritania	6.0	3.96	8.6	3.48	8.67	2.94	8.5	3.21
Chile	10.8	7.12	10.35	4.18	9.21	3.12	6.70	2.53
Peru	7.6	5.01	9.9	4.0	6.50	2.2	5.0	1.89
Angola	-	-	5.58	2.26	3.85	1.31	-	-
Others	28.5	18.8	30.3	12.25	18.84	6.39	1.60	0.6
Total	151.6	100.0	247.42	100.0	295.0	100.0	265.04	100.0

Source: BNDES(1980)

In this context, countries such as Brazil and Australia performed particularly well: in 1965, their market shares in the global transoceanic trade were, respectively, 7.5% and 0.1% and in 1978, they respectively increased to 24% and 28%. CVRD had led the Brazilian expansion of transoceanic iron ore market share.

Table 3.3

Largest Iron Ore Supplying Companies-million tonnes.

	1973	%	1974	%	1975	%	1976	%	1977	%
CVRD (Brazil)	37.5	12.5	46.2	14.0	47.3	16.0	47.3	16.1	39.8	14.4
Hamnersley (Australia)	27.7	9.2	32.0	9.7	32.5	11.0	34.9	11.9	33.1	12.0
Mt.Newman (Australia)	23.9	7.9	27.3	8.3	24.6	8.3	21.9	7.5	22.8	8.3
L.K.A.B. (Sweden)	29.0	9.6	29.7	9.0	18.9	6.4	21.0	7.2	18.3	6.6
ISCOR (South Africa)	0.5	0.2	0.4	0.1	0.6	0.2	2.8	1.0	12.2	4.4
MBR (Brazil)	1.9	0.6	6.8	2.1	8.2	2.8	11.3	3.8	10.7	3.9
Others	180.6	60.0	187.5	56.8	163.1	55.3	154.5	52.6	139.1	50.4
Total	301.1	100.0	329.9	100.0	295.2	100.0	293.1	100.0	276.0	100.0

Source: BNDES(1980)

From the CVRD's perspective, CIOP was seen as a necessary requirement to maintain its leadership position in the world iron ore market. The progressive depletion of its hematite reserves in the Quadrilatero Ferrifero in the Minas Gerais state (Southern Brazil), meant rising extraction costs, which could undermine the CVRD position as a leader in the international market. Thus, as part of the enterprise strategy there was the aim to switch production from the reserves in the Minas Gerais state to Carajas. Moreover, given that the iron ore quality in Carajas is much higher than that in Minas Gerais, CVRD thought a major benefit would result from the switch of its production to Carajas.

CIOP investment costs summed US$ 3.8 billion estimated at the end of 1980, distributed according to Table 3.4

Table 3.4

CIOP Costs Breakdown as Estimated at the Appraisal Stage in 1980 Applying to the Period 1980-1987.

	US$ million- Dec. 1980	%
Mine/Beneficiation	463	12
Port	233	6
Railway	1,690	44
Urban cities	168	4
Engineering and Management	467	12
Pre-operational costs	29	1
Contingencies	313	8
Financial costs	330	9
Working capital	99	3
TOTAL	3,800	100

Source:BNDES(1980)

On the revenue side, it was assumed that the full project operation would be attained in 1987 (35 million tonnes per year) and that its time horizon was 24 years (the railway lifetime). The CIOP's operation was expected to start in 1985 with a capacity of 15 million tonnes per year and 25 million tonnes per year in 1986. It was assumed that the price that would prevail all over the project lifetime was US$ 18.62 per tonne. In this case and accepting that the CIOP income statement is as Annex 3.1 indicates, the internal rate of return is 9.1% per year. With a more optimistic view about the projected iron ore price (assuming a 7%

increase in its value) and other things remaining equal, the internal rate of return increases to 10.1% per year[13].

The impact of CIOP on CVRD financial accounts was expected to bring large amounts of profits to the company. Financial indicators suggested that CIOP was a highly profitable project. The ratio of net profits to sales in 1987 was 9% , 24% in 1990, 40% in 1995, 43% in 2000 and 42% in 2005. The amount of income tax exemptions through SUDAM incentives over the fifteen years (up to the year 2000) is US$ 752 million at 1980 prices (see Annex 3.1 to get these estimates). Without SUDAM incentives, the ratio of net profits to sales in 1990 would be 21%, 29% in 1995, 30% in 2000 and 26% in 2005.[14] As SUDAM incentives are a subsidy, and so they distort the right prices, if we are purely concerned with the CIOP efficiency we should look at CVRD financial accounts excluding them, what will be done in the "ex-post" analysis in Section 3.3. CIOP would receive 28% of the total necessary resources from BNDES, 32% from external sources[15] and the remaining would be financed with own resources from CVRD.

[13]This estimate is based on the CIOP 's Income Statement(Annex 3.1) and the Capital Cost Estimates (Annex 3.2)

[14]1987 was a year of negative taxable income and so SUDAM incentives do not apply.

[15]The main sources of foreign financing have been:the World Bank (US$300million), the EEC(US$ 400 million), among others.

3.2) Recent Past Trends and Future Outlook of the Iron Ore Market

The iron ore market has remained stagnant since the mid-1970s. As this market demand is a derived one, linked to that of the steel market, the slowdown trend in the iron ore market has followed that of the steel market. This last trend has resulted from the reduced levels of economic growth as well as from the decline in the steel intensity ratio[16] in the industrial countries.[17]

World crude steel apparent consumption is projected to grow by 0.8% per year in the 1990-2000 period. Industrial countries' consumption is expected to decline at a 0.4% per year while that of developing countries is expected to increase at a 3.5% per year during that period. Following these trends and aggravated by the increased use of scrap based electric arc furnaces for steel making as well as improvements in steelmaking,[18] the projected growth rate of iron ore consumption is 0.6% per year. Developing countries' iron ore apparent consumption is expected to increase by 2.3% per year, while that of developed countries is expected to decline by 0.4% a year, according to the decline in the steel production.

---

[16]The steel intensity ratio, which is defined as the ratio of steel demand to GDP, is determined by economic factors as relative prices that lead to material substitution, technical factors such as changes in the steel use per unit of product or change in the consumers taste.

[17] This section is based on a World Bank Report(1987) and a document provided by CVRD(1990)

[18]There are three major types of furnace: basic oxigen furnace, electric arc furnace, and open hearth furnace. The electric arc furnace process relies almost totally on scrap or direct reduction of ore(or a mixture of the two). The expansion of steel production by electric arc furnaces is expected to result that 27% of world steel production will be produced by this method, with a negative impact on the iron ore demand.

Iron ore excess capacity for the period 1990-2000 is expected to put a downward pressure on real prices. The Carajas project, adding about 35 million tonnes a year, further aggravates this trend. However, declining iron ore prices will cause some high cost mines in West Africa, North America and Europe to shut down or to operate close to a loss. World iron ore capacity is expected to reach 1,080 million tonnes, with a positive contribution from developing countries (1.5% per year) and a negative one from developed countries (-0.4% per year). By 2000, Brazilian sinter fines' prices from Carajas are expected to be US$ 24.1 per tonne in current terms, or US$ 14.2 in 1985 prices.

In the context above outlined, to understand the Carajas's undertaking imposes that we look at the locational trends in the iron ore market.

The expanding world economy of the 1960s and early 1970s reflected very favourably on the iron ore seaborne market. Production capacity in the steel industry was built up: from 345 million tonnes in 1960, world production increased to 595 million tonnes in 1970. Iron ore supply had to be secured. Two supply sources became available at that time: Brazil and Australia. Massive investments had to be made in mining and domestic transportation to guarantee the iron ore supply to developed countries. Japan and Germany took a leading role in the promotion of the development in the mining sector. The huge resources needed for integrated projects-mine/railroad/deepwater port- were obtained from the international banking system, backed by long term supply contracts. The characteristics of the contracts that were made provided for investment incentives and stability to mine operations.

Prices were set in such a way as to guarantee a rate of return compatible with the necessary large investments. Ore prices for major projects were set for long periods of time, up to 5 years, with adjustment formulae as guidelines for the prices to prevail in the following period. Contracted quantities in a world scenario of growing demand were met. Moreover, low inflation rates for the strong currencies allowed and encouraged price stability with benefits for both sides of the market. Another important point to explain this favourable context was the virtual stability of the main currencies against the dollar, the currency used in all contracts. Forecasts at that time produced encouraging figures: in April 1972, the year when world output reached 630 million tonnes, IISI indicators pointed to a production of 939 million tonnes in 1985, an expected increase of 50% in 13 years.

Nevertheless, the situation changed dramatically for the period 1974-82, due to the fall in steel output and the technical changes that have improved the efficiency of steel output in the last ten years.[19] Steel consumption in industrial countries declined from 398 to 318 million tonnes in the 1974-84 period. Production, over the same period, declined by 94 million tonnes. The iron ore market, following these trends, had its demand decreased by 0.7% per year in the 1975-84 period. The slowdown of steel demand growth since the mid-1970s has resulted in excess of capacity and, since that time, several iron ore mine projects have been cancelled, postponed, or delayed.

Certainly, the situation in the mid-70s was one of excess of supply in the iron ore market. Large capacity expansion in the 1960s, high energy costs and economic recession on a global scale are the main reasons to explain this state of disequilibrium in the ore market. New developments in iron preparation techniques involving beneficiation and

---

[19] The decline in steel output can be mainly attributed to: a) the slowdown of GDP growth in industrial countries;b) the decline in steel intensity in industrial countries. The technical developments in steel production that reduced iron ore demand are mainly the increased use of electric arc furnace for steel making and the increased use of direct reduction methods in iron making.

agglomeration have made things worse: several low-grade deposits became economically viable. In this context, it becomes difficult to understand on a rational basis the CIOP's undertaking.

Although sinter fines, the main ore type found in the Serra dos Carajas, appear to be the dominant iron ore product of the future, the same tendency of excess supply is present, and thus projected falling real prices are expected. In light of the shift of location tendency of iron ore supply since the mid-1960s, we can start to understand the CIOP's undertaking, which has given Brazil the role of major iron ore supplier in the Western world. In 1961, the major iron ore producing countries in decreasing order of importance were the USSR, the United States, France, China and Sweden. In 1984, while the USSR maintained its position as the world's largest iron ore producer, it was followed by Brazil, Australia, China and India. To maintain the Brazilian situation in the world market, the Carajas project will be very important. We can understand the CIOP only as an alliance between foreign and domestic interests, these last represented mainly by CVRD as a company which has its own strategy.

According to CVRD, the short recovery in the iron ore market after the negative effects of the first oil shock was interpreted as a signal to undertake new investments in the mining sector. The Carajas project seemed to be compatible with two objectives. To secure iron ore supply, it received support from steel mills around the world and international organizations. On the other hand, it was imperative for CVRD to ensure its long-term operations in view of the imminent exhaustion of some of its deposits.

The iron ore price trend is clearly downward on a long-term basis, as can be seen in Annex 3.3. Although there are periods when there are short recoveries, clearly the long-run tendency is a declining one. The world situation is of excess supply what, associated with specific features in the determination of iron ore prices, has resulted in falling projected real prices for the period 1990-2000.

Japanese and European steel makers dominate the market for iron ore and these countries are thus able to influence prices. Most of the iron ore is bought through annual or multi-year term contracts on a tonnage basis, with an annual renegotiation of prices. Although the exact pricing policy during the contractual negotiations for a specific type of iron ore is rather complex, some basic mechanisms have been established.

Up to 1970-75, contractual negotiations between the Swedish iron ore exporters and the steel mills of the Federal Republic of Germany set the pace for other contractual arrangements. In subsequent years, the negotiated price between the same steel mills and CVRD served as a benchmark price for other ore price negotiations.

In the 1980s, however, a worldwide abundance of iron ore put the producers at a great disadvantage during price negotiations. The oversupply of iron ore, reinforced by expectations of declining world steel demand and the fear of smaller iron producers that the upcoming increase in high-quality low cost Brazilian capacity from Carajas would undercut their market shares has made the market very competitive and led to iron ore prices declining in real terms. Furthermore, steel companies have diversified their markets and ensured the expansion of available iron ore, while the iron ore exporters have not been successful in diversifying their markets. Each of the major exporting countries relies mainly on one market, which weakens their bargaining position.

The 1984 and 1985 spot CIF prices of Brazilian sinter fines delivered in North sea ports were US$ 23.2 / tonne and US$ 22.7/tonne, respectively. Iron ore prices are expected to continue their downward trend. From 1990 to 2000, the world iron ore capacity is expected to increase by close to 3.7 million tonnes, while demand over the same period is expected to increase by 9.3 million tonnes. It is expected that this excess of demand will put upward pressures on nominal iron ore prices. Spot iron ore prices of Brazilian sinter fines are expected to reach US$ 24.4/tonne in 2000. However, ample underutilization of mineral capacity will continue depressing the real price of Brazilian sinter fines and it is expected that, from 22.7/tonne in 1985, that price will become US$ 14.2/ tonne in 2000 (both in 1984 US$ terms). Certain mines in West Africa, North America and Europe are expected to close because of the declining real prices. In the 2000 year's scenario, the expected distribution of sinter fines by supply region gives a 28% share to Brazil, the largest one, followed by Oceania, with a figure of 19%.

Moreover, it is unlikely that there will be any reversal in the downward trend in the iron ore price. There is no international or intergovernmental institution directly involved in price negotiations or in investment planning. There are, however, two institutions which promote coordination among iron ore producers and between iron ore producers and steel mills. The first is UNCTAD and the second one is the Association of Iron Ore Exporting Countries (APEF), which is mainly concerned with the exchange of information and increased marketing cooperation. The formation of APEF, in 1975, has only marginally improved the negotiating posture of iron ore producers since both Brazil and Canada have opted not to join.

Just to illustrate the operation of the iron ore market, a recent negotiation process is described. In 1987, Japanese mills and one of the Australian signatories to the letter agreed on a 5% reduction on iron ore prices, which defined the 1987 market. By the end of the year, that company's deliveries to Japan reached 14.5 million tonnes while the largest Australian shipper was left with stocks of as much as 18 million tonnes, and deliveries to Japan dropping from 17 million tonnes in 1986 to 11 million tonnes in 1987. In such a context in which large firms hold large stocks, the incentive to agree on price reductions so that to gain on quantities is always present. So, it seems that while excess of capacity is present, the tendency to falling prices will exist.

What is important is that while at the CIOP's appraisal the forecast price was US$ 18.26 per tonne, the 1989 iron ore price was US$ 16.2, both in the respective same year prices.

3.3) Ex-post Analysis

Abstracting from ecological and social aspects that will be considered later on and concentrating on costs and revenues of the project, a preliminary analysis of the CIOP's internal rate of return has to consider the changes in the world iron ore market that were not forecast at the time of its "ex-ante" appraisal. Both the expected prices and volume of sales were not met, what has contributed to the significant decrease in the CIOP's economic profitability.

Costs of the project at completion in 1987 totalled about US$ 2,786 million, 25% below the initial estimate of US$ 3,750 million, both in current prices. In 1982 constant prices, investment costs were 17% below forecast costs. Total financing required was about 22% below the appraisal estimate. CVRD points three factors for this positive result: a) favourable exchange rates between the Brazilian cruzeiro and other currencies; b) lower prices of goods and services, due to the world recession in the 1980s; c) cost reductions because of permanent effective cost control.

Data referring to actual production and sales are summarized in Table 3.5. As can be seen, both figures are lower than expected throughout the period.

Table 3.5

CIOP Production and Sales

(million tonnes)

	1985	1986	1987	1988	1989
Production					
Planned	6.1	20.3	31.7	35.0	35.0
Actual	1.0	14.1	24.4	28.6	31.2
Sales					
Planned	5.0	20.0	31.5	35.0	35.0
Actual	0.6	11.6	23.4	29.8	30.0

Source: CVRD(personal communication in 1990)

Sales' revenue in 1989 amounted to US$ 487 million with a current price of US$ 16.2/tonne.

An appraisal of the CIOP's profitability was undertaken assuming that there has been a 17% decrease in project costs which have affected investment items in an uniform way compared to 1980 estimates, and that the sales volume will remain at 30 million tonnes per year. Two scenarios are considered for the projected iron ore price: the most recent actual price (US$16.2/tonne for the period 1985-88) (Scenario A) and the iron ore estimated price by the World Bank (US $ 14.2/tonne in 1985 prices-Scenario B). Deflating both prices to be compatible with 1980 project estimates using the US GNP deflator, the iron ore price in the scenario A is US$ 13.4 per tonne and in the scenario B this price becomes US$ 11.3. No other changes are assumed compared to those of the original financial appraisal.

The internal rate of return in scenario A is 4.4% and the financial one, that is net of taxes but including SUDAM incentives is 3.6%. Excluding SUDAM incentives, this rate becomes 2.2%. The time profile of the cost-benefit stream which generate these rates is provided in Annex 3.4 .

The internal rate of return in scenario B is 2.2% and the financial one, that is, net of taxes but including SUDAM incentives is 0.8% . Excluding SUDAM incentives, this last rate becomes -1.2%. The time profile of the cost-benefit stream which generate this rate is provided in Annex 3.5.

Table 3.6 gives detailed information about the financial interest rates charged on the Carajas project. The weighted average of the financing terms is 10.8% per year interest for 14 years, including 4.7 years' grace.

Table 3.6

Long Term Debt Financing Terms

	Interest Rate (%)	Commitment Fee (%)	Grace Period (years)	Repayment (years)	Total Maturity (years)
Local Loans					
a.BNDES	9.0	0.1	6.0	12.0	18
b. FINAME	9.0	0.1	3.5	9	12.5
c.Banco da Amazonia	9.6	0.1	3.5	9	12.5
d. CVRD Convertible debentures	11	--	6	1	7
Foreing Loans					
a. Japanese Import Loans	8.5	0.5	5	10	15
b. Japanese Exim Bank	8.0	0.5	5	10	15
c. Japanese Syndication	9.2	0.5	5	5-8	10-13
d. Japanese Bond Issue	9.4	--	5	7	12
e. EEC	12.4	--	4	11	15
f. KFW	11.75	0.25	5	10	15
g. IBRD	12.8 *	0.75	3	12	15
h. Morgan Guarantee	Libor** + 1.25	--	5	7	12
i. European Export Credits	10.5	0.5	5	10	15
j. Japanese Export Credits	8	--	5	8	13
k. US Exim Bank	10.5	--	5	7	12
l. Commercial Co-financing	Libor** +1.25	0.5	5	5	10

Source: World Bank(1982)

* The interest rate for the IBRD loan will be the prevailing variable interest rate plus guarantee fee of 1.2 percentage points. For the purposes of financial projections, however, a constant rate of 11.6% interest plus 1.2% guarantee fee has been applied.

** About 15%.

Considering an average annual inflation rate of 4% per year for the relevant time period, the real rate of interest is approximately 6.8% per year, above the internal rate of return of the project. At the rate of 6.8%, which stands for the financial capital cost of the project, the net present value of the CIOP is negative under the two scenarios considered. CIOP on purely private financial grounds could be rejected at this stage.

3.4) Explaining the Divergence Between Projected and Actual Outcomes for CIOP's Financial Profitability

The divergence between projected and effective results is basically explained by the optimism at the time of the CIOP's appraisal, when the short recovery in the iron ore price in the period 1978-80 was taken as signalling a permanent recovery in the market. In fact, at that time, a more careful analysis would have disallowed that conclusion, because even with that short recovery, prices were still extremely depressed when compared to the price levels prevailing in the 1950s and the 1970s. (See Annex 3.3)

Certainly, the long-term downward trend in the iron ore price since the mid-1950s reflects structural characteristics in that market that couldn't have been overlooked by the Brazilian government, financing agencies, and CVRD. As was pointed out in section 3.2, the structural characteristics of this market that lead to declining prices are the generalized excess of supply, technical changes and the market structure which put sellers at a disadvantaged situation in face of the buyers' side. And, moreover, there is no reason to expect a reversal in the iron ore market that would revert favourably iron ore prices.

What matters is that the project's profitability has been substantially affected as a consequence of declining iron ore prices, and we expect that, as the declining tendency goes on, CIOP's profitability will still decrease further. As estimated in the previous section, the internal rate of return of CIOP at current prices is of the order of 4% and, using the projected iron ore price for the year 2000 undertaken by the World Bank, that rate becomes of the order of 2%. As the capital cost is of the order of 6%, as a minimum asssessment, CIOP is an inefficient project.

3.5) Other Services Provided By CIOP

As stated in Chapter 2, the iron ore project is associated with important regional benefits, some of those will have a monetary revenue for the company responsible for the project, CVRD. We need to investigate those benefits which will affect CIOP profitability in the longer run. In particular, all the projects listed in Section 2.4 will use the transportation network provided by CIOP and this will be an additional source of revenue for the company from the project. Unfortunately, as those projects have not been implemented and expected production targets from them are not available, it is not currently possible to estimate CIOP rates of return considering those transportation benefits.

However, it should be stressed that the transportation of products other than iron ore, especially pig iron and other metallurgical products, will become increasingly important in the future. For the moment, as actual production figures for the whole GCP area are still very low, the monetary value of transportation benefits is also likely to be low. This means that the CIOP's 'ex- post' rate of return inclusive of these benefits is unlikely to diverge much from the one estimated in Section 3.3. Some actual physical data on transported passengers and products are provided below.

The supply of passenger transportation provided by the Carajas railroad has resulted in an important benefit to the regional development of the GCA. CVRD points out that the railroad carried more than 210,000 passengers during its first nine months of service in 1986 and transported some 400,000 passengers during 1987 and 1988. Thus the railroad has greatly facilitated the mobility of the intraregional labour force in Eastern Amazonia, permitting a potentially more productive use of labour in the region, and raising revenue for CVRD.

Moreover, products other than the iron ore from Carajas have also used the transportation component of CIOP. According to CVRD, a broad range of products has been carried by the railway since its inauguration in 1985. Figures for these products in the period 1985-1988 include: diesel oil (320,000 tonnes), lumber (63,000 tonnes), cement (30,000 tonnes), beverages (28,000 tonnes), vehicles and machines (16,000 tonnes), soybeans (5,000 tonnes). In 1988, the transportation of pig iron started. In this year, 55,000 tonnes of pig iron were transported. In the future, the transportation of products other than the iron ore will become increasingly important. This is especially true for pig iron and other metallurgical products. Anyway, if data on the expected transportation revenue were available, CIOP's financial profitability would tend to increase.

3.6) A Joint Profitability Evaluation of the CIOP - Iron Smelting Complex

The extent to which minerals found in Amazonia should be processed before being exported has always been present in the GCP planners' minds. In other words: what should be the optimal degree of vertical integration of industries to be installed in the region so that as to maximize the foreign exchange gains? The answer to this lies in the comparison of domestic and international prices: it pays to further process a mineral resource if the domestic cost of that processing is below the international average, given that there are no demand constraints in the international market. In the attempt to provide some evidence on the profitability of the pig iron industry compared to CIOP's profitability, an evaluation of the financial profitability of a typical pig iron smelter industry is provided in this Section. The estimation of this profitability is important because CIOP's financial profitability has been shown to be low. An alternative to increase it would be to further process the iron ore made available by the project.

Data from thirteen pig iron industries show that, on average, the capital cost estimate per tonne of pig iron is on the order of US$ 110 in 1987 prices (PGC obtained from CVRD). This sample of firms has a total pig iron production of 1,456,000 tonnes and total investment costs of US$ 159 million. As there are important technical differences between firms, the adoption of an average capital cost estimate is a simplified way to deal with the problem. Roughly, the cost breakdown of a tonne of pig iron is as shown below (PGC obtained from CVRD):

Iron ore- US$ 20	Charcoal- US$ 35
Labour cost- US$ 5	Electrical Energy- US$ 5
Transport- US$ 7	Expenditure Associated with Sales- US$ 3
Depreciation- US$ 1	TOTAL- US$ 76

The international price of pig iron per tonne has been around US$135 in 1987-1990, which, excluding capital costs, results in an average profit level on the order of US$ 59 per tonne produced, or a profit rate of 44%. Introducing capital costs and assuming that the project lifetime is twenty four years and assuming constant returns to scale, the financial internal rate of return of a typical pig iron project would show a value of 54% per year. Anderson (1989), on the other hand, has estimated how the pig iron costs of production would be affected if the responsible companies were to obtain charcoal from afforested areas. As one tonne of charcoal from afforested areas costs about US$ 83, this would mean that the charcoal cost component would increase to US$ 66 per tonne of pig iron. [20] In this case, the unitary profit level from the pig iron activity would decrease to US$ 28. With the same price and investment lifetime assumptions, the financial rate of return would decrease to 25 % a year. Still, the pig iron industry shows a very high financial rate of return even if all consumed charcoal comes from afforested areas

Bearing in mind that the CIOP financial rate of return is of the order of 3.5% a year, it becomes evident that one possibility for CVRD to increase the financial rate of return from its operations would be to further process its iron ore produced. Assuming no demand constraints for the pig iron in the international market, CVRD with additional investments on the order of US$ 110 per tonne of pig iron produced, could substantially increase its net benefits. If all CIOP's output was to be transformed into pig iron, the financial rate of return of the joint activity iron ore- pig iron would show a financial rate of return of 9.4%

[20] For this, it is assumed that one tonne of pig iron needs 0.8 tonnes of charcoal

a year.[21] The cost benefit stream of the joint iron ore -pig iron project is shown in Annex 3.6. When internalizing the costs of deforestation induced by the complex iron ore-pig iron, which is to be done in Chapter 9, this joint pig iron- iron ore cost benefit stream will be used. This seems a sensible way to internalize environmental effects indirectly produced by CIOP without penalizing the project, as long as the benefits of the pig iron industry are being considered.

---

[21] The assumptions to obtain this estimate are that: 30 million tonnes of iron ore result in 17 million tonnes of pig iron, the investments associated with the pig iron industry are concentrated in the first year, the price will remain stable at US$ 135 per tonne and that all charcoal used comes from native forest. Moreover, CIOP capital costs remain as they were in the absence of the pig iron industry.

CHAPTER 4- ECONOMIC ANALYSIS I

4.1) Economic x Financial Analysis- Private and Social Profitability

The concept of profitability is closely linked to that of economic rationality. According to it, a determined course of action is judged acceptable if benefits outweigh costs. This is so in a context of economic scarcity: there are more possible uses of resources than their availability. Both economic and financial analyses seek to evaluate the profit arising from alternative investments. They differ, however, to the definition of what are considered to be benefits and costs and, for this, we necessarily need to introduce the perspective from which the evaluation is being undertaken.

A financial analysis is basically concerned with the money profit arising from investments. Benefits are those associated with the revenue generation, and as a collorary, they are limited to those for which there are markets where they have a monetary expression. Costs are identified as the necessary monetary outflows to generate revenues. In the context of project planning and appraisal, costs are mainly linked to investment costs of the production process in question. The profitability of projects in a financial analysis measures the extent to which the costs of a project will generate enough revenues to justify its undertaking. Market prices are suitable for use as parameters in a financial analysis.[22]

An economic analysis introduces the society's perspective in the activity of assessing projects' profitability. Benefits and costs are classified as such insofar as they bring something desirable for society and involves a sacrifice to society, respectively. Along this perspective,

---

22 See UNIDO(1972), Little and Mirrlees(1974), Mishan(1975), Squire and Van der Tak(1975), Dasgupta and Pearce (1978), Pearce(1983).

benefits and costs are not necessarily associated with money flows. A good example to illustrate the nature of economic costs is an environmentally damaging project that should include as one of its costs the extent to which society is loosing as a consequence of the harm arising from the undertaking of the project. Social profitability is the proper concept to assess the desirability of projects.

The reasons why financial and economic analyses differ are several.[23] As a first approximation, we can say that the recognition that we don't live in a perfectly competitive world which can be framed as a general equilibrium model answers partially the question on why there is such divergence between social and economic profitability analyses. The presence of externalities, defined as the effects of a project that work outside the market, have to be considered in a social analysis. Income distributional considerations have to be taken into account in a social analysis: benefits of a project accruing to poor and rich people have to be valued differently by society. Moreover, market prices are not good indicators of consumers' satisfaction: we have to consider the excess of what consumers are willing to pay for the product of a project over what they actually pay. Furthermore, the literature has pointed out a number of specificities in developing countries' economies that deepen further the divergence between social and economic analysis: inflation, currency overvaluation, underemployment, imperfect capital markets, large projects, distorting trade policies, deficiency of savings and government income, unequal distribution of income and wealth, external effects.

---

[23] See, for instace, UNIDO(1972), pp 18-33; Little and Mirrlees(1974), pp18-38; Mishan (1975), pp13-16; Squire and Van der Tak(1975), pp 15-25;Dasgupta and Pearce(1978) pp118-135; Pearce(1983).

The activity of identifying benefits and costs of a project is far from being a trivial one. In fact, it can be said that it involves at least two stages. In a first instance, it is necessary that society has an idea where it wants to reach with development plans. Society has to have an end and to know how to reach social objectives with the tool of project planning and appraisal. The growth objective in itself is not enough: it is just the means by which social welfare can be improved. The different uses of resources put to investment in infrastructure, industry, agriculture, education, health and so on should be made in light of social objectives as the poverty removal, the reduction of income inequalities, just to cite some. In light of a specific set of social goals, benefits and costs of projects can be identified and classified as such. This is a more general way to understand benefits and costs of a project. In the literature, it has been stressed the redistribution objective[24], the employment goal[25], besides, certainly, the growth objective.

A good starting point to understand the nature of benefits and costs of a project is to say that " whatever the nature of a project, its implementation will always reduce the supply of inputs ("consumed by the project") and increase the supply of outputs ("produced by the project")" (Squire and Van der Tak,1975). The analysis of the supplies of inputs and outputs available to the economy with and without the project is the basic method of identifying its costs and benefits. The way to reconcile this more traditional definition of benefits and costs with the more general way introducing social objectives is to interpret inputs and outputs of an economy in a broad framework. Inputs to an economy include not only the material resources but also the state of

---

[24] See, for instance, UNIDO(1972), pp75-84, Little and Mirrlees(1974), pp 52-60.
[25]See, for instance, UNIDO(1972), pp85-98 and Little and Mirlees(1974), pp 60-62.

macroeconomic variables that measure the well being of a society's citizens.

Although it may be difficult, for intance, to establish the bridge between the project level and the impact on key macroeconomic variables, such as, for instance, the income distribution, this theoretical formulation is suitable to the definition of benefits and costs as was done. Certainly,the improvement of the relationship between the impacts of specific projects on economic variables that reflect the society's objectives would be a major step to improve investment decisions. Anyway, there are a number of common features in the economic analysis of projects that have been applied at a practical level.

It is common practice to use the projected financial statement as a starting point for identifying costs and benefits.[26] Two types of adjustment are necessary: it is necessary to include certain benefits and costs that are omitted, in general, in a financial analysis as well as a revaluation of market prices to shadow prices is required (this last aspect will be treated in Chapter 5).

Some payments that appear in the cost stream of a financial analysis such as taxes, subsidies, depreciation allowances, interest and amortization of loans in principle should be excluded as real economic costs because they just represent transfer of resources' control in a society. Investment costs less the present value of its residual value fully reflects the economic cost to society of putting resources to a specific project. By the same reasoning, contingency allowances should be included as economic costs of the project because they represent expected costs. Sunk costs shouldn't be included.

---

[26]See Squire and Van der Tak(1975) for a very practical emphasis on the theme.

It is within the theme of externalities and linkages that lies one of the most interesting aspects of the economic analysis of projects. Effects of a project that confer a benefit or cost outside the limits of the project itself, these effects being known as externalities, should be included in an economic appraisal in light of the country's social objectives. External benefits should be included in a way that increases the social profitability measure while external costs should be included so as to reduce the social profitability measure being utilized. Although difficult to identify and, worse still, to measure, externalities, either positive or negative, should be recorded as such according to the social objectives. In case economic theory hasn't been able to provide a method whereby certain externalities are measured, at least the project analyst should provide a range of possible values for the extent to which the social profitability of a project should be increased or decreased as a consequence of the presence of externalities.

Linkage effects among industries in the context of project appraisal have been restricted to price effects. The project may lead to higher prices for the inputs it requires or lower prices for the outputs that it produces. Forward linkage effects may occur in industries that use or process a project's output through lower prices and backward linkages for industries that supply its inputs, through higher prices. Through complementary effects between products and through increased competition, other producers or consumers may lose or gain as a result of the project insofar as it affects the structure of demands and supplies in an economy. Certainly linkage effects are not restricted to price effects: effects may be stronger than that. This is the case of projects that are fundamental to a kind of development process in an unexplored region. In this case, the project would have to have its forward and backward linkages evaluated in light of the desirability of the development pattern made possible by the project undertaking. Price effects, although existing, become of smaller importance compared to the development process itself being or not desirable.[27]

Externalities present difficulties in their identification and measurement. Attempts to identify and measure them should be made in an economic analysis that intends to be meaningful, in case they are relevant. It may be the case to internalize externalities by considering a package of closely related activities as one project, as Little and Mirrlees (1974) have suggested. This is also convenient in cases in which externalities play no role but in which it is difficult to estimate demand and hence the social value of the output from the project without closely linking it to related projects.

Multiplier effects arising from a project refers to its positive effects in case there is a situation of general excess capacity. Certainly these effects should be considered when assessing the desirability of projects. International effects refers to the effects of a project that extend beyond the borders of the country concerned. This may happen through price effects. It may also be the case of environmental consequences.

---

[27]see Hirschman (1958) concerning forward and backward linkages in the development process.

4.2) Cost Benefit Analysis

The need for cost benefit analysis (CBA) exists because, generally, there will a divergence between social and financial profits arising from projects, as was outlined in the previous section. CBA applied to the context of project appraisal and planning is a method by which benefits and costs can be compared in a consistent way with the objective of maximizing net social gains.

As Dasgupta and Pearce(1978,p.19) highlights: "Essentially, CBA purports to be a way of deciding what society prefers. Where only one option can be chosen from a series of options, CBA should inform the decision-maker as to which option is socially most preferred". Implicit to this judgement is that individual preferences should count. CBA is a way of recording the preferences of the society's individuals, either revealed directly through the market or revealed indirectly through other means, and of reducing all these preferences to a unique overall figure, which gives the net benefit to society. Two questions are raised in this context: whether or not individual preferences should always count and what role should CBA play in the decision making process. The answer to the first question is far from being an easy one: it depends on whether or not there are reasons to accept a "paternalistic" attitude of the government. The answer to the second question is neither an easy one. Whether CBA should be viewed as a guide to, or a substitute for essentially political decisions gives the clue to the second question. Judgement elements cannot be avoided at all in CBA exercises. As Dasgupta and Pearce (1978,p.21) point out: " The role which CBA plays in decision making will depend in part upon the extent to which its objective function coincides with that of the decision-making body".

A major shortcoming limiting the credibility of CBA is that it often happens that it is not possible to measure all the gains and losses and, other times, if they are measurable, there seems not to exist an unique way of measuring them. When we face the first situation, we have what is called the intangible aspects of projects, what will be further exploited in the next section. On the other hand, measured gains and losses in CBA may carry errors which may arise either from inadequate information, the nature of the data, uncertainty or from errors in the models used for "simulating" behaviour in non-market contexts.

It is unavoidable to have an objective function underlying any CBA exercise. The maximization of, may be, profits, income, or net social benefits, defined in a way so as to incorporate issues other than income. Policy objectives as income distribution, regional balance, balance of payments problems can be incorporated into the analysis as constraints when it is the case that they cannot be built up in the objective function[28].

Basically, CBA has relied on two methods by which project selection should be made. The first is the net present value : costs and benefits occuring in different periods are discounted to a base date and then they are compared. The other frequently used criterion to apply in project selection is to calculate the economic rate of return, which is that makes the stream of benefits equal to the stream of costs. Both methods should conduct to the same results and they raise the question of the proper discount rate to be applied, what will be dealt later on.

The net present value method leads to the rejection of projects with a negative value: if the discounted value of the benefits is less than the discounted value of the costs, the project should be rejected. Projects

---

[28]The reader interested in the theoretical foundations of CBA should consult Dasgupta and Pearce(1978) as a guide.

with a positive (or zero) net present value should not necessarily be accepted. In case of mutually exclusive projects, project acceptance involves comparing all the net present values of alternatives and selecting the one with the highest net present value. It is not possible to rank not mutually exclusive projects according to this criterion.

According to the method of the economic rate of return, a project is acceptable if its rate is greater than the discount rate considered acceptable. The rate of return , however, is defective as a measure of the relative merits of mutually exclusive projects; a higher rate of return does not necessarily indicates the superior alternative as measured by the size of the surplus when costs and benefits are discounted at the shadow rate of interest. When using the rate of return method, the critical point for accepting projects is the accounting rate of interest whereas, when using the net present value, is the zero value.

Both methods outlined above do not preclude the first stage of project selection: projects have to be selected according to the basic objectives of the country's economy. Once this is done, both methods just express the degree of the desirability of undertaking specific projects.

4.3) Intangible Impacts

In section 4.1, it was suggested that benefits and costs of a project have to be defined according to social objectives. Some of those benefits or costs do not have a market value because simply there is no market at all in which people can reveal their willingness to pay for the commodity in question. Because the property rights system, in general, has not evolved in the sense of creating markets for environmental resources, they are taken as free goods. In other cases, by the nature of the public good commodity, the market place is not suitable to assess the value to society of certain effects arising from projects.

As Dasgupta and Pearce (1978,p.112) exemplify, there is no market in changes in delinquency rates. Yet urban renewal programmes are justified frequently with respect to non-market effects: e.g. reductions in the level of street crime. In such cases where the market place is not suitable to evaluate the intangible effects of projects, the project analyst should try to understand the nature of those effects and, if possible, devise alternative frameworks in which an approximate value is provided to value intangible effects. If project appraisal and planning does not do it systematically, it is likely that society will be lacking certain services and commodities, because the process of selecting projects is biased to projects that produce marketable products. Moreover, any development plan requires, at least in the very beginning of its implementation, a kind of integrated planning through the conception of interlinked investments. A good example of this would be GCP. Understanding projects in an integrated framework can substantially modify their social profitability measures. When properly taken into account, intangible effects of projects may make projects either acceptable or not from a social point of view, compared to the alternative of analysing them on a single basis.

Little and Mirrlees (1974) have distinguished some stylized effects of projects that are classified as external economies related to outputs, external economies related to inputs, industrial and spatial complexes, external considerations affecting infrastructural projects.[29]

Projects often yield a net gain to society that is not wholly captured by those that acquire the project output. The training of labour force has been indicated as representing an external economy related to outputs: the new skills acquired by workers in a project will be used in other projects when workers move. Another example is in the construction of a steel project, where a system of access roads is included for transportation of the project's materials. The benefits provided by the roads should include the improvement in communications and lower transport costs for the whole area. There would be a host of other illustrative examples on the generation of outputs other than those produced by the project.

External economies related to inputs can be illustrated by the example of a project that requires as input deforestation for its operation. In theory, if a project receives some inputs for which it does not pay, this should be counted as a cost and the producer of the benefit should receive an equal recompense. Similarly, if there is a harm produced by third parties to the normal operation of the project, for instance by another's smoke, its costs should be reduced by an appropriate amount. Other type of example is the new demand for inputs created by a project. This can happen if the demand of the project for an input is either sufficient to result in the establishment of a socially

[29] See Little and Mirrlees(1974), pp 335-349. See also UNIDO(1972), pp 64-74 on the topic of external effects.

profitable project or sufficient to induce economies in the production of the input, when this is already produced domestically.

The case of industrial and spatial complexes is intended to deal with the frequent situation in which a set of plants may be socially profitable but, taken one by one, and without the local market provided by other plants, no constituent plant would be socially profitable. Petro-chemical complexes illustrate this situation well. Some of the gases in a petro-chemical complex are very expensive to transport and, so, they have to be produced locally so that to serve as inputs into other processes.

Infrastructure projects produce outputs that are either supplied free or at prices that do not reflect costs or benefits. Transport projects, hydroelectricity projects, ports and so on, are examples of projects that fall in this category. On the other hand, large projects involving great areas of land and natural resources may produce major damages to the environment, which are, in general, neglected at the stage of appraisal.

Another issue that has received attention in the literature (UNIDO,1972) is the treatment of savings and investment as an external effect of projects. If the Government judges the level of savings of the whole econmy as insufficient, project planning and appraisal can be used as a tool to increase the rate of savings and investment in the economy.[30] If a project is thought to have beneficial effects on the rate of savings and investment in an economy, then it is the case to treat this as a positive indirect effect. [31]

[30]This aquires meaning in a context where there are constraints in fiscal and monetary policies to achieve the optimal rate of savings and investment.

[31] Two ways of approaching this question have been advocated. The first is to link the consumption-investment effetc of the project to the technological nature of the goods and services used as inputs or produced as outputs. The alternative approach would link the consumption-investment effect of the project to the expenditure patterns of the groups who gain and lose by the project. See UNIDO(1972),pp 67-72.

Although difficult to quantify, the important intangible effects of projects should be envisaged and an attempt should be made to quantify them. Opponents and proponents of projects tend to treat external effects in an exaggerated way. To avoid this, the intangible impacts of projects should be given proper treatment and not to be used in an arbitrary way either to justify or to reject specific projects. (Little and Mirrlees, 1974)

Some procedures have been used in the attempt to measure intangible impacts. As Dasgupta and Pearce(1978) say, the "value of human life" could be thought as being valued through death or accident prevention schemes such as road barriers, lighting, speed limits and so on. This is not to be confused with the fact that the value of human life to dearest people is of infinite value in the sense that in a family, for instance, its members would be willing to spend what they could to save the life of any member. However, society is prepared to allocate a limited amount of resources to improve the safety of its citizens. It is in this sense that we can speak of a value of human life, that is, as a valuation of a statistical life. Another approach in the same line is to use the legal system to provide indicators through damages awarded to persons involved in accidents or to their dependents.

The attempt to find the relationship between single projects and physical units of noise, pollution, and so on in principle should provide a basis for evaluating certain "bads". Technically speaking, once a physical unit exists, it must also be possible to find the willingness of society to prevent additional units of "bads" produced by projects. In case this last step is not possible, but physical units are found to be related to a specific project, the analyst can still prescribe " best available" efficiency rules in terms of "maximizing physical benefits subject to a cost constraint" or "minimising costs for a desired level of physical benefits".

This is called " cost-effectiveness" analysis because of the absence of measures of explicit monetary measures of benefit.[32]

Moreover, other possible strategies to deal with the measurement of intangible effects include the use of questionnaires to induce people to reveal their preferences; rely on markets for similar goods outside the public sector, as for instance, education and health in private markets; using cost schemes as a proxy for the social value of certain services. Sensibility and creativity should be used in the activity of project appraisal and planning to avoid the great danger of ignoring substantial gains and losses clearly associated to specific projects simply because they seem to be of difficult evaluation. The two seminal project appraisal manuals (Little and Mirrlees, 1974, and UNIDO, 1972) have neglected the importance of incorporating the environmental impacts of projects in a practical way. However, recent theoretical contributions have arisen to deal with particular shortcomings in CBA. In the next section, it will be shown recent trends in CBA to include in an analysis the environmental care as a goal and as a constraint in the growth process.

[32]see Dasgupta and Pearce(1978),p.114.

4.4) Cost-Benefit Analysis and Environmental Considerations

CBA has evolved progressively to devise alternative frameworks to deal with the intangible impacts of projects. There has been concern with not only suggesting possible ways of thinking in specific problems but also proposing ways of operationalizing concepts so that CBA can effectively integrate economic analysis with social goals. This is true for the environmental impacts of projects as well as, for instance, the distributional effects of projects. The history of CBA, thus, should be an additional reason against the oppponents to this method who claim that the intangible impacts of projects are dominant in general.

The concept of " sustainable development" has arisen in part to incorporate the concern for the environment as a world social goal.[33] It symbolyses the worlwide concern that economic growth is not enough. Natural resources all over the world have been depleted as a consequence of unsuitable ways of managing them in the growth process. The Brundtland Report states that : " If needs are to be met on a sustainable basis the Earth's natural resource base must be conserved and enhanced " (World Commission on Environment and Development, 1987, p.57). Efforts have been done to better define and to operationalize the " sustainable development" concept so that to integrate it into CBA.[34]

Defining " sustainable development" can be represented by a vector, D, of desirable social objectives, which may include as components increases in real income per capita, improvements in health

---

[33] See World Commission of Environment and Development(1987), Repetto(1986), Redclift(1987), Turner(1988), Pearce, Barbier and Markandya(1988), (1990).
[34]See Pearce, Barbier and Markandya(1990)

and nutritional status, access to resources, a fairer distribution of income, increases in basic freedoms. Sustainable development is better interpreted by stating that dD/dt is generally positive over some selected time horizon. With this general definition,the components of the vector D may vary according to the meaning given to development, and it is required that the same components are monotonically increasing over time. It should be noted that the time horizon under this definition is still an open issue and ethical considerations to reflect how far into the future society is concerned with have to be introduced in the problem. (Pearce, Markandya and Barbier,1990).

Basically what is sought and required is that the natural capital stock should not decrease over time. Natural capital stock is that which includes all environmental and natural resource assets.

Sustainability can be introduced in CBA by setting a constraint on the depletion and degradation of the stock of natural capital. This means that projects whose benefits exceed costs should only be accepted if the environmental damage produced is zero or negative. Basically, what is sought is to introduce environmental costs in the analysis in an explicit way. At the level of specific projects such a requirement would make very few projects feasible. However, at the programme level, that condition has to be interpreted in the following way: across a set of projects, the sum of individual damages should be zero or negative. That is, if E_i is the value of the environmental damage done by the i^{th} project, it is required that (abstracting now from temporal considerations) $\Sigma E_i < o$.

Under what is called weak sustainability, the net present value of E_i is constrained to be nonpositive. Under strong sustainability, each E_i is constrained to be non-positive for each period of time. This is achieved in a programme by including shadow projects so that to compensate for the environmentally damaging projects.

The environmentally compensating projects, j, would be chosen such that:

Σ PV(A) j> Σ PV(E_i) (weak sustainability criterion)

and

$\Sigma A_{jt} > \Sigma E_{it}$ for all t (strong sustainability criterion)

where the j^{th} project is designed to compensate for the damage done by the other projects. CBA normal procedures do not apply to these projects. We could only want to minimise the cost of achieving the sustainability criterion.

One alternative approach to the method of introducing environmentally compensating projects is to adjust the discount rate. It should be lowered for environmentally beneficial projects relative to those that generate environmental damage. This process can be shown to produce similar results to those suggested above. Basically, a risk premium would have to be calculated for damaging projects (or a discount for beneficial projects), what may turn out to generate impossible informational demands. Another common suggestion that has been made to deal with the problem is to lower the discount rate so that future environmental costs are made higher. However, the net effect of this procedure on the natural capital stock is not clear because a lower discount rate encourage a larger total of investments and this will result in that more energy, inputs and hence more waste will have to be absorbed by the system. The compensating project approach is a possible way of practically modifying CBA to incorporate environmental effects in project appraisal and planning, although this may be difficult.

4.5) Social Incidence of Costs and Benefits

Underlying CBA is the assumption that people themselves are the best judges of their own welfare: their preferences are reflected in their willingness to pay for improvements or willingness to accept compensation. Although this view can be somewhat modified to give the government to decide what is desirable or not, still that basis is most common in conventional CBA as a theoretical underpinning as well as a practice. Anyway, both the willingness to pay and to accept compensation are measures that reflect the prevailing income distribution in a society. This recognition has resulted in new ways of dealing with income distribution issues in the specific context of CBA.

To ignore the distributional issue completely has often been the rule, although the theoretical basis for doing so are poor. This view relies on the desirability of using macroeconomic policies to promote the necessary adjustments in the income distribution of a certain society, leaving project appraisal and planning to be done solely on the efficiency basis.

The introduction of distributional weight to benefits and costs has been the answer given by CBA to the concern that income distributional considerations should enter the analysis. According to it, gains and losses arising from a project are to be weighted depending on the income-groups to which gainers and loosers belong to. The distributional weights could be derived, for instance, from a social welfare function in which the marginal income of consumption of different individuals can be compared. Distributional weights could be used to illustrate switching values which are the the income distribution weights that makes the decision switch from accept to reject according to some decision criteria.

Among the proponents of the approach to introduce distributional weights are UNIDO(1972), Little and Mirrlees(1974), Helmes(1979), Pearce and Nash(1981), Squire and Van der Tak(1975), among others.[35] In practice, such approaches are rarely used because of data difficulties and the lack of objectivity in the choice of weights.

On the other hand, there has been an alternative approach to the question that prescribes that the economic analysis of projects should be done on efficiency grounds rather than on equity considerations. According to it, CBA should not introduce distributional weights because it has been argued that there exists no objective way of weighting one group against another. The main representatives of this thinking have been Harberger (1971), Gittinger (1982) and Mishan(1982). Here it is argued that possibly the project analyst could present the distribution of costs and benefits among income groups but not to introduce distributional weights as a means to promote income redistributions.

There are good arguments for the inclusion of income distribution as a concern in CBA. The position to simply ignore the issue is not tenable in the light of the modern definition of development itself: one variable that should measure the degree of development in society is the income distribution. The alternative approach of not introducing distributional weights but possibly presenting its distribution in a CBA can neither be accepted insofar as, to do it, is consistent with weighting individuals equally. There is no escape from value judgements in this view. In principle, the idea of distributional weights should be viewed as a very positive contribution to make CBA an instrument to improve the income distribution in a society.

---

[35]See Ray(1984) for a good mathematical treatment about the introduction of distributional weights in CBA. Squire and Van der Tak(1975) is also a good reference for the mathematical treatment of the question

Certainly, there are serious practical problems in the implementation of distributional weights. It is very difficult to identify the differential impact of gains and losses across income-groups. This can usually be done only in very broad terms. Another point is that it is unlikely that decision-makers would implicitly announce weights to be given to various income-groups or regions, and to be used consistently for making project decisions. However, this should not prevent the project analyst from illustrating the use of such weights. The use of switching values is highly desirable in this context.

4.6) The Need of a Regional Approach For Dealing With Large Scale Projects in Fragile Ecosystems

Large scale projects such as CIOP, penetration roads, transportation projects, hydro-dams, among others, have important indirect effects that should not be overlooked in any appraisal framework. In fact, a whole pattern of land use and economic development may follow as a result of the project in question. This does not mean at all a rejection of the CBA framework in its basic principles but rather the recognition that CBA as a tool has to be modified, if this is to help decision making. Benefits and costs of such projects have to be defined in a broad spatial way so that the impacts of such projects are evaluated in terms of their effects on the larger area of influence. General equilibrium models may have to be used if they are available.[36] Ideally, we should model the regional economy with and without the large project in question to define what are the benefits and costs induced by the project over its larger area of influence.[37] The problem is that rarely they are available for a specific region of a determined project and, moreover, it is virtually impossible to model the environmental effects of projects in the framework of a general equilibrium model, given the non linear nature of these. However, practical problems of this nature should not be a reason enough to neglect important benefits and costs associated with a project in its larger area of influence. On the other hand, research can contribute

---

[36] See Markandya and Richardson (1990) for a discussion of the use of general equilibrium models to assess large investments.

[37] The net welfare change from the introduction of such project would be the ideal measure of its net benefits.

towards this end, either through new concepts and/or methodologies to assess costs and benefits of a project in a regional perspective.

Anyway, the need to take a regional approach in such cases means that benefits and costs of projects, in particular environmental effects, have to be assessed in a spatial unit that is the region where the project will impact in some way.[38] Pearce and Markandya (1989), motivated by the question of how natural resource degradation in developing countries is linked to the development process in these countries, rely on the concept of marginal opportunity cost (MOC) to measure the true cost of an action or policy that has negative environmental impacts. Accordingly, MOC has three important dimensions: a) the complex nature of externalities, given the multiple interactions economy-ecosystem; b) externalities have to be considered in a broad spatial unit, since their effects may extend over wide geographic areas; c) externalities have a temporal nature insofar as resource degradation now precludes future resource use. Item (b) is especially relevant for assessing CIOP effects, since the project is recognized to have wide geograghical effects, mainly through the railway component. Morever, it should be stressed that MOC is relevant to either benefits or costs, and it could be extended to varied natures other than environmental effects.

The idea that a system shock can produce cumulative impacts in locations distant from a project's place is quite useful if we are to take a regional approach. As a first requirement, the linkages between economy and ecology have to be understood in the specific region where the project is to be located. For instance, "loss of tree cover increases soil erosion, erosion adds to watercourse contamination, which reduces electricity output and raises flood plains, and so on" (Pearce and

[38] See Pearce and Markandya (1989).

Markandya, 1989, p. 43). Applied to our case, CIOP could be thought as a system shock that will impact on the physical and social environments in many ways. CIOP through its transportation components will allow mineral and metallurgical products to be produced and transported; settlers from other parts of Brazil will use the railway component to reach the region and to settle there; a pattern of development in the cities crossed by the railway is made possible because of transportation facilities made available by the project and so on.

As a lesson, large scale infrastructure projects, especially those that open up or significantly contribute to the increased settlement of new areas, need to be analysed in terms of their potential environmental impacts in both their immediate and larger areas areas of influence. Additionaly, this broader analysis should not be restricted to physical environmental effects but also those larger impacts on social processes taking place in the region have to be considered. Finally, longer run effects of potential projects on migration, population growth, induced expansion of productive activities, together with the likely repercussions of these tendencies on the natural resource base of the region should be considered in any cost benefit analysis extended to environmental and social effects.

At a practical level, such a regional approach requires the identification of the likely area of influence of a project, then the surveying and analysis of the principal physical, demographic, social and institutional characteristics prevailing there. Of particular importance is how other development initiatives already installed in the area of influence of a project will interact affecting the main regional characteristics. Although generally it will be impossible to separate out the effects of single projects on those variables, at least an effort should be made to understand how the dynamics of a region evolves as new developments are taking place.

The iron ore project needs such a regional approach in its evaluation. Not only this is a large scale project with a transportation component that will allow a pattern of growth in the GCP area, but also CIOP is located in a territorially large and sensitive area in environmental and social terms. Certainly that this task is made difficult because not only of data problems but also because of the complex nature of the linkages between economic activities and ecology. However, difficulties of this nature should not prevent us recognizing that the relevant framework to identify CIOP benefits and costs is a regional one, extended to the social and environmental components. Once these benefits and costs are identified in a regional approach, CBA can play an important role both in the measurement and in the weighting up of costs and benefits.

CHAPTER 5- ECONOMIC ANALYSIS II: ACCOUNTING PRICES

5.1) Estimating Accounting Prices

Shadow prices[39] are intended to provide a set of values of goods and services in an economy, so that they are representative of their economic scarcity. Moreover, they are intended to be compatible with government's objectives in development plans. Market prices are not necessarily suitable for the activity of project appraisal and planning because of distortions and, on the other hand, due to the fact that the operation of free markets won't necessarily lead to the social and development objectives being aimed by government.

Market prices can be an unreliable indicator of the true economic cost of commodities because of taxes and subsidies. Also, some markets, especially in developing countries, can operate in an imperfect way so that the resulting market prices do not reflect the opportunity cost of goods and services.[40]Typical examples of imperfect markets are those of labour and foreign exchange. In the former, wage legislation, for instance, may introduce a divergence between market and shadow wages. In the latter, government controls of many kinds distort foreign exchange markets. Furthermore, some resources have to be valued even without the existence of markets. This last is particularly true in what concerns environmental resources.

---

[39]The term accounting prices can be used alternatively to shadow prices. Here, both terms will be used with the same meaning.
[40] See UNIDO(1972).

Also, the term shadow or accounting price refers to the activity of the estimation of a value for goods and services reflecting social objectives in mind, such as maximizing economic growth, improving the balance of payments, promoting employment opportunities, improving the income distribution, among other possible government targets. If, for instance, government sets to increase the rate of investment in the economy, because it wants to increase future consumption at the cost of decreased present consumption, then savings and consumption generated by a project are to be valued differently so that to be consistent with that government objective.[41]

Shadow prices are further classified as efficiency and social prices. When shadow prices are intended to correct only for distortions in market prices, they are called efficiency prices. Social prices refer to shadow prices which embody development objectives. Anyway, shadow or accounting prices stand for prices corrected either form distortions in markets and/ or from development goals.

Shadow prices may be divided in two classes, specific commodities or national parameters, when it seems useful to do so.[42] National parameters are to be used uniformly across all projects being apppraised in an economy, and reflects the development objectives being sought by the society at a certain point of time. This set of shadow prices provides project evaluators guidelines by which macroeconomic objectives are to be taken into account when assessing the social profitability of projects. Unskilled labour, foreign exchange are examples of these types of shadow prices. Also, national parameters could be a set of weights representing how the different government's goals are to be valued and compared with each other and put into practice.

---

[41]See Little and Mirrlees(1974), pp 44-45.

[42] See UNIDO (1972),p13

Although we won't be commited to dividing shadow prices in the above way, because the classification depends on data availability[43], we find that we gain an insight about project appraisal and planning with this division. This is so because we are reminded that there is always a social and political background that has to be respected in the activity of project appraisal and planning. Projects which are considered to be socially profitable in one policy context can be found not to be so in another one. So, to state that projects are socially profitable or not depends a great deal on what is being sought by the government at a certain point of time. This is compatible with the activity of project appraisal and planning done on a continous basis. So it is important to retain the idea underlying the division between national parameters and specific commodities so that to introduce explicitly the question of social goals being aimed at by a society in our empirical case.

5.1.1)The Methodology of Accounting Prices:

The system of accounting price estimation that has been widely used in empirical studies is that based on the work of Little and Mirrlees (1974), and further developed by Squire and Van der Tak (1975). The reasons why such a system has been so widely applied in practice stem from the plausibility of its assumptions and from the facility of operationalizing it, as we shall see later on. [44]

---

[43] For instance, the case of labour, which is considered generally a national parameter. If there is data on the impact of the project being analysed on the labour demanded, then labour can become a specific commodity.

[44] See, for instance, Schohl(1979); Powers(1981).

The system adopts as numeraire uncommited social income[45] measured in terms of convertible foreign exchange in the hands of government, compared to the more traditional procedure of using consumption as numeraire.[46] As it is very complicated to assess the impact of a project on the direct and indirect consumption, the use of public income as numeraire is a step further in the sense of making the method easily applicable.

Another cornerstone assumption of the method is that international trade opens real opportunities to a country. The patterns of production and trade of a country should be designed taking into account that goods may be imported, exported or domestically produced. So, the method of shadow price estimation is heavily affected by this assumption.

Goods and services have to be classified according to whether they are traded or nontraded. Traded goods are those for which increases in demand will be satisfied either from increases in imports or a reduction in exports, or a combination of both, leaving domestic production and consumption unaffected. Nontraded commodities are so classified because increases in their demand and supply will produce no impact on imports and exports. The most general case, however, is the case of partially traded goods, for which changes in their demand and supply will have impacts on imports, exports, production and consumption. As it is extremely complicated to trace out the effects of changes in the demand and supply on those four use categories of goods-exports, imports, consumption, production-, it is a useful simplification to treat goods as traded and nontraded in the estimation of accounting prices.

[45]The social income of a project in a particular point of time is its net output: the value of the increase in supply less the value of the increase in the inputs demanded by it.

[46]See UNIDO(1972)

Moreover, as we shall see, the method requires that nontraded goods are classified into their their tradable components as far as possible.

5.1.2) Accounting Prices for Traded Goods

Compatible with the assumption that international trade provides real opportunities for a country, one basic principle for the estimation activity is that the accounting price for traded goods is the border price[47]. The set of border prices represent the terms at which a country can trade.

The estimation of the correct accounting price depends on three factors: the good being exported or imported, the amount traded affecting or not the border price, the point of comercialization used as the reference price level.[48]

The accounting price at the purchaser's level of an imported good whose quantity being transacted does not affect the border price is its CIF cost plus the expenses for transport and handling to deliver it to the final destination.[49]Although import tariffs represent a cost to the buyer, they are not included in the calculation of accounting prices because from the social point of view they are merely a transfer of resources from buyers to the public sector.

The accounting price of an exported commodity at the purchaser's level is its FOB value less transport and handling costs incurred from the point of manufacture to the point of export. In case the amount being

---

[47]In the case that the border price varies substantially with the amount either imported or exported, then the marginal import cost and the marginal export revenue should be considered instead.

[48]See Powers(1981) for a comprehensive explanation on the estimation of shadow prices.

[49]These later costs have to be converted to their accounting prices, since they are usually expressed in domestic prices.

traded affects the price, we have to consider the marginal export revenue.[50]

5.1.3) Accounting Prices for Nontraded Goods

Nontraded goods cover not only those commodities which by their nature are considered as such[51] but also those goods which cannot be traded because of a restrictive trade policy.

There are two main cases for estimating the accounting price of a nontraded good. When it is reasonable to assume that increases in the demand will be met by an increase in the supply, the accounting price of such a good will be its cost of supply with all inputs being valued at shadow prices. When the supply is fixed , the use of the good in question by the project will produce decreased consumption elsewhere in the economy. In this case, the accounting price will be the value of the decreased consumption valued at shadow prices.

The marginal supply cost method for nontraded goods requires that inputs be classified as traded and nontraded. Traded inputs are shadow priced at the border price. Nontraded inputs are further broken down into tradable and nontradable. Tradable inputs are again valued at their accounting prices while the remaining nontradable inputs are converted to accounting prices by the appropriate conversion factors, which are a weighted average of several accounting prices. This last definition is made more precise later on.

---

[50] In the case of an exported good diverted to the domestic market we have to consider not only the costs saved and revenue foregone by not exporting the good but also the transport and handling costs spent in using the good in question in the domestic economy.

[51] That is when their domestic price lies above the FOB and below the CIF cost. Electricity generation, civil construction and so on are good examples in general of this definition.

For nontraded goods in fixed supply, the accounting price is the value of the foregone consumption. Market prices can be taken as an indicator for this calculation, when markets are expected to work reasonably well.

When it becomes very difficult to proceed along the lines described above, it is useful to adopt the conversion factor approach to convert nontraded inputs into their accounting prices. Basically, conversion factors are estimated for a typical production process that can be applied to a variety of situations.[52] Good examples would be the generation of electrical energy, trade and transport margins, construction and civil engineering. Moreover, average conversion factors can also be used to convert minor inputs or outputs into their corresponding accounting prices. These average conversion factors are intended to be an estimate of the extent to which domestic prices diverge from border prices in a multiplicity of different situations. Common examples of this are the standard conversion factor, the consumption conversion factor, the investment conversion factor. To estimate these conversion factors, we can employ either a weighted average of the goods composing the typical basket[53] or to use an aggregated approach using trade balance data.[54]

---

[52]See Little and Mirlees(1974), pp 211-219
[53]See Little and Mirlees(1974) pp 217-219.
[54]See Squire and Van der Tak(1975)

5.1.4) Accounting Price for Labour

The accounting price of labour involves two factors: what is given up elsewhere in the economy when a worker is hired by a project and the change in effort required, if there is any. As the labour market behaves very differently in what concerns skilled and unskilled labour, the analysis and estimation for these two types of labour has to be done separately.

The use of labour in a project prevents its use elsewhere.The foregone output of this labour is the first component of the economic cost of labour. The second component of the economic cost of labour is the change in effort required in the new job, if there is any. Both have to be valued at the respective accounting prices.

The economic cost of labour (APl) can be expressed by:

$APl = \Sigma a_i m_i APR_i + sCCF$ (5.a)

where

a_i- the proportion of time labour is engaged in activity i

$m_i APR_i$ - economic value of the i^{th} activity in accounting prices

CCF- consumption conversion factor

sCCF- economic value of disutility of effort measured in accounting prices

If it is assumed that the market for skilled labour operates well enough so that the market wage can be taken to represent its opportunity cost, and if it is further assumed that the change in effort involved is negligible, then the correct expression for the accounting price for skilled labour (APsl) is given by:

$APsl = Wsl \Sigma a_i\ APR_i$ (5.b)

where Wsl - market wage

$\Sigma a_i APR_i$ -weighted average of sectoral accounting prices for activities that demand skilled labour

To understand the economic cost of unskilled labour in developing countries, it is a common assumption that there is the coexistence of a formal and organized sector and a informal one. In the first, labour unions and government wage legislation control salaries and employment conditions, making prevailing wages above market conditions. Bearing in mind this aspect, it is useful to distinguish between rural unskilled labour and urban unskilled labour.

When a project in the rural sector demands labour, labour's accounting price is measured by how the additional demand for workers affects agricultural production and employment. During peak seasons, if unemployment is negligible, the accounting price of labour can be taken as approximately the foreign exchange equivalent of the market wage. The economic cost of labour in the off peak months depends on alternative employment opportunities available to workers. The reservation wage measured in foreign exchange is appropriate when there are no alternative productive alternatives available to workers. Usually, the economic cost exceeds this value because workers turn to subsistence activities.

The economic cost of urban unskilled labour (APul) has to take into account other factors as migration patterns. As there is an increase in the opportunities for the unskilled workers in the urban sector, there will be a migration from the rural to the urban sector because of the wage gap. The intensity of the migration will be such that the expected earning in the rural and urban sectors are equalized. We have that:

$$APul = \Sigma c_i a_i m_i APR_i + sCCF \qquad (5.c)$$

where c_i- migration multiple per urban job created

$\Sigma a_i m_i APR_i$ - foregone output per migrating worker sCCF- economic value of disutility of effort with the change of job

5.2) Accounting Price Ratios for Brazil

5.2.1) Estimates of Shadow Prices for the Brazilian Economy

There are two basic approaches to estimating shadow prices for commodities. The first may be called the "Trade Data Approach"(TD) and the second is the "Input-Output Approach"(IO) [55]

The TD approach uses as weights for the rates of import duties and export taxes or subsidies statistics from the trade balance. So long as nontraded sectors are not taken into account in this estimation, values obtained will be affected by this simplification. In the IO approach, this shortcoming is avoided because the interdependencies between traded and nontraded production are taken into account.[56]

In fact, the TD approach is a first step to the IO approach, which consists of calculating the shadow prices for all traded sectors using data on import duties and export taxes. A next step of the IO approach is to estimate shadow prices for primary inputs which have to be fed into the system to estimate the shadow prices of nontraded commodities. An iterative technique has to be used.

Estimates of shadow prices for the Brazilian economy are presented in Annex 5.1 [57] and were estimated using the most recent IO table published.[58] National accounting estimates were calculated for 23 sectors of the Brazilian IO table as well as 211 products belonging to these sectors, thus allowing the obtention of fairly disaggregated estimates (see Annexes 5.1 and 5.2). A brief description of the methodology used follows.

---

[55]See Schohl(1979)
[56]A very didactical presentation on the IO approach is given in Powers(1981).
[57]See Seroa da Mota(1988)
[58]IBGE,1987.

Shadow price ratios, defined as the ratio of border or shadow price to domestic price, were estimated at two reference price levels: consumer's and producer's price. The shadow price ratio (SP_i) of traded products group i would be:

$$SP_i = Pw_i/Pd_i \qquad (5.d)$$

where

Pw_i is the border price of commodity i

Pd_i is the domestic price of commodity i

Based on previous estimates on the implicit nominal tariff (INP)[59] for the sectors and products constituting the Brazilian IO table, and assuming that transport and distribution margins are negligible, it was calculated SP_i as:

$$SP_i = 1/1 + INP_i \qquad (5.e)$$

where INPi is the implicit nominal tariff for commodity i[60]

Those estimates become the starting point for the calculation of traded goods accounting prices ratios.

As Seroa da Mota (1988) argues, the assumption that transport costs are negligible for such a large country as Brazil is not reasonable. This observation motivated the author to redefine SP_i considering trade and distribution margins at two levels:1) $SP1_i$-at the producer's reference price level; 2) $SP2_i$-at the consumer's reference price level.

As CIF and FOB prices are used as starting point in the calculation, some corrections have to be made to take into account transport and distribution margins. At the producer's price level, a correction has to be

---

[59]See Braga et al.(1987)

[60] Imports control in Brazil is done mainly by non-tariff barriers.So, to obtain the INPi the author made a direct comparison between domestic and international prices.

made for exported products.[61] From the FOB price, we have to subtract the transport and distribution margins, both measured at accounting prices. Imported products when valued at CIF prices are already in their shadow prices and so there is no need for correcting the shadow price of imported goods.Thus, we have:

For imported goods :

$$SP1_i = SP_i \qquad (5.f)$$

For exported goods:

$$SP1_i = SP_i(1 - Tx_i Cft - Cx_i CFc) \qquad (5.g)$$

where Tx_i-transport margin to export product i

CFt-conversion factor for transport

Cx_i-trade margin to export product i

CFc-conversion factor for trade costs

At the purchaser's reference price level, the shadow price has to take into account the transport, trade and indirect taxes associated to deliver commodities to consumers (both FOB and CIF prices).That is, we have:

For exported goods

$$SP2_i = SP1_i(1 + Td_i CFt + Cd_i CFc)/(1 + Td_i + Cd_i + Id_i) \qquad (5.h)$$

For imported goods

$$SP2_i = SP1_i(1 + Td_i CF_i + Cd_i CFc)/(1 + Td_i + Cd_i + Id_i) \qquad (5.i)$$

---

[61] With trade balance data, it was estimated the ratio between exports and imports made by a sector. Ratios greater than one led to the classification of an exported product while less than one led to the result of an imported product.

where Td_i-transport costs to domestic consumers to deliver product i

Cd_i-trade costs to domestic consumers of product i

Id_i-net indirect taxes on product i

CFc and CFt-defined as above

Trade and net indirect taxes are available in the Brazilian IO table. Transport margins were obtained as the difference between values referring to purchaser's prices and trade and net indirect taxes tables.

The results of the shadow prices for traded goods can be seen in Annex 5.1.

Further assumptions are needed to estimate accounting prices for nontraded products. The estimation used here, as most empirical works, is based on the assumption that increases in the demand for nontraded production will be met by an expansion in the supply, at constant marginal costs valued at accounting prices. 23 sectors were classified as nontraded. Primary inputs consist of taxes, subsidies, labour costs and surplus.

As it is important to distinguish between skilled and unskilled labour, and, on the other hand, this disaggregation is not available in the tables, the labour shadow price was obtained as a weighted average of unskilled and skilled labour employed in each sector. This information was obtained elsewhere.[62] The shadow price for unskilled labour was set at 0.5.[63] For skilled labour, a standard conversion factor was applied to convert market into accounting wages under the hypothesis that an increase in the demand for this type of labour will impact on all sectors proportionally.

---

[62]Bonelli and Cunha(1982)

[63]See Seroa da Mota(1985)

The surplus is further divided between capitalist and noncapitalist. This last corresponds to the difference between the production value and intermediate consumption of the farms which do not employ payed labour. To shadow price it, it was used the agricultural conversion factor. In the case of the capitalist surplus, this was accepted as an approximation to the capital return given by the ratio between added value and capital stock. This last was estimated as the ratio between the standard conversion factor and the investment conversion factor.

The results of the shadow prices for nontraded goods can be seen in Annex 5.2

The estimates for the conversion factors obtained by Seroa da Mota (1988) are as follow:

	Producer prices	Consumer prices
Agricultural	1.116	1.111
Investment	0.785	0.761
Consumption	0.899	0.878
General	0.858	0.837

5.2.2) Summary Accounting Ratios for Brazil

In order to obtain recent estimates of accounting prices for Brazil, we here proceed to calculate some useful summary accounting ratios for the Brazilian economy using the most recent available database.

Summary accounting ratios are a short-cut method to provide an estimate of the average deviation of world prices to domestic prices for categories of goods usefully defined. They can be calculated either as a weighted average of the commodity ratios relevant to a goods' category or they can be obtained using aggregate data on output, exports, imports, taxes, etc. Ideally, it would be desirable to have accounting ratios calculated from both methods, so that we can contrast both estimates. In what follows, the summary accounting ratios used as framework are described and the estimates are calculated.

a) Standard conversion factor

The standard conversion factor (SCF) measures the extent to which domestic prices diverge from border prices. The SCF is an economywide aggregate, useful to convert minor nontaded inputs into their accounting prices. In general, there is no satisfactory basis for weighting the individual prices, exactly because it is intended to be such a broad statistic. An alternative approach is to select the median of estimated commodity accounting prices As Squire and Van der Tak(1975) propose, the SCF can be calculated by the aggregate method as follows.

$$SCF=(M+X)/(M+Tm+X-Tx) \qquad (5.j)$$

where M-CIF value of imports at current prices

X-FOB value of exports at current prices

Tm- net value of taxes on imports at current prices

Tx- net value of taxes on exports at current prices

At 1985 prices, a standard conversion factor of 0.93 was obtained, using the above formula. The value of imports and exports were taken from IBGE (1989) and are, respectively, Cr$169.3 billion and Cr$ 98.1 billion in 1985. Net taxes on imports and exports were taken from Guimaraes (1989) and also refer to 1985. Guimaraes (1989), through a comparison of international and domestic prices for the Brazilian manufacturing industry, estimated average actual tariff collection for imports (5.68%) and net taxes on exports(- 8.32%), both measured as a proportion of the value of imports and exports, respectively.

b) The consumption conversion factor

The consumption conversion factor (CCF) measures the average deviation of domestic prices from international consumer prices. Ideally, one should obtain different CCFs according to the various income classes, since the basket of goods consumed may vary a lot across income groups. If there are data on the pattern of consumption, we can calculate a weighted average of consumer goods, the weights being the proportion of spending on those items in total expenditure.

However, the pattern of consumption for the group of consumers as a whole was only available, using 1980 data (IBGE, 1987). The final demand vector for consumers was transformed so that we could obtain the spending on the different goods and services as proportion of the total spending(Table 5.1).

Table 5.1

The Pattern of Final Demand- 1980

Group of Goods Consumed	Spending as a Proportion of Total Spending(%)	Conversion Factors
Vegetable Products	0.50	0.9
Agricultural Products	4.00	1.32
Livestock and Poultry	1.00	1.10
Products made of non-metallic minerals	0.40	1.09
Products made of non-ferrous metals	0.20	0.76
Electric Equipment	2.00	0.64
Electronic Material	2.00	0.54
Automobiles	3.00	1.53
Other vehicles	0.50	1.33
Wood and Furniture	3.00	0.77
Paper and Printing	1.00	0.97
Rubber Products	0.03	0.57
Alcohol	0.10	0.60
Products derived from Petrol	1.00	1.40
Fuel	5.00	0.63
Other Chemical Products	0.30	0.64
Perfumery and pharmaceutical Products	3.00	0.62
Plastic Products	0.30	0.18
Textiles	2.00	0.65
Clothing	5.00	0.41
Footwear	2.00	0.59

Table 5.1- Continuation

Coffee	1.00	2.01
Processed Vegetables	6.00	0.94
Meat	6.00	1.19
Milk	2.00	0.81
Sugar	1.00	0.26
Vegetable Oils	1.00	1.03
Other Edible Products	5.00	0.57
Other products	2.00	0.93*
Electrical energy	2.00	0.97
Transport	4.00	0.84
Communications	1.00	0.92
Financial Services	1.00	0.95
Domestic Services	16.0	0.95
Commercial Services	0.20	0.95**
Rent	3.00	0.95**
Rent inputed to propriety	9.00	0.95**
Public Services	0.04	0.95**
Private Services	3.00	0.95**
Total	100.00	

Source: Annex 5.1 for the conversion factors and the proportion of spending from IBGE (1987)

* The SCF was used

** The conversion factor was that corresponding to other services from Seroa da Mota(1988)

Since the accounting price ratios estimated by da Mota (1988) are at a more disaggregated level, we use the average of the more disaggregated conversion factors. It was found a value of 0.89.

c) Capital goods conversion factor

This conversion factor is important in the calculation of the marginal product of capital,q. As Squire and Van der Tak(1975) propose, the following steps can be used to estimate the capital goods conversion factor (KGCF):

a) estimate the weight of the construction sector in the capital formation of the economy and multiply it by its respective conversion factor

b) As long as it is likely that the remaining portion of the capital formation represents importable items, estimate the average deviation of world to domestic prices using the aggregate method:

$$KCF=(Mk)/(Mk+Tmk) \qquad (5.k)$$

where Mk-imports of capital goods

Tmk-net taxes on capital goods imports

The result of the formula (5.k) is to be multiplied by the participation of tradable items in the capital formation.

c) sum the results obtained in items a and b.

Following the above method, it was found an estimate for the capital conversion factor with the value of 0.78. The figures are: 0.69 and 0.31 for the participations of construction and equipment in the total capital formation in the Brazilian economy in 1985, taken from IBGE (1989); 0.741 for the the accounting price ratio of the construction sector taken from Seroa da Mota (1988); and 0.86 for the capital goods conversion factor calculated from Guimaraes (1989).

e) Investment goods conversion factor

The investment goods conversion factor is a weighted average of the accounting ratios of land, buildings, other construction, machinery, and furniture and fixtures. Suitable weights could be the proportion of gross fixed capital formation in each of these sectors on total gross fixed capital formation of the economy.

Using the final demand column vector of 1980 for the 1980 capital formation in the economy (IBGE, 1987), and the estimates undertaken by Seroa da Mota (1988), a value of 0.80 was obtained. Again, similar to the procedure adopted for the consumption conversion factor, when the conversion factors were more disaggregated than the items in the capital formation in the Brazilian economy, the average of the more disaggregated estimates was used. A value of 0.80 was found for the investment goods conversion factor.

Table 5.2

Composition of the Capital Formation in the Brazilian Economy in 1980

Group of Goods	Weight (%)	Conversion Factor
Reforestation Activities *	4.00	0.95
Machinery	13.0	0.85
Parts for Machines	1.00	0.78
Machines Maintenance and Repair	1.00	0.83
Electric Equipment	3.00	0.64
Electronic Equipment	3.00	0.54
Automobiles, Trucks and Buses	6.00	1.28
Other Vehicles	2.00	1.28
Furniture	1.00	0.62
Industrial services	1.00	0.94
Construction	61.0	0.74
Private Services	3.00	0.94
Total	100.0	

Source: Seroa da Mota(1988) and IBGE(1987).

* In the absence of a specific conversion factor for this activity, it was used that corresponding to other services.

5.3) The Rate of Discount and Distribution Weights

The discount rate measures the rate of fall over time of the numeraire. When the numeraire chosen is consumption, then the appropriate discount factor is called the consumption rate of interest (CRI) and when the numeraire is public income measured in foreign exchange, then the suitable discount factor is the accounting rate of interest (ARI). For project appraisal and planning, we need an estimate of the discount rate, since in most of the cases, benefits and costs will occur over several periods of time, and so they must be made commensurable to each other.

The CRI depends on two main factors: the rate of society's time preference and how additional units of consumption are related to increases in utility, that is the marginal utility of consumption. Generally speaking, two assumptions have been made about these factors: a) as per capita consumption grows, each additional unit of consumption has a lower marginal utility than previous consumption gains; b) the time preference of society is such that a unit of consumption today is preferred to the same unit tomorrow.

With those two assumptions and, furthermore, specifying a relationship between additional units of consumption and the marginal utility of extra consumption, we can estimate the CRI by:[64]

$$CRI = ng + r \qquad (5.1)$$

where r-the rate of pure time preference

g-per capita growth rate of real consumption

n-the elasticity of marginal utility of consumption

---

[64] See Powers(1981) for a derivation of this result.

The CRI summarizes the intertemporal weighting system of an economy. Clearly, r and n are judgemental variables and, so, it is not possible to estimate them without the explicit introduction of value judgements. When the numeraire chosen is public income measured in foreign exchange, the appropriate discount factor is the accounting rate of interest (ARI). There is not an unique way to interpret th accounting rate of interest. This depends on the particular situation of each country. However, a lower estimate for the ARI is the real rate of interest on foreign lending or borrowing, depending on whether the country in question is lending or borrowing from abroad, respectively. Another possibility is to interpret the ARI as the interest rate that balances the demand and supply for public investment funds. In this case, the ARI equals the social rate of return on the marginal project accepted for financing.

An approximation that is widely used to estimate the ARI is:[65]

$$ARI=sq+(1-s)q/CCF.v \qquad (5.m)$$

where s-the proportion of the public project yield that is reinvested

q-the marginal product of capital in the public sector

CCF-consumption conversion factor

v- the value which the government places on its income at the margin relative to additional consumption at the average level of consumption

CCF was already obtained, remaining estimates for s, q, and v.

v depends on s, q, CCF and the CRI.An approximation for v which is accurate for small values of s is given by:[66]

---

[65]See, for instance Squire and Van der Tak(1975), p.142 and Ray(1984), pp 84-89.
[66]See Ray(1984), pp 94-95.

$v = q/CCF.CRI$ (5.n)

which becomes when substituted:

$ARI = sq + (1-s)CRI$ (5.0)

That is, the ARI is a weighted average of the marginal product of capital, q, and the CRI, the weights being given by the proportions by which income is saved and consumed, respectively.

We need estimates of the CRI, s and q to be able to estimate ARI. The way of estimating CRI was already outlined before. One possibility to estimate s is to regress savings on public income (including foreign sources). Q can be estimated in different ways: a) the interest rate on foreign borrowing; b) microevidence on the rate of return; c) macroevidence on the rate of return.

A macroeconomic approach will be used here, because this seems the best alternative. The interest rate on foreign borrowing is not suitable for Brazil because for a country with such a large external debt and with so many balance of payments problems, it is likely that the interest rate paid to external creditors has no relationship with the real profitability of new economic opportunities in the economy. On the other hand, a microeconomic approach, although theoretically preferable, would require too much work in data gathering.

Some estimates, although slightly outdated, are available for Brazil. Bacha et al. (1971), using a sample of projects financed by a Brazilian public agency-SUDENE-, estimated that the lower bound for the internal real interest rate was 10-15%. On the other hand, using data from the largest 500 Brazilian firms in 1969, the author obtained an average rate of return of 15%. Based on these results, the authors adopted a 15% real market rate and a 18% real social rate.

The results of Langoni(1974) for the real rate of interest are very close to those estimated by Bacha et al.(1971). Langoni(1974) estimated a 13-16% real rate, using data from the 500 largest largest Brazilian firms for the period 1954-67. With data from the National Accounts, the author found rates varying between 18-22% for the period 1948-69.

More recent estimates for the real rate of interest prevailing in Brazil are available in Seroa da Mota(1985). He calculated a real rate of return in the range of 15-21% for the Brazilian economy during 1966-81. The social rate of return estimated is in the range 16-23%. A macroeconomic approach was used.

In order to calculate the ARI following a macroeconomic approach, we need estimates of s, q, and CRI. To calculate this last one, it is generally assumed that the rate of pure time preference (r) lies in the range 0-2 %; that the marginal utility of income (n) in the range 1-2. The 1980s were marked by negative rates of growth in the per-capita consumption. As we expect that there will be a change in the per capita consumption trend for the 1990s, we set its expected rate of growth, instead of trying to project it from past data.

Range of Values of the CRI for Different Rates of Per Capita Growth in Consumption (g) (r= 0 to 2% and n= 1 to 2)

g (%)	CRI (%)
1	1 to 4
2	2 to 6
3	3 to 8
4	4 to 10
5	5 to 12
6	6 to 14

The relevant formula for q, the rate of return from capital, is :

$$q = 100 \, [DQ/DK - MPL(DL/DK)] \, SPP/ KCF \qquad (5.p)$$

where

DQ/DK - is the incremental output/ capital ratio

MPL- the marginal productivity of labour

DL/DK- the marginal labour/capital ratio

SPP- the shadow price of net income

KCF- the capital conversion factor

SPP is estimated as:

$$SPP = (1+ b) SCF - b \, SW \qquad (5.q)$$

where

b-the average employment cost as a proportion of value added in the economy

SW- shadow wage rate

The incremental capital output ratio for Brazil is taken as its average for the period 1970-80, whose value is 3.32.[67] The reciprocal of this value, 0.30 , is an estimate of DQ/DK. The marginal product of labour is estimated from the average wage bill and levels of employment in 1980 as Cr$ 171,600 (IBGE, 1989)[68]. The marginal labour capital ratio is approximated by dividing the incremental output- capital ratio by the value of average productivity for the manufacturing sector.[69]In 1980, the latter amounted to Cr$ 485,000. The whole expression (DQ/DL)(DL/DK) is equal to 0.11. SPP was found to be equal to 0.91 and it was assumed that the shadow wage rate was equal to 1 and, on the other hand, b was calculated to be 0.35 (IBGE, 1989). KCF had already been calculated as 0.78. The estimated value of q is 22% under these circumstances. We are able to proceed to the estimation of the ARI using the expression (5.o), repeated below for convenience.

$$ARI = sq + (1-s)CRI \qquad (5.o)$$

Over the period 1970-87, s has constantly shown a value around 0.20 (IBGE,1989b). Assuming CRI equal to 4 (which corresponds to g=1%, n=2 and r= 2%), ARI becomes 5%.

---

[67]This is because this ratio has been highly affected by the behaviour of the Brazilian economy during the 1980s,when a deep recession in its beginning followed by a recovery in its mid has resulted in abnormally low and high values for the incremental capital output ratio.

[68]In fact, only the manufacturing sector was considered.

[69] See Pearce and Markandya(1987)

5.4) The Carajas Iron Ore Project's Reappraisal Using Accounting Price Ratios

A CIOP's reappraisal is undertaken here using the summary accounting price ratios previously found in Section 5.2 and the ARI estimated in section 5.3.

The following modifications are introduced: the SCF will be used as the correcting factor for the net income generated by the project and the KCF for the capital costs. The ARI can be used as a discounting factor.

As in Chapter 3, two scenarios were envisaged in the CIOP's appraisal: scenarios A (current price for future net benefits) and scenario B (the World Bank projected price for future revenues). The internal rates of return when prices are corrected are 5.8% and 3.5%, under scenarios A and B, respectively . The net present values of the project are, respectively again, US$ 196 millions and -US$ 350 millions, which is compatible with the fact that the internal rate of return in scenario B is below the ARI.

The application of accounting price ratios to the CIOP's stream of benefits and costs has slightly increased the internal rates of return under both scenarios considered and, in particular, has made the project marginally acceptable under scenario A. This is compatible with the fact that developing countries such as Brazil enjoy a competitive position in mining operations "vis-a-vis" developed countries.

CHAPTER 6- CARAJAS IRON ORE PROJECT'S INTANGIBLE IMPACTS

The activity of assessing all costs and benefits of a project may turn out to be very difficult, especially if we want direct and indirect effects to be considered. It is unavoidable to have to circumscribe ourselves to those effects judged to be mostly related to the project being undertaken.

CIOP has some features as a project that were not considered in the original economic appraisal and that are worth analysing at more depth in a broader social and economic analysis.

CIOP created infrastructure in a up-to-then unexplored area. This was important at two levels: it contributed to the success of the project and also it allowed a type of growth in the surrounding area based to a large extent on it. In what follows, environmental aspects as well as social effects related to CIOP are considered in its area of influence.

6.1) The Carajas Iron Ore Project's Environmental Effects

CIOP involved transport (port and rail), infrastructure and mining investments. The 890 km railway corridor was opened up exclusively by CIOP: originally, that area was covered by dense tropical forest, with the exception of the area near the port terminal which is covered by extensive coastal marshlands and other parts of the region crossed by the Carajas railway which consist of drier savannah grasslands. The area where the project was implemented, in particular that along the railway corridor is characterized by the process of rapid rural and urban settlement typical of contemporary frontier region expansion in central and northern Brazil. The economic activities being implemented there included small and large-scale farming, ranching, extractive and others, most of them promoted by the Brazilian government. It is clear enough that to consider the proper environmental effects of CIOP one has to look at where it is being implemented, the place being characterized by the geographical and economic space as well as by the social interactions occuring at a given point of time.

Basically, the approach followed by CVRD and accepted by the funding institutions involved, was to demarcate the land belonging to CIOP and to take all the precautions against possible environmental damage. Outside the demarcarted area, extensive deforestation has been occuring along the immediate rail and road corridors opened up by CIOP. Small farmers, commercial loggers, large ranchers and prospectors have settled there, in search for a place where they can live. Deforestation with all the environmental consequences of this process, such as erosion and the rapid loss of soils nutrients, the proliferation of second growth vegetation, water course contamination, and the loss of biological diversity has been accelerated in the surrounding area of the territory controlled by CVRD. Moreover, the mineral processing industry being settled along the corridor has further contributed to the deforestation process.

Directly, as with forest displacement, or indirectly, as is the case of the social and economic process taking place there, CIOP has accelerated the pace at which the environment is being degraded. It is extremely arbitrary as a solution to confine the analysis of the costs and benefits of a project in a geographically and juridically well demarcated area, and neglecting obvious forward linkages, as with the CIOP- pig iron industry, in assessing environmental impacts. Such an approach breaks the basic guidelines in project appraisal and planning.

The next step to be followed is to clarify the concept of the area of CIOP's influence. Certainly this is very difficult because not only is this a very large project but also due to the fact that the CIOP's surrounding area is very dynamic and will continue to grow as new investments involving the CIOP iron ore processing and/or the increasing utilization of the infrastructure created by the project, mainly port and rail facilities. The answer to this should be on the basis of perceptions and simple technical linkages. As a first approximation, it has to be included the industries which are likely to use the rail and port network, those that will process the iron ore, the people affected by the project, both as a means of transport as well as those that are likely to form expectations that to settle in the region will bring them a better way of living, the Amerindian communities[70] affected and so on. All that can be perceived as having a direct or indirect relationship with the project has to be included in a deeper environmental analysis.

The area directly under the CVRD control included the 410,620 ha around the mine site, a 2,221 ha plot owned by CVRD at the port site at Ponta da Madeira, an 80 m wide strip along the 890 km railway, as well as areas occupied by railroad maintenance patios at Santa Ines and Pequia, near Acailandia and Maraba. An alternative approach to defining the CIOP's area of influence is that taken by CVRD in a recent study of socio-economic development and environmental impact along the railway (CVRD,1987). With the caveat that only first order approximations are possible in such a dynamic context, CVRD selected

---

[70]The World Bank included in the project a component designed to pretect the Amerindian populations. CVRD was required to sign a contract with FUNAI, the National foundation for the Protection of Amerindian Populations, so that to reduce adverse impacts of the project on those populations. This component costed CVRD about US$ 13 million. As in the BNDES appraisal there was not such a requirement in the CIOP approval, and, on the other hand, the present work has mainly relied on data from the BNDES report, we do not deal with this component of the CIOP.

the municipalities whose territory is cut and which are served by the railroad as the areas where the CIOP's effects have been most felt. In 1980, theses municipalities were Maraba (which has been divided into the municipalities of Parauapebas, Curionopolis and Maraba) and Sao Joao do Araguaia in the Para state; Imperatriz and Acailandia(this last created from the growth of Imperatriz), Santa Luzia, Santa Ines, Pindare-Mirim, Vitoria do Mearim,Arari, Itapecuru-Mirim, Arajatuba, Santa Rita, Rosario and Sao Luis in the Maranhao state (see Figure 2.2, p.38)). The area that is likely to be affected by CIOP is larger, as investments associated with CIOP either directly or indirectly, are likely to materialize[71].

In order to better understand the environment of CIOP, we proceed to give the main ecological features along the Carajas railway in what concerns soil characteristics, vegetable cover and biodiversity.

Soil quality throughout the Carajas corridor is generally poor, presenting low fertility levels. Although there is considerable variability in soil origins and chemistry, that statement applies everywhere. The introduction of truely sustainable agriculture is problematic, and agricultural uses that have been made around the region are extremely environmentally damaging. In general, Amazonian soils are poor in nutrients, in contrast to the exuberance of forest cover typical of tropical forests. Deforestation, either for the purposes of land clearing for agriculture or for cattle raising, has various adverse environmental impacts such as: a) reduced soil fertility due to the loss of nutrients

---

[71]The above study-CVRD,1987- points that other parts of the Eastern Amazonia and Pre-Amazon regions where the railroad's area of influence could expand over time: the entire Carajas "metallurgic province", thus expanding the area of influence to other large municipalities in the state of Para immediately to the West(Sao Felix do Xingu) and South(Conceicao do Araguaia, Redencao, Rio Maria and Xinguara).This potential expanded area has been found to have large reserves of tin, iron, lead, copper, zinc.

through leaching; b) elimination of the most fertile upper layer of the soil as the result of erosion; c) reduction of the quantity of organic material in the soil previously provided by the now absent forest. These factors make it extremely difficult to grow annual crops in the same location for a period of more than two or three years in most humid tropical areas, especially with the low capital-intensive techniques used by small farmers in Eastern Amazonia[72].

The native forest cover varies significantly along the Carajas rail corridor: dense tropical forests predominate in the western part of the corridor and other types of vegetation including secondary growth, characterize the eastern part of the region. Data taken from project RADAM points that in the early 1970s, the area around the Serra dos Carajas was composed nearly of 75% of dense forest, with the remaining 25% being classified as open forest. In the area around Santa Ines, on the other hand, dense forest occupied roughly 45% of the area in the 1970s and secondary growth close to 50%, while near Sao Luis, 25% of the area was taken up by mangroves, 14% by vegetation typical of humid flood plains and 41% by secondary growth which, as in the case of areas around Santa Ines, covered areas which had previously been in forest[73].

Associated with the native forest, especially in the western part of the Carajas area and in the coastal marshland regions around Sao Luis, there is a considerable diversity of animal, bird and aquatic (both freswater and saltwater) life, some of which has been inventoried in connection with CIOP.[74] The coastal marshlands represent the most extensive refuge for aquatic birds from Northeast Brazil, to where about

---

[72]See Falesi(1987)

[73] Projeto RADAM. The Falesi article indicates that some 68% of the GCA is covered by forests; 9% by savannah grasslands and the rest by various types of food plain, coastal marshland and secondary growth vegetation.

[74]See, for instance, Silva(1987), Novaes(1987), Oren (1987), and Tundise(1986)

50 different species can be found there in the dry season. On the other hand, 91 different species of birds have been found inhabiting the areas around the Carajas mountains. Moreover, some of the species found in the Carajas corridor have been included in a recent list of Amazonia fauna under threat, either as the result of predatory hunting or because of the destruction of their habitats. The permanent loss of not yet identified and inventoried species may become a reality with the increasing process of deforestation and settlement in the area.

The Carajas corridor is both extremely rich and highly heterogeneous in ecological terms. Much of this biological richness is still not properly documented.[75] It can be said that much of the physical environment in the Carajas- Sao Luis corridor has already been substantially altered as the result of different types of human productive activity over varying periods of settlement in distinct sub areas. It is true that much of the occupation took place previous to the development of CIOP. However, it cannot be denied that this project has accelerated the speed at which that disorganized occupation is taking place. If CIOP hadn't been implemented, the area opened up by the Carajas railway would have remained as an inacessible place, most covered by dense tropical forest.

The environmental care component of CIOP included measures at some specific locations: mine and port sites, as well as along the Carajas railway.

In the mine, air and water quality monitoring measures have been taken to prevent changes in air and water quality. Although staff from CVRD have pointed out that no significant changes have occurred since the beginning of the project, researchers elsewhere have reached

---

[75]Some studies undertaken by the Goeldi Museum supported by CVRD and others carried out by IBGE. See, for instance, IBGE(1987).

different conclusions. Researchers at the Goeldi Museum have found that water quality around the Serra dos Carajas has been altered as the result of human intervention in the region.[76] Changes in colour, increased turbidity, a relatively high concentration of sediments and relatively low concentrations of dissolved oxygen have constituted the basis on which those conclusions have been reached.

Moreover, the CVRD's environmental preservation activities at the mine site include the establishment and maintenance of botanical and zoological parks. The objectives of this initiative from the part of CVRD are the preservation of plant and animal species; the education of people who live and work in the Carajas townsite; the raising of animals for purposes of reproduction; the production of seedling for reforestation; the provision of recreational opportunities.

The monitoring of air and water quality is also carried out by CVRD at the port site. However, there is no available evidence to evaluate the extent to which those measures have really prevented air and water quality deterioration successfully.

Along the corridor, soon after construction was completed, a process of restoration of vegetation cover was initiated extending to an area roughly forty meters wide on either side of the railway. Through a process of hydroseeding using a variety of native and exotic grass and legumes species, this proces was accomplished[77]. This treatment appears to have been largely succesful both in controlling soil erosion and in restoring vegetation to the immediate rail corridor. However, in several stretches along the railroad erosion continues to be a problem and additional control measures, including improved drainage and further restoration of vegetation needs to be undertaken by CVRD. Moreover,

---

[76]See, for instance, Amaral et. al.(1988)
[77]See Anderson(1989)

CVRD through its forestry subsidiary (Florestas Rio Doce SA) operates a number of experimental stations and forest reserves at various points along the corridor, whose purposes are to test the technical and economic viability of different varieties of planted tree species for cellulose production.

Altogether, CVRD spent about US$ 64.4 million between 1982 and 1987 on environmental control and protection activities, about 2.2% of the overall project's costs. Over three-fifths of that total(US$ 39 millions) was utilized for hydroseeding and landscaping activities, primarily along the railroad. The second largest expenditure item was drainage and effluent control, accounting for 30% of environmental control and protection. The remaining 11% (US$ 6.8 million) was spent in air and water quality monitoring, zoobotanical park and research. Environmental protection measures at the Carajas mining concession, immediately along the railroad and in the port area have been considered effective by specialists in the limited area under direct control of CVRD. Yet, environmenal protection measures should have been taken considering the whole development process taking place in the GCP's area. These developments include both the expansion and diversification of mining activities within CVRD's concession itself and increasing industrialization and urban growth along the Carajas corridor.[78] Within the CIOP's undertaking, these broader measures were completely overlooked.

Outside the areas under CVRD's control, there was a complete lack of any environmental protection. Uncontrolled rural settlement and urban development, accompanied by increasing environmental devastation, happened in the areas adjacent to the CVRD's dominion

[78]See Anderson(1989)

during project's implementation. As a result, while CIOP in itself is an example of effective environmental management, at the same time it is also an example of inadequate environmental planning and control in the larger region directly and indirectly affected by these investments.

The CIOP's area of influence has experienced the highest rates of immigration and deforestation over the past two decades. CIOP has directly contributed to these processes by attracting large number of people to Eastern Amazonia and making it possible by the railroad component. Deforestation in the Carajas area has accelerated as a result of some factors, directly and indirectly associated with the iron ore project. Deforestation in the project's area of influence has increased significantly over the past decade and a half(see Section 7.2). In what follows, the main factors of deforestation associated to the project are cited.

The attraction of migrants to the area to help install the Carajas mine and the railroad in itself is not an additional factor of deforestation besides the project. The problem is that many of these workers have remained in the region to pursue prospecting, small farming and other employment opportunities, once the project was completed.

The project improved access to extensive and previously much less accessible parts of the region due to the new or improved road and railroad infrastructure. This, summed with SUDAM fiscal incentives, has made especially attractive from a financial standpoint to clear areas through the implantation of ranching ventures. Moreover, there has been the expansion of logging operations, the establishment of official colonization projects and increasing occupation of rural areas by squatters and prospectors. Also in this context where infrastructural facilities are being provided by the project, private land-speculation along the corridor has increased substantially. Furthermore, lumber requirements for construction of the railroad (especially railroad ties) and other facilities(buildings, other mine installations etc.) have also been a factor responsible for deforestation.

A major threat to the forest is the establishment of a metallurgic industry along the the Carajas corridor, which uses fuelwood to produce charcoal for the pig-iron smelters. This is a direct and natural consequence of the extraction of iron ore at the Serra dos Carajas. This was one aspect of the GCP's whole conception and it is difficult to accept the vision that this consequence was not foreseen.[79] Four pig-iron industries, as mentioned in Chapter 2, are currently in operation and several others have already been formally approved by GCP. These four industries have the capacity to produce 240,000 tonnes of pig-iron per year. Considering the total productive capacity approved by GCP, the total expected capacity is of the order of 1,578,000 tonnes per year. Moreover, planning studies point to an annual production of pig-iron by the year 2010 on the magnitude of 2.8 million tonnes per year. There is also the real possibility that these industries will eventually verticalize their output by producing various types of finished steel commodities.

The pig-iron industries, either those in operation as well as those planned, use or plan to use wood based charcoal as an energy source. The potential expansion of the metallurgic industry is very large, since the availability of high quality iron ore is enormous in Serra dos Carajas. In this context, it seems sensible to analyse jointly the pig iron industry-CIOP to internalize environmental costs to each unit produced by CIOP and destined to the pig-iron industry.

---

[79]Seefor instance, Anderson(1989), p.35:" the installation of metallurgic industries in the region has long been envisioned by CVRD as a logical offshot of the Iron Ore Project, and it was as integral part of the PGC development model from its inception.

Basically, a major shortcoming in the CIOP's appraisal stage was to adopt a narrow approach in assessing the impacts of the project. A regional and integrated approach, compatible with the GCP's conception and in which it is taken into account not only the social and environmental context of the region but also the understanding that CIOP is part of a investments package, lacked completely at the appraisal stage.

6.2) The Carajas Iron Ore Project's Social Impacts

Although it is difficult to isolate the CIOP's effects on social movements occurring in GCA, the project and its associated investments have had a major influence in determining the nature and speed of social change in the region. As the region is characterized by several others development initiatives, it becomes difficult to determine the exact extent to which CIOP has affected the social processes taking place there.[80]

CIOP has had a very strong effect on the nature and rate of recent urbanization in the Carajas corridor. Towns and cities have experienced high rates of growth over the past two decades. Basically, what happened is that after 1980, with project implementation, there was an acceleration in the flows of rural to urban migrants towards cities along the corridor[81] seeking survival opportunities (see Table 6.1). This has resulted in a large gap between the growing local demands for urban infrastructure and services and the ability of municipal authorities to meet these needs. Some figures indicate the intensity of the acceleration in migration rates.

While 59.7% of the migrating population of the region moved to GCA in the period 1970-80, 26% of the same population moved in 1979-80. The cities to where most of these "recent' migrants went were Sao Luis (323.1%), Imperatriz(25.6%), Santa Luzia(10.0%), Maraba(8.7%) and Santa Ines(6.8%). (IBGE, 1980).

The same tendency of acceleration in the migration process occurs during 1980-85. Maraba, for instance, grew at a rate of 206.6% per year;

---

[80]This section draws largely on CVRD(1987).

[81]Especially to Sao Luis, Imperatriz, acailandia, Maraba, Parauapebas/Rio Verde.

Imperatriz and Acailandia at an annual rate of 65.6%; Santa Luzia at an yearly rate of 47.7% and Santa Ines at 35.1% per year. It is worth stressing that the quarrying activity in the area was also an important factor in attracting people from outside the region, in the search for better prospects of life. More recently, the settlement of the industrial zone along the railroad has also been an important factor to attract more workers from outside the region. We can see in Table 6.1 the growth of the cities under the influence of the Carajas railway.

Table 6.1

Growth of the Cities under the Influence of the Carajas Railway-1980

City	Annual Rate of Growth (%)		Cummulative Growth(%)		Population Size
	1970/60	1980/70	1980/70	1985/80a	1980
Sao Luis	5.51	5.20	66.1	25.6	449,493
Rosario	---	2.48	27.8	12.6	28,325
Vitoria do Mearim	2.27	3.83	45.6	24.2	50,409
Santa Ines	---	5.76	75.0	24.2	49,449
Pindare-Mirim	---	0.93	9.7	7.8	26,466
Santa Luzia	---	6.88	94.7	24.2	94,210
Imperatriz*	7.80	10.16	163.2	39.5	220,095
Maraba	---	9.22	141.6	122.9	59,915

Source: IBGE(1980)

* It included the municipality of Acailandia in 1980

a-estimated

The region's frontier status can be attested by the fact that about half of the total population in the Carajas corridor in 1980 consisted of migrants , 60% of whom had arrived within the previous decade. To a large extent, this influx was the result of official development policies during the 1970s which actively encouraged poor farmers to come to

Eastern Amazonia from the Northeast part of the country as well as from the Souhern Brazil where mechanized soybeans and wheat production was forcing out a large number of farmers. However, the vast majority of migration was spontaneous, without any government support. Certainly, CIOP was a very important factor in accelerating migrant patterns. More recent IBGE estimates indicate that the municipalities located along the corridor have experienced population growth on the order of 5.8%. a year between 1980 and 1985, while the country as a whole a rate of 2.2%. Total population in the area increased from 1.1 million inhabitants in 1980 to nearly 1.5 million in 1985, or by more than 350,000 people. Although IBGE estimates do not break down population increases according to rural and urban, most of the observed increase has certainly taken place in towns and cities, particularly Sao Luis, Imperatriz, Acailandia and Parauapebas, with much of the latter being a direct consequence of CIOP. Both in the urban and rural environments we can portray some recent processes which, as said, have as one important factor the CIOP's implementation.

Among the rural development impacts in the rural sector in Eastern Amazonia, it can be said that it has included land speculation and concentration, growing land conflicts and rural violence and changes in rural occupational structure and land use, together with impacts on rural health and food security and on socio political organization in the countryside over the past decade and a half. [82]

Land concentration and speculation have increased over the past 25 years, being largely reinforced by CIOP. The project has stimulated land occupation in the areas around the mine, the railway and the port and, thus, has contributed to the polarization process in the region which

---

[82] A very careful study of the social impacts of CIOP is provided by Hall(1989).

had been taking place before the 1980s. Land prices in the region have increased substantially as a result of the construction of the mine and railway. Also, as a result of major influences of labourers to the region, there has been growth of a variety of local commercial and service activities that have further contributed to the rise of property values and land prices, thus worsening the process of land speculation and concentration. Moreover, incentives granted to livestock, lumbering and pig-iron enterprises under GCP have made Eastern Amazonia an increasingly attractive place for private investment where the provision of infrastructural facilities by CIOP constitutes a major facility for investors. Such subsidies, combined with the high rates of inflation, have encouraged the aquisition of large land holdings purely for speculative purposes. Data from the agricultural census show that there has been increasing land concentration in GCA in the late 1970s and early 1980s, and that land and property prices have risen substantially in the same period.

Behind this process of land concentration and speculation, a lot of rural violence has occurred as a result of the struggle over land: on the one hand, small cultivators and Amerindian groups and, on the other hand, large commercial farmers, ranchers and speculators. There has been an increase in rural violence in Eastern Amazonia in the 1980s. According to official figures, by 1981 over half of Brazil's land conflicts took place in Amazonia, this share rising to almost two thirds by 1987. Most deaths associated with land conflicts in Amazonian frontier areas have resulted from the hiring of gunmen by large landowners to expel peasant farmers. The resistance of squatters (posseiros) as well as the spread of organized estate occupations over the region is also a factor to explain the rising number of deaths.[83]

Urban development associated with the Carajas project has been insufficient to meet the incoming population. Underemployment, poverty and public health problems are characteristics of towns and cities along the corridor. The rapid migration stimulated directly and indirectly by CIOP and other public interventions in the region has made the supply of urban developments indequate to meet the demand. Common to all major towns and cities along the Carajas corridor, we find problems such as untreated water supplies, sewage and trash collection and storm drainage systems being restricted to few, inexistent sewage treatment and adequate solid waste disposal. Urban poverty and inadequate public health standards have resulted in widespread urban poverty and malnutrition. High indices of infant mortality, which average 125 per 1,000 live births in Sao Luis, while almost 90% of the low income population suffers from infections caused by intestinal parasites. These are some reflections of the urban situation.[84]

It is true that CIOP has provided the population with some benefits. Interurban transport services were made available to the population: although originally intended to carry only iron ore, due to local demands the railway now transports a variety of other kinds of freight and a large number of passengers. Moreover, outside its concession, CVRD has provided some basic urban infrastructure: sanitation as well as a secondary school and a hospital were built in Parauapebas, road improvements in Maraba were provided and in various towns and cities along the corridor, CVRD built housing for its employees.

---

[83]See MIRAD(1987)
[84]See Gistelink(1988)

Employment generation was another topical point of the project. During construction, CIOP directly generated substantial amount of direct employment: at the peak of building, in 1982, a total of 27,000 workers were employed in CIOP. The great majority of these workers were brought in by contractors from outside the Carajas area, from southern and northeastern Brazil. Many of these migrants, however, as said before, chose to remain in the region after building activities were completed. Permanent jobs during the operational phase of the project presently amount to 4,200 within CVRD alone, this number being likely to rise by 20% when the mining operation expands to 35 million tonnes per year. It is supposed that a total of 20,000 and 25,000 people are directly supported by the project (considering family members of employees).

Indirectly, additional jobs will be created as a result of the metallurgic industry being settled along the corridor. The thirteen industrial projects approved by the GCP will result in an estimated 5,200 direct and 31,500 indirect employment opportunities, in what is included not only the workers at factories but also those associated with the charcoal industry. Official estimates for the total amount of employment to be generated, directly and indirectly through food processing and services, is that by the year 2000, 85,000 direct jobs and 106,000 indirect jobs will be created.

Some comments are in order about the whole social process taking place in the region. At the time of the conception of the project, both the settlement of new urban areas and the induced growth of existing cities were judged to be major social benefits. In a country still sharing many characeristics of a dual economy, especially in its North and its Northeast parts, and on the other hand, with the large unoccupied Amazon area, the perfect combination seemed to settle economic activities in this part, thus attracting workers whose opportunity cost was virtually nil. However, some factors have to be considered before we can accept this view. First of all, we have to bear in mind that other economic alternatives would exist for these workless populations, both at the regional and the national levels. Secondly, we have to consider that the resources used up by the project have an opportunity cost. To consider as a social benefit the settlement and growth of cities, led by migrating populations and with the economic activities before described, is equivalent to assuming zero opportunity cost both for the resources involved and for the workers, which is not necessarily true. Further research would be needed to answer this question. This would involve investigating alternative patterns of development in the region.

Furthermore, the investments carried out for CIOP are extremely capital- intensive and require a reasonably skilled labour to operate them. This is also true for the iron ore smelters along the railway. Insofar as most of these migrating populations are constituted by unskilled workers, it is doubtful that those projects were really a step further in the sense of integrating surrounding populations in an economic life. The employment generated was low considering the investments and it is also probable that the labour demand was fulfilled by skilled labours from other parts of Brazil. The result of net immigration in itself tells nothing about whether new employment opportunities were made available to populations who had no economic integration in their original places. It is a case to investigate whether or not those workers were made worse-off or better- off with the move.

6.3) Social Incidence of Costs and Benefits

Analysing the social distribution of costs and benefits, it is important to distinguish the different actors in the context of Eastern Amazonia. Local populations, businessmen, the Brazilian government, the state owned enterprise CVRD, the international community, the Brazilian population are the main agents involved, directly or indirectly, in the process of Amazonian occupation through the project in question, CIOP.

Local populations as well as migrants who went to Eastern Amazonia in search for better prospects of life have borne directly most of the up to now perceived CIOP costs. As Hall (1989,p.234) states: " the specific pattern of industrial and agro- livestock investments in the Carajas Programme has grossly exacerbated a situation of already severe agrarian crisis over a large part of the Amazonian Basin." With the worsening of social and environmental conditions for most of the rural population, it becomes increasingly difficult for small farmers to earn their living from the land on a sustainable basis. As the same author highlights, on the one hand the state has encouraged the acquisition of land for commercial and speculative interests and, on the other hand, it was also encouraged by the Government land-hungry peasant farmers expelled from the Northeastern and Southern parts of Brazil to settle the frontier as a solution to mounting social problems in those parts of Brazil and simultaneously occupying the Amazon frontier for geopolitical reasons. Those contradictory goals have resulted in rapid rural violence escalation since the early 1980s[85]. About 5 million rural dwellers are in the situation of losers in so far as access to land has become more and

[85]See Hall(1989), chapter 6; Hecht and Cockburn(1990), Chapter nine.

more dificult. Moreover, several key socio-economic and environmental indicators have shown the deterioration of the situation for small farmers: rising violence indices, higher skewed land distribution, forced population displacements[86], worsening food security[87], increasing environmental destruction through deforestation.

About 350,000 people migrated to the cities along the corridor during the period 1980-85. As was indicated in the previous section, the towns and cities infrastructural facilities were not prepared to receive such a large influx of people. The conditions of urban life for most of the population are very precarious and a host of sanitary and health problems have emerged as a consequence. Moreover, very few workers managed to and will get jobs in GCP. CIOP during construction offered up to 27,000 jobs in the peak time on a provisional basis and now, only about 4,200 during the operational phase. Comparing the figures between migration and direct creation of jobs, it is doubtful that one maintains the vision that one of the CIOP benefits is the employment generation. Certainly, it is difficult to say whether or not those migrants were made better-off or worse-off with the move, as would be required. Only those who have survived in such an adverse context (either those who chose to move or those who stayed in the Northeastern and Southern Brazil) can tell us something about this still unanswered question. The group of local populations is likely to be a net loser in the CIOP assignment of costs and benefits.

A CBA on purely efficiency grounds is extremely unfavourable to CIOP. As was indicated in Chapter 3, the internal rate of return, not considering environmental and social factors, is below the capital cost. Certainly, if we include environmental and social costs, although they

---

[86]About 30,000 in Sao Luis with the port construction and 35,000 in Tucurui.
[87] As a result of the growing inability of people to feed themselves.

are very dificult to evaluate in monetary terms, that rate would become negative. Even if we accept CIOP as a project worth being subsidised by the Brazilian population, we have to ask what are the benefits of doing so. Clearly, CIOP has allowed a certain pattern of development in a region covered by forests. The question is thus whether this pattern is likely to bring benefits to most of the Brazilian population, the price of those being high: environmental destruction, social disruption and so on. Visibly, the possible benefits of the project, foreign exchange generation, employment generation, and so on could well be achieved by other means without imposing such large social costs.

The Brazilian government certainly had its own objective with CIOP. The temporary relief of foreign exchange debt servicing was an important point[88]. By the 1970s, the Brazilian government was wondering what to do with the Amazon region in order to secure the territory on geopolitical grounds as well as how to integrate the region into the national and international economies. GCP was seen as a quick way to promote development and to ocupy the territory. It can be said that those objectives were partially fulfilled, but, again it has to be stressed at very high costs and on an unsustainable basis.

Linked to the Brazilian government, we can identify CVRD as an independent enterprise which had interests in the whole GCP's conception. The large company had a clear interest in transferring iron-ore production from Minas Gerais to Amazonia, while taking advantage of heavily subsidised electricity prices and infrastructural facilities. A plentiful cheap supply of charcoal will permit an economically feasible integrated iron ore and industry to set up in the region. This was a very

[88] According to GCP's early plans, it was estimated that US$ 40 billion in direct investments would generate US$ 17 billion annually in foreigh exchange from a combination of industrial and agro-livestock enterprises.See IBASE(1983)

important point in encouraging the switch to Amazonia from the South. This interest has made CVRD take a leading role in the GCP's design with Japanese technical assistance. With CIOP, CVRD has reached the third place in the iron ore largest companies in the world. Although the declining iron ore prices, still, for CVRD, CIOP is an extremely interesting project because it has given CVRD a prominent role in the world market, and, additionally, being largely subsidised by the Brazilian population, especially by the local populations more directly affected. Moreover, as there are no charges for environmental and social costs, CIOP is considered a profitable project in the mining sector. CVRD as a company has been a major beneficiary of the project, although not paying the whole costs. This is the only actor who has been clearly a net gainer.

The international community has participated in the project in several ways: as financers, as consumers, as populations affected by trans-boundary externalities. Certainly, some of the CIOP's benefits, mainly the cheap and plentiful supply of high-quality iron ore have accrued to them. Bankers were willing to lend money to the project at Libor rates. But also they should consider that the environmental costs of deforestation in Amazonia, although not completely quantifiable, may be high. Some recognised international externalities include: loss in species diversity, increase in the greenhouse effect,poosible effects on climate and hydrologic cycle, among others. It is difficult to say if they are net gainers or losers in a broader temporal perspective.

Finally, businessmen, either national or from abroad, in their narrow profit making strategies are likely to be net gainers because of the generous financial incentives and, on the other hand, having paid nothing for environmental and social costs. Clearly, their business decisions are the best indicator that this group has benefitted hugely from the whole story.

CHAPTER 7- ECONOMIC ANALYSIS III: ENVIRONMENTAL IMPACTS

7.1) Deforestation in the Greater Carajas Area: Causes

Covering an area of 5.5 millions km^2, the Amazon is the world's largest tropical moist forest and it extends into nine South American countries (see Figure 7.1, p.148). The Brazilian portion is the largest, corresponding to 69% of the total area. Four main types of vegetation are found there. The dense tropical forest[89] is found mainly in the northern Amazon states (Amazonas, Amapa, Roraima, Para and Maranhao) and it covers about 48.8% of the region. The transition forest[90] covers the central Amazon (Acre, Rondonia, northern Mato Grosso and Goias, and western Maranhao) and corresponds to 27% of the region. Savannah shrublands[91]extend over Goias and southern Mato Grosso covering 17.2% of the region. The fourth type, savannah grasslands[92], is found mainly in the "varzea" foodplains along the Atlantic coast in Amapa and Marajo Islands, and in Northern Roraima, and covers only 6.9% of the "Legal Amazon" region (Browder, 1988). According to Myers figures (1989), originally almost 2.9 million km^2 were covered with Amazonian forest and today, the forest expanse has declined to around 2.2 million km^2 (that is dense and transition forest). Still Brazilian tropical forests account for 27.5% of all tropical forests totalling 8 million km^2.

It will be difficult to list all the causes of deforestation in the Amazon region, because all the activities that have been taking place

[89]"Floresta densa" or "hylea"
[90]"Floresta aberta" or "fine"
[91]"Campo cerrado"
[92]"Campos naturais"

there have had a net impact on deforestation.[93] Economic activities presently taking place in the region, as well as direct governmental action towards developing Amazonia have resulted in deforested areas. Small scale agriculture, logging, cattle ranching, mining are all examples of economic activities that have been sources of deforestation. Government has played a major role in the promotion of those activities, either directly or inducing the private sector to start business in the region through packages of generous benefits.

Governmental programmes designed to occupy Amazonia after the military coup in 1964 have been a major source of deforestation: the road building programme, hydroelectric development, the provision of infrastructure to the region, settlement programmes in the region. From that date up to now, we can identify different phases in which the pattern of occupation and the degree of governmental intervention have varied.[94] However, a common feature in all periods is that government has been a major factor in promoting economic activities, either directly or indirectly.

The actual extent to which Amazonian forest has been disturbed is a controversial question. It is necessary to consider not only those parts of the region where primary forest cover has been totally removed but also those areas where hardwood timber of commercial value has been selectively logged. As a practical shortcoming, satellite photographs are not able to distinguish parts of the forest that are undisturbed from those which have been subject to logging activities. These last affected

---

[93] Except in the period of the Amazonian rubber boom, which took place from the last quarter of the nineteenth century up to 1912. See Mahar(1989) pp. 10-11. This is an example of sustainable economic activity in the region.

[94] The programmes to occupy Amazonia in the 1960s, PND I in 1970-74, PND II in 1975-79, the Greater Carajas Programme in the 1980s. See Hall(1989) or chapter 2 for a short review. See also Browder(1988);Hecht and Cockburn(1990); Binswange(1989); Fearnside(1988).

parts, in the absence of replanting, have become impoverished from both an ecological and economic standpoints. In the present study, what matters to emphasize is that figures on deforestation rates of the Amazonian forest should be taken as preliminary, compatible with the present conceptual and practical problems affecting the measurement process. It is unavoidable to rely on ranges of values, instead of single values, for deforestation rates.

Yet, it must be taken by granted that deforested areas, although a small proportion of the total area, have increased substantially since the mid 1970s. A recent World Bank publication, based on Landsat satellite images, indicated that about 600,000 km^2, or 12% of "Legal Amazonia" had been cleared in 1988, whereas the same figure for 1975 is 30,000 km^2, or 0.6% of "Legal Amazonia" (Mahar,1989- see Table 7.1). Another study estimates that as much as 20% of the Amazonian forest, involving a total of 1,000,000 km^2, may already have been partially or completed altered by human intervention, including the effects of selective logging and small farmers. (Malingreau and Tucker, 1988).

As can be seen in Table 7.1, deforestation has been concentrate in certain subregions . In Rondonia and Mato Grosso nearly one fourth of the forest has already been cleared whereas more than 99% of the forest is still intact in Amapa. Although deforestation has taken place at decreasing rates, the proportion of total deforested areas has increased from 0.6% in 1975 to 12.0% in 1988 .

Table 7.1

Landsat Surveys of Forest Clearing in Legal Amazonia

State or territory	Area (km^2)	Area Cleared (km^2) By 1975*	By 1980*	By 1988*
Acre	152,589	1,165.5 (0.8)	4,626.8 (3.0)	19,500.0 (12.8)
Amapa	140,276	152.5 (0.1)	183.7 (0.1)	571.5 (0.4)
Amazonas	1,567,125	779.5 (0.1)	3,102.2 (0.2)	105,790.0 (6.8)
Goias	285,793	3,507.3 (1.2)	11,458.5 (4.0)	33,120.0 (11.6)
Maranhao	257,451	2,940.8 (1.1)	10,671.1 (4.1)	50,670.0 (19.7)
Mato Grosso	881,001	10,124.3 (1.1)	53,299.3 (6.1)	208,000.0 (23.6)
Para	1,248,042	8,654.0 (0.7)	33,913.8 (2.7)	120,000.0 (9.6)
Rondonia	243,044	1,216.5 (0.3)	7,579.3 (3.1)	58,000.0 (23.7)
Roraima	230,104	55.0 (0.0)	273.1 (0.1)	3,270.0 (1.4)
Total	5,005,425	8,595.3 (0.6)	125,107.8 (2.5)	598,921.5 (12.)

Source: Mahar(1989)

* The number in parenthesis refer to the area cleared as a percentage of state or territory.

Myers (1989) points out that in 4 states (Acre, Rondonia, Mato Grosso and Para), deforestation rates have markedly increased in 87 and 88, reaching, respectively, 50,000 and 48,000 km^2, approximately. On the other hand, the total deforestation in Brazilian Amazonia in 1989 possibly amounted to at least 45,000 km^2, what means a 2% rate as a proportion of the remaining forest expanse there (2,200,000 km^2). WRI estimates (1990) indicate a range of annual deforestation rates for Brazilian Amazon between 1.7 and 8 million ha per year and, thus, the global deforestation rate could be 13.9- 20.4 million ha per year, depending on Brazil's rates. Still, figures are heavily affected by the way deforestation is measured and a cautious attitude requires that upper limits of deforestation rates are taken seriously.

The land use that has been made in the region is one factor that has been a major source of deforestation, both in opening up new cleared areas as well as in expanding already cleared areas. The expansion of agriculture frontier has meant that farmland in Amazonia increased from 313,000 km^2 in 1970 to over 900,000 km^2 in 1985 (Mahar, 1989). This expansion has been spread all over the region, and was particularly rapid in Rondonia, northern Mato Grosso, Goias and southern Para.

The pattern of land use, as can be seen in Table 7.2 , shows that 11% of the total land in Legal Amazonia has been allocated to pasture while a mere 6% has been used by crops. Pasture has been the predominant form of agricultural land use, taking place on large landholdings. Annual crops, in general taking place in small farms, is the second most important factor of agricultural land use. Frequently, these areas will be converted to pasture, given that yields decline very quickly only a few years of use.

Table 7.2

Agricultural Land Use in Legal Amazonia- 1980

Use	Area	Percentage of Area
Crops	(Km^2)	(%)
Annual [a]	42,231.6	5.0
Perennial	7,619.5	0.9
Subtotal	49,851.1	5.9
Pasture	94,098.1	11.1
Undisturbed[b]	704,994.3	83.0
Total	848,943.5	100.0

[a] includes fallow land

[b] Forest, natural pastures, and areas unsuitable for agricultural use (such as rivers, mountains).

Source: Mahar(1989)

Commercial logging, although still being an incipient activity in the region, is increasing rapidly.[95] Although sometimes being a by-product of land clearing for agricultural purposes, this activity promises to be a major source of disturbance with the depletion of southeast Asia's forests which have been supplying tropical hardwoods to world markets. Mahar(1989) estimated that between 1975 and 1985 regional wood production, from 4.5 million cubic meters per year (14.5% of the total national production), increased to 19.8 million cubic meters per year (46.2%). Browder(1988) points out that the number of government-licensed mills increased more than eightfold since 1965, from some 200 plants in that year to 1,639 plants in 1981. Average annual output per

[95] See Fearnside(1989), p.217.

mill increased from about 2,000 cubic meters of sawnwood in 1962 to 4,500 cubic meters in 1984.

Industrial activities in the region, mainly the mineral processing industry inducing the development of a charcoal industry, is expected to further contribute to deforestation. Under GCP, the settlement of the pig-iron industry along the corridor railway poses a major threat to the forests because of the use of charcoal as an input. The expected annual pig-iron production is 2.8 million tonnes, which will require deforesting 82,000 ha of native forest per year (Fearnside,1989). Although originally GCP had a component for silviculture plans, so that "eucalyptus" plantations would feed the pig-iron industry, the failure of the "Jari" project has shown that large-scale silviculture in Amazonia is a much more expensive and much more difficult option than originally thought.[96]The likely result in Carajas is that charcoal production will be supplied from native forest as long as accessible stands remain in existence. As Fearnside (1989) puts it: "The Carajas pig-iron scheme is the latest in a long list of development misadventures in Amazonia where projects have been decreed before confirming their sustainability and level of impact".

Moreover, direct government action has played a key role in promoting deforestation.[97]An extensive road building programme in the 1960s and in the 1970s made large areas of the region available by land. The construction of the Belem-Brasilia highway (BR-010) in 1960 and the Cuiaba-Porto Velho highway (BR-364) in 1967 were very important in creating nucleus of deforestation in Amazonia (Fearnside, 1989).

---

[96] Jari is a pulp manufacture project that includes "eucalyptus " plantations in approximately 78700 ha in Amazonia. These last have suffered a number of biological problems, including poor growth of the plantations on unsuitable soil, much lower growth rates overall than originally anticipated and losses to a variety of pests and diseases. See Fearnside and Rankin, 1980,1982, 1985)

[97]See Mahar(1989), Hall(1989).

Migration to the Amazonia, initially directly promoted by the government in the early 1970s, was positively fedback by the improvement of these two roads (see Figure 7.2, p. 149)[98]

The high rate of population growth in Amazonia substantially led by migration to the region, created another focus of deforestation. The population of Brazil's Northern region grew at 4.9% per year between 1970 and 1980, compared with 2.5% per year in Brazil as a whole in the same period and 14.9% per year in Rondonia, where the deforested area increased at a rate of 3.7% per year between 1975 and 1980, indicating that deforestation reached rates even higher than population growth (Fearnside,1989).

Population growth has three major implications for the region's forests (Browder,1988). First, it has increased the demand for subsistence products, such as food crops, and therefore the demand for farmland. Secondly, it has increased the size of the agricultural labour force and it has increased political pressure for road building and other social overhead investments that not only damage forests directly, but also facilitate further migration and population growth.

The recent GCP, whose ecological impacts are given in the next section, has been another factor causing deforestation, as well as the hydroelectrical projects being built there to support GCP. The Tucurui hydroelectricity project on the Tocantins river has flooded 2,160 km^2 of forest land (Goodland, 1985)

The characteristics of the economic activities taking place in the region were outlined above. It is time to ask why they have taken this

[98] The improvement for year-round traffic of the Belem-Brasilia highway in 1967 and its paving in 1974 as well as the paving of the Cuiaba-Porto Velho highway in 1984 provided further stimulus to migration. Moreover, the extension of this last road from Porto-Velho to Rio Branco is expected to further stimulate migration to the state of Acre.

pattern rather than another. The answer has to be found in the design of governmental policies that lead rational economic agents to deforest, as well as in the macroeconomic aspects of the Brazilian economy, that lead that businessmen from all over the world to invest in the region, in the activities previously mentioned.

The causes of the deforestation process can be understood in two frameworks. There are direct causes, as Fearnside (1988) calls them, that can be understood in a microeconomic context. Landowners and squatters (posseiros) are led to deforest land, as much as they can in a particular time period. A good example would be the legislation that gives the right of owning a piece of land to whoever has cleared it, the official interpretation of this law being that deforestation means that an economic use has been made of that. Another perspective is to understand the causes of deforestation in a macroeconomic context: deforestation is the result of the action of rational economic agents in a particular macroeconomic environment. An illustrative example of this would be the hedge against inflation that buying pasture land offers.

The direct causes of deforestation are several and can be appreciated in Table 7.3. Among them, it is worth mentioning some distortions that make the act of clearing forests a highly profitable business: the land speculation that arises from the law that gives the right of owning a piece of land to whoever claims to have deforested it; a tax scheme that applies higher rates to lands not yet deforested and, moreover, that gives income tax exemption to enterprises who invest in Amazonia; subsidized credit to large cattle ranches engaged in large scale export crops as coffee, rubber and so on.[99]

[99]For a detailed exposition of Brazilian policies that encourage deforestation, see Binswanger(1989).

Table 7.3

DIRECT CAUSES OF DEFORESTATION

PRESENT MAIN REASONS	CONNECTION TO DEFORESTATION	IMPORTANCE BY REAL ESTATE SIZE SMALL PROPRIETIES	LARGE PROPRIETIES
Real estate speculation	Clearing grants the right of possession and increases the land market value	Important in land grabbers areas	Important in areas taken by land grabbers as well as areas legally documented
Tax incentives	Enterprises may avoid tax payments in other parts of Brazil if the money saved is invested in Amazonia	not applicable	Important to projects approved by SUDAM
Higher taxes	Higher tax rates are applied to land"not in use", that is not deforested	not applicable	It may become important
Loans at negative real interest rates	Government financing to farms has been made at lower interest rates than inflation rates	not applicable	It is important and,in general, it is superposed to tax incentives
Schedules for incentived projects	Farm projects have their shedules adjusted so that to take advantage of continous government financing	not applicable	Important in areas of SUDAM projects
Special loans for culturas	Cacao,coffee,rubber,sugar cane and annual cultures are financed by government and made attractive because of the generous terms at which they are contracted	Important in areas of colonization led by the government	Important to few large scale farms
Exportable production	Meat and to a lesser extent cocoa, rice and other cultures	Important for small farmers who depend on crop sales (for reasons of subsistence)	Important factor but, in general, farms have other activities
Subsistence production	Relatively smaller	Not very important	not applicable

Source: Fearnside (1988)

The tax and credit system resulted in a large number of projects being approved by SUDAM (950 by late 1985).[100] Most of these projects (631) were in the livestock sector. About 44% of the tax credit funds administered by SUDAM were channelled to livestock projects. Subsidies to SUDAM cattle ranches included grants of up to 75% of the ranch development costs; tax holidays of up to 100% if the amount due was invested in the Amazon region or in the Northeast; imported equipment used on these ranches were exempted from import duties; subsidized credits at negative interest rates; land concessions what meant free concessions of land at nominal prices.[101] As stated in Chapter 2, some recent changes in the Brazilian policy has meant stopping some SUDAM incentives, in particular those to the livestock sector. Although this should be seen in a positive way, it is too early to conclude that the causes of deforestation in the Brazilian Amazon have ceased to exist. Moreover, some causes of the deforestation process are related to specific features of the Brazilian economy, which means that it is still important to understand the causes of this process.

The indirect causes of the deforestation process are found in the particular features of the Brazilian economy, as said before what can be seen in Table 7.4 . High inflation rates make real estate speculation, especially pasture land, highly attractive to businessmen; population growth puts additional pressures both because of subsistence agriculture as well as because of the need to build more roads; low value of land in the Amazon region; geopolitical considerations that lead government to occupy Amazonia; the inexistence of laws that impose environmental costs from deforested areas; low productivity in agriculture.

---

[100] Mahar(1989)

[101] See Hecht(1989) The incentives for development summed US$ 600 million.

As Hecht(1989) points out, a whole industry- "a industria da posse"- has developed around clearing land for pasture, acquiring the rights of possession and speculating with its rising value in a context where the Brazilian government has commited itself to sustaining investment in Amazonia through large scale projects. Land has acquired value as a commodity in itself, instead of as an input into production (Hecht,1989). Moreover, claiming lands through pasture can disguise the holder's true objective of asserting royalty rights on subsurface

Table 7.4

Indirect Causes of Deforestation

Causes	Results
Inflation	a)Real estate speculation,esp. pasture land b)Increasing attractivity of subsidised loans for deforestation
Population growth; agriculture mechanization in the South of Brazil; absorption of small farms by large farms in the South and Northeast	a) Higher demand for subsistence production (minor factor) b) Increasing capacity to deforest and to plant both for subsistence and crops purposes c) Higher political pressure for building road
Building and improvement of roads	a) Migration of landless workers b) Migration of small owners to buy land
Low land market value	a) Migration to Amazonia b) Increase in the deforestation rates by people settled in Amazonia c) Speculative gains increase
National policy	a) Parties in power incentive the coming of colonists-increase in political representation b) Government programmes serve as a relief to social tension in Brazil
International geopolicy	a) Occupation in Amazonia is used as a means to protect the frontiers of the country
Concentration of land ownership in Amazonia	a) Small pieces of land tend to be absorbed by large farms, what results in the expulsion of people who will search for unoccupied land
Feeling of fear about the forest	a) The psychological aversion to forest inhibit the land uses that preserve intact the forest
Livestock status	a) The iberic tradition gives a higher social status to cattle ranchers
Possibility of alternative investments elsewhere in Amazonia	a) Many attractive opportunities sponsored by government lead businessmen to the lack of care about the sustainability of projects
Deforestation environmental costs are shared by the whole society	a) This makes projects that require deforestation more profitable than those that are linked to afforestation programmes
Deforested areas are put to unsustainable uses	a) It leads to deforest more areas to replace lands no longer productive

Table 7.4/Continuation

Demand for labour is low, given the economic activities in existence	a) A small size population can deforest and exploit a large area b) As those activities are very low labour intensive,there is further stimulus to deforest more areas
Low agricultural productivity	a) It results in that there is an increase in the demand for land with subsistence purposes (minor factor) b) Subsidised unproductive farms have an impact on inflation insofar as a monetary flux is created without a real counterpart

Source: Fearnside (1988)

minerals which are technically owned by the Brazilian state.[102] Cattle ranching has been the most important contributor to forest conversion. Given the 1980 Landsat images which point to an estimate of vegetation cover alteration (12,364,681 ha), pasture formation would account for more than 72% of the total deforested area.[103]

An important indirect cause of deforestation which certainly contributes significantly to speed up this process is that the distribution of costs and benefits is very unequal. The individuals making profits from deforestation are not the same as those paying the environmental costs. Benefits are concentrate in a small group of businessmen while costs are widely distributed. For instance, Browder (1988) shows that financial and economic analyses of the typical SUDAM supported ranch demonstrate that such operations have been uneconomic. The typical cattle ranch, without subsidies, fails to generate positive return from livestock production. The long term financial analysis indicates that livestock investors reap their profits only from governemnt tax and credit subsidies, allowing a large private return from such social unprofitable projects. If environmental costs of such projects were to be given a value, the overall economic unprofitability would be higher.

[102] see Hecht(1985) for an analysis of suitable frameworks to understand environmental issues in developing countries in the specific case of livestock development.

[103] See Browder,1988). He assumes an average stocking rate of one herd per ha and that in 1980, the estimated herd size was 8,937,000 head of cattle.

Figure 7.1

<u>The Brazilian Amazon</u>

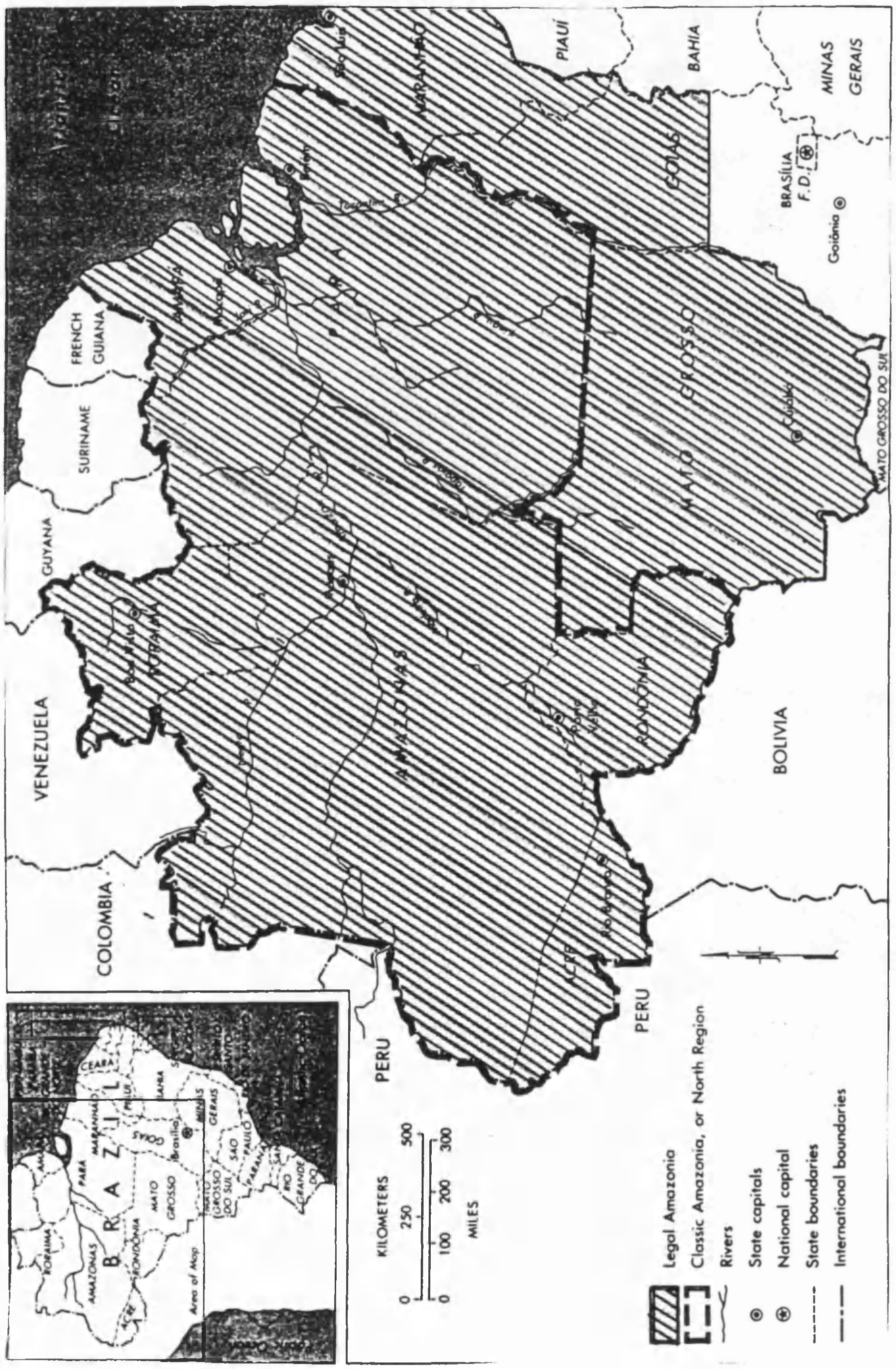
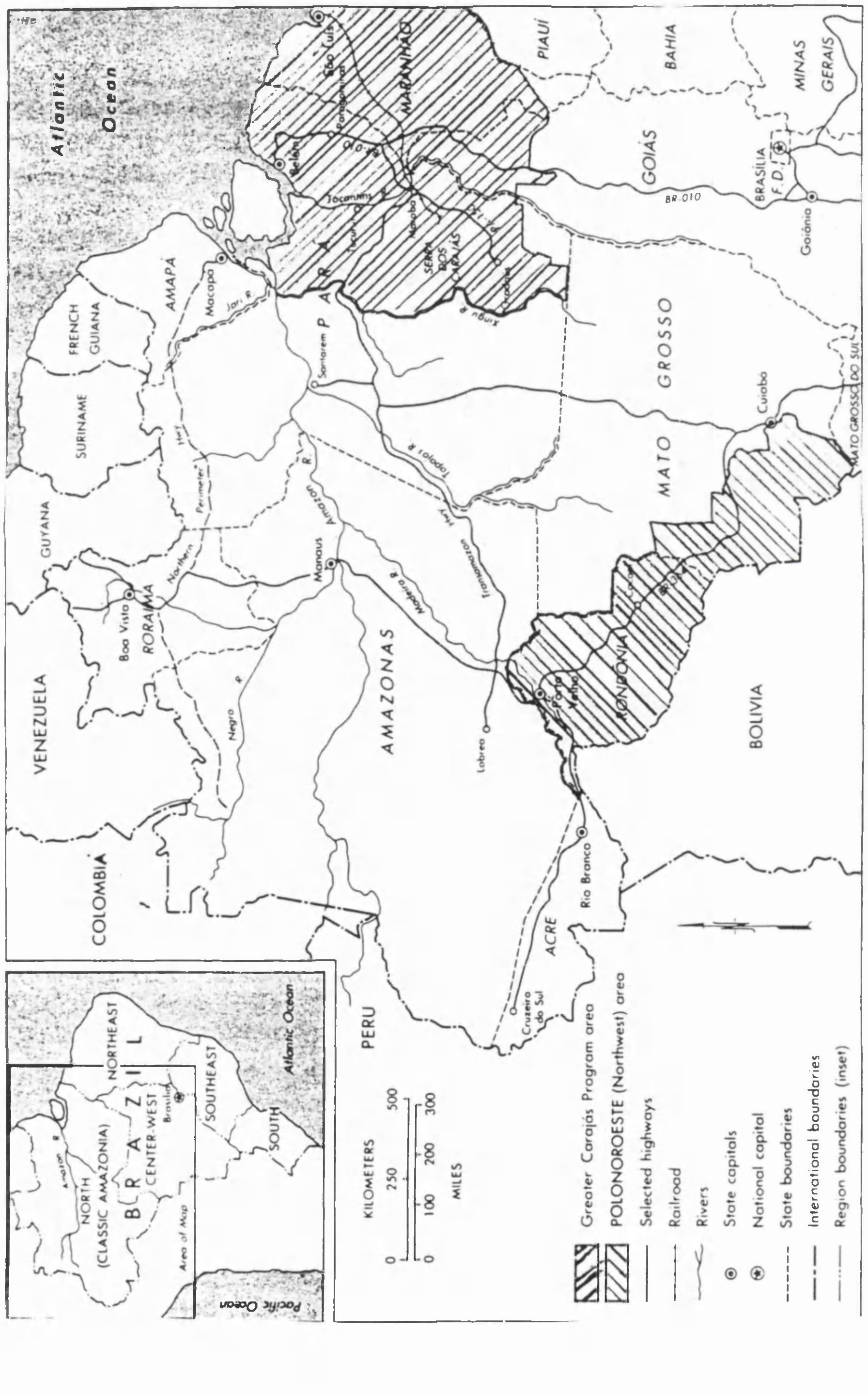


Figure 7.2

Amazonia Main Federal Highways



7.2) Deforestation due to the Carajas Iron Ore Project: Some Estimates

The integrated nature of the GCP programme requires that we analyse the environmental impacts of the projects belonging to it within a framework in which the linkages between industries is highlighted.

As suggested before, CIOP in itself contributes little to deforestation. The activity of mining does not require nor imply deforestation as an input to the productive process. However, the development of the pig-iron smelters along the railway has as an input the development of the charcoal industry, which induces deforestation. Although the dividing line between CIOP and the pig iron smelting industry is physically and juridically well demarcated, as long as there is a close economic relationship between CIOP and smelting, it seems reasonable that we analyse jointly their impact on deforestation. Moreover, given a probable retraction in the world iron ore market and that a major part of CIOP output goes to supply the pig iron industry, we are justified in analysing jointly the behavior of both industries. In fact, the conception of the whole GCP is compatible with a risk- averse behaviour of CVRD in the sense of securing alternative markets for its output (domestic and international). It is difficult to accept the World Bank vision that CIOP is an example of "environmentally sound" project as well as the argument from CVRD that it was undertaken the best in environmental terms. This seems contradictory to the integrated nature of the GCP programme in itself, in which CIOP acquires meaning as part of a wider package of investments intended to establish a pattern of development in the eastern part of Amazonia.

The company responsible for CIOP, CVRD, was given an area of 4,290 km^2, plus a narrow strip on both sides of the railway. CIOP was developed taking into account its potential adverse ecological impacts, and so, close attention was given to adopt mitigating measures so as to minimise them. The CVRD's experience acquired from its mining operations located in the southern part of the country, where less than 0.5% of the Atlantic forest remains as such, led the company to be very careful on ecological aspects since the very beginning of the project[104].

Even before the CIOP's approval, the company created an independent group formed by specialists who were to prepare a manual setting guidelines to be followed to protect the environment. Also, internal commissions in CVRD- CIMAs (Comissao Interna do Meio ambiente)- were created as permanent groups in the enterprise to implement and control the ecological policies so formulated.[105]Aspects linked to climatology, ecology, botany, and related disciplines were taken into account in the manual and the company followed policies designed to deal with forest clearing, topsoil, stockpiling, erosion control, vegetation regeneration, protection of fauna and other environmental matters. Between 1981 and 1985, CVRD spent around US$ 54 million on the environment protection from the CIOP adverse impacts, which included land reclamation, the creation of protected natural reserves and the promotion of environmental awareness and training (Mahar,1989).

However, large scale deforestation is expected to occur with the implementation of the metallurgy and charcoal industries along the corridor. The most recent targets of mineral production are shown in Table 7.5.

---

[104]See Freitas(1987),p.102.
[105]See Freitas(1986)

Table 7.5

Mineral and Metallurgy Production (1.000 tonnes per year) as Compared to the Original Targets (CVRD, 1981)

	Present production	Target GCP*	CVRD/1981**	GCP/CVRD 1990***
Iron Ore	30,000	35,000	35,000	35,000
Pig Iron	229	2,832	3,500	1,550
Steel(not yet approved)	---	3,500	10,000	3,500
Alumina	600	3,800	7,840	3,800
Aluminium	405	700	1,740	700
Manganese	---	800	---	800
Ferrous Alloys	---	320	550	670
Bauxite	---	100	18,780	100
Metallic Silicon	32	32	30	32

(*) Projects already approved by the GCP's Interministerial Council
(**) Production plans at the time of the GCP's conception(1981)
(***) Revised production plans in the PGC's Report(1988)

There is some controversy about the impact of the charcoal industry on deforestation. CVRD estimates assume that: 3.5 m^3 of wood are necessary to produce 1 tonne of charcoal; 0.8 tonnes of charcoal are necessary to produce 1 tonne of pig iron; 1 ha of forest results in 100 m^3 of charcoal. To achieve the GCP production target of 2.8 million tonnes a year, 1.1 million ha of forest would be required for the twenty year period.

Other estimates of deforestation as a result of the pig iron industry can be seen in Table 7.6.

Table 7.6

Estimated Deforested Area due to the Charcoal Demand by the Pig Iron Industry at the Annual Production of 2.8 million tonnes (1,000 ha)

Source	Annual Rate of Deforestation	Total Deforestation (in 20 years)
Mahar(1989)	90-120	1,800-2,400
Cagnin(1988)	48	960
Anderson(1989)	152	3,040
Fearnside (1989)	81	1,620

As can be seen above, the divergence in the estimates is significant (in the range 10,000- 30,000 km^2) for the 20 year period. Although this represents only about 0.2-0.6 % of the Legal Amazonia area, it is worth emphasizing that the limits to the growth of the pig iron and steel industry are given by the iron ore reserves in the Carajas mountains, which means that that value could be much higher in the future. This point will be further explored in the final chapter when some simulation exercises will be undertaken according to this line. Just to illustrate this, suppose that all the CIOP's output (35 million tonnes) is transformed into pig-iron. This could require that about 2.5-7.5% of the Legal Amazonia is deforested per year.

Another important point to consider in the evaluation of the environmental costs is that they should be put in perspective of the whole process of deforestation taking place in the Amazon region. This is because there is an important interaction effect among the environmental costs due to the various projects being undertaken there. Although estimates of deforestation from CIOP and the metallurgy industry are low when compared to the total forest still remaining, if we consider the sum of deforestation figures for the different economic activities, the total value will be significant (see section 7.1). Moreover, environmental costs of any project have to be corrected for the fact that the total environmental costs from all economic activities damaging in ecological terms the Amazon are not the sum of individual environmental costs. It has already been pointed out that ecological effects are conditional on what happens on the rest of the environment as well as on what will happen next.

So, in the estimation of environmental costs of CIOP and the pig iron industry, it seems more sensible to deduce the whole environmental costs from the several activities taking place in the region, and then assign a share to the Carajas project than the other way round.

7.3) The Economic Value of a Tropical Forest

At the end of the 1980s, global deforestation rates appear to be somewhere between 14 and 17 million ha per year(WRI,1990 and Myers, 1989). These figures correspond to 1.8-2.2% deforestation rates as a proportion of the area of remaining tropical forests.[106] By late 1970s, this rate seemed to be less than 1% per year, while deforestation rate levels lie around 7 million ha.(FAO, 1981). So, the global deforestation rate as a proportion of the remaining stock of tropical forests has accelerated not only due to an increase in deforestation levels but also due to a decrease in the forest stock, which is shown in Table 7.7 .

Table 7.7

Rates of Tropical Deforestation(million ha per year)

(Closed Forests Only)

	Late 1970s	Mid 1980s	Late 1980s
South America	2.67	9.65	6.65
Central America	1.01	1.07	1.03
Africa	1.02	1.06	1.58
Asia	1.82	3.10	4.25
Oceania	0.02	0.02	0.35
Totals	6.54	14.90	13.86
% of remaining forest	0.6	----	1.8-2.1

Source: WRI (1990)

Tropical forests are associated with many functions, all of them being economic in the sense that they contribute to human welfare,

---

[106] This area is taken to be 8 million km^2 or 800 million ha.

either directly or indirectly. Some of them are widely known and, in general, are those which have a monetary counterpart: hardwood supply, other forest products such as fruit, nuts, latex, rattans and so on and the provision of a recreational facility (ecotourism).[107]Besides those trivial functions, tropical forests are associated to other roles: they are the homeland of many indigenous peoples; provide the habitat for extensive fauna and flora (biodiversity), which is both valued in itself and also for educational and scientific purposes; have been the repository of animal and plant species of medicinal and crop- breeding value; protect watersheds in terms of water retention, water pollution and organic nutrient cleansing; scrub atmospheric sulphur oxide; fix carbon dioxide.

The concept of total economic value (TEV) applied to environmental resources attempts to value all the functions perceived as being performed by them, independently on whether or not monetary expressions are associated with. As components, we have to distinguish "user value" from "existence value". While the total user value component encompasses the value assigned to the use of environmental resources, both the actual and the option to use them in the future, the existence value component represents the people's preferences for their existence. This last component is called the existence value component.[108]The TEV concept will be further detailed in the specific context of forests later on.

The decision about the use of a tropical forest land, although still being made in a context of an imperfect understanding, should be done taking into account the wider range of functions performed by forests.

---

[107]Although the marketing of ecotourism is still in a very incipient stage, it is easy to think in how to make it a marketable service.
[108]See Pearce(1987)

Better forest management requires the evaluation of the important environmental services. Although there has been the tendency to concentrate on benefits which have a monetary counterpart, a proper evaluation of the total economic value of forests certainly has to be made taking into account all functions.

Cost-benefit approach (CBA) tells us that decisions to "develop"[109] a tropical forest would have to be made when the net benefits from development exceed those from conservation.[110] As a requirement to properly apply CBA techniques, a first step is to investigate the TEV of forests. Otherwise, a bias will be introduced against the alternative to conserve tropical forest.

Figure 7.3 shows the components of TEV, applied to the specific context of forests[111] .

---

[109]Development here means the uses made that are inconsistent with retention of the forest in at least approximately its natural state.

[110]Two dimensions: preservation and sustainable conservation, the first being equivalent to outright non-use of the resources and the second would involve limited uses of the forest consistent with retention of natural forest.

[111] See Pearce (1990)

Figure 7.3

Total Economic Value(TEV) of Forests

TEV

=

Use value + Non-use Value

Direct Value +	Indirect Value +	Option Value +	Existence value
(1)	(2)	(3)	(4)
Non and	Nutrient	Future Uses	Biodiversity as
timber products	Cycling	as per (1)+ (2)	object of intrinsic
Recreation	Watershed		value, as a bequest
Medecine	Protection		as a gift to others,
Plant Genetics	Air Pollution		as a responsibility
Education	Reduction		(stewardship)
Human Habitat			

Source: Pearce(1990)

The direct value component is straighforward in concept but not necessarily easy to measure. Given that research can still discover many applications from forest biodiversity, the true direct value from conserving a forest cannot be estimated for the moment. Indirect values stand for ecological functions while option values relate to the amount individuals would be willing to pay to conserve a tropical forest for future use. Existence value relates to valuations not associated either with current or optional use. It represents the individuals' preferences for the preservation of environmental assets. On the other hand, it should be stressed that there is a trade-off between the different forest land uses, not only at a qualitative level but also at a quantitative one. Moreover, the development of forest management systems can alter the balance between the different land uses in tropical forests on a sustainable basis.

The production of marketable products, one of the components belonging to the direct value category, can be broadly classified as timber and non-timber products (fruits, nuts, rattan, latex, resins, honey and wildmeat).

Logging for timber can be consistent with conservation if the timber management regime practises sustainable forestry. Non-timber products can be important sources of revenue. It may be the case that exports of non-timber products may exceed timber revenues. Tropical forest management may, in fact, be justified on purely financial grounds. Sometimes, clearing forests may be more profitable because governmental incentives distort the choice of putting land into timber and non-timber products.

Ecotourism may attract visitors to tropical forests from all parts of the world and this may be a substantial source of revenue.

Wild fauna in tropical forests generates revenue which may come from meat production, fishes, games, hides and skins.

Tropical forests are the the source of genetic material for modern food crops. Crossbreeding with wild varieties is essential to reduce diseases and pests; tropical forests are also the habitat of many insects that are the natural enemies of plant damaging pests and plant chemicals that are aused as inseticides. There are no estimates of the value of these functions and the informational needs for securing such estimates may be substantial relative to what exists in codified form.

The pharmaceutical value of tropical forests, expected to be high, poses serious problems. Many currently used drugs have as their origin tropical forests (one in four chance of any drug).

The indirect use value component includes watershed effects, nutrient cycling, carbon cycling (connected to the greenhouse effect), sulphur cycling and, probably, other effects not yet discovered. Approaches to measure such indirect use values have focused either on the cost of replacement or the damage done. Althoug there is uncertainty about the nature and extent of ecological functions performed by forests, certainly that the forests generate positive economic value.

Nutrient cycling includes the cycling of elements such as calcium, magnesium and potassium which are bound to soil and water, and elements such as nitrogen which are interchanged with the atmosphere. These elements are stocked in the biomass. Litterfall is critical in cycling the nutrients through rapid decomposition and take up through mycorrizal associations. Disturbance of forest systems release the nutrients into aquatic systems, which has to be valued.

One of the most important ecological functions of forests is in the photosynthesis process since they fix carbon dioxide and gives off oxygen. Deforestation releases CO_2 and thus contributes to the greenhouse effect. Estimating carbon credits is important to assess the TEV of forests. This aspect will be further treated in Chapter 8.

There is uncertainty about the nature of ecological functions performed by tropical forests. The forests certainly generate positive economic value. Given the uncertainties surrounding the ecological functions, a risk averse behaviour would lead to a very cautious attitude before deforesting them.

Non-use benefits refer to the value placed by individuals for the existence of tropical forests. Contingent valuation methods are used in which a "willingness to pay" is measured. CVM studies have not so far been applied to tropical forests, but have been for the existence of wild animal species. Existence values may be very high and they may dominate the use and indirect values.

Although the concept of the tropical forests value is reasonably clear, its empirical estimation is complicated due to the lack of precise knowledge about specific tropical forests, especially the Amazonian tropical forest, as well as the lack of suitable methodologies to measure some of its components. It seems that a lot of promising activities could be developed in the Amazonian rain forest but, in fact, few experiments have been undertaken(only the activities mentioned in Section 7.1). A lot of research and experiments, complemented by market studies, still are in need to serve as an input to the estimation of the TEV of tropical forests.

For instance, the assessment of the use value of the Amazonian forest raises questions. Potentially, many activities could take place there: agriculture, industry, extraction, rubber. Certainly, we can evaluate the use values derived from the activities taking place there. But alternative use values, both sustainable and non-sustainable, presupposes a lot of knowledge not only technical but also related to the behaviour present and future of certain markets.

Indirect values also pose difficulties in their estimation. Not only there is uncertainty on certain ecological functions provided by tropical forests but also on the importance of the Amazonian rain forest in relation to the total stock of tropical forests in the world.

Existence values, by their own nature, seem to be the easiest concept to apply. Although no market exists where people can show the intensity of their preferences for environmental assets, it seems that only operational problems would be the major obstacle to reach such estimates.

Presently, given the preliminary state of technical and scientific knowledge and uncertainty, the activity of estimating the value of the Amazonian tropical forest poses more questions than gives answers. However, in fact, an important dimension is present in the state of things as such they are. Economic activities, being taken there allows us to treat the Amazonian forest as a depletable resource. A high rate of deforestation, summed with the fact that practices of afforestation are not known succesfully lead us to treat the Amazonian rain forest as an stock which is disappearing and will be depleted in a future, if measures are not taken to prevent it..

7.4) Valuation Techniques

The search to put a price on environmental benefits or deterioration has originated the development of alternative methods that can be used in different situations.[112] A common argument against monetary evaluation of environmental resources is that some benefits and costs, by their nature, are very difficult to have a "price". However, we believe that the activity of estimating prices for environmental resources, although facing several practical and theoretical problems, is worth pursuing because it is unthinkable the view that this type of commodities is free to society, which is compatible with a zero price. According to conventional economic theory, scarce resources have to have a price.

Moreover, on the demand side, monetary values to evaluate environmental costs and benefits stand for the individuals' preferences for environmental quality. This does not depend on the marketplace where individuals can show their preferences for clean air, for instance, to make the procedure of putting prices legitimate. Instead, we only need that individuals have preferences for it. In this sense, clean air is an economic benefit insofar as it improves the welfare of people. Money in this context is just a numeraire to evaluate environmental benefits and costs.

In some contexts, environmental improvements will have a clear monetary counterpart: through increases in the production level or the quality level of crops before subject to higher levels of pollution, making more people to visit an improved area, among others. Even when there is

---

[112]For further details, see Pearce and Markandya(1988),(1986)

not a monetary value associated with an environmental improvement, for instance the value of saved human lives, still the approach is a licit one because the resources put to any use are limited.

To measure environmental improvements, the usual procedure is to look at direct markets, when this is applicable. Indirect markets (surrogate markets) or experimental markets can be used when direct markets simply do not exist.

In our study case, CIOP produces deforestation, causes welfare losses to Amerindian populations and, moreover, allows a type of industrial growth in the surrounding area which has further devastating effects on the environment. These last include deforestation, water and air pollution. Ideally speaking, we would like to put a price on the environmental damage that CIOP produces on nature, insofar as the Carajas project cannot be thought to result in any environmental benefit. This way, the environmental impact of CIOP in an extended economic-social appraisal will tend to reduce its social profitability.

Broadly speaking, there are two kinds of techniques designed to measure the value of environmental resources:direct and indirect. Direct methods seek to put a price on the environmental good in hand, either its use or existence value, through the measurement of benefits derived from them. Indirect techniques are based on alternative ways to measure benefits, in general using an approach that seeks to relate environmental benefits to a production process, broadly understood.

Direct Valuation Techniques

Basically, direct techniques use surrogate markets as a way to evaluate environmental benefits or, alternatively, when lack of data and related markets make this task difficult, experimental markets can be employed. As examples of the surrogate market approach, we have the "hedonic technique", wage risk studies and the travel cost approach, among others. As illustration of the experimental market approach, we have the "contingent valuation".

In the surrogate market approach, an important method is that known as the property value approach. This technique has as a first stage the identification of how much of a property value is attributable to its environmental characteristics. As a second step, the technique tries to infer how much people are willing to pay for an improvement in the environment.

In general, multiple regression techniques are employed at the first stage, either being cross section or time series data. All the variables that affect property values are to be included as explanatory variables (quality of the environment, acessibility, level and quality of local public facilities, taxes, etc.). In case of the exclusion of relevant variables, the coefficient estimates will be biased, as it is the case usually in regression analysis. The direction and magnitude of the bias will depend on how excluded variables are related to included variables and to the value of property. The choice of the variables to be included and the functional relationship as well as the measurement of the variables are problems that the researcher will have to face in this first step.

The inference of environmental benefits from the first step outlined above may turn out to present technical difficulties. What is sought, basically, is a measure of the consumer surplus for environmental improvements across different consumers. Compensated demand curves should be used. Moreover, there are a number of difficulties with the inference stage of the hedonic approach: the assumption implicit in the analysis of equilibrium; the issue of market segmentation; the possibility of mitigating the effects of environmental pollution by the installation of equipment designed to it; the need to clarify the concept of willingness to pay for exactly what; the link between annual benefits and present value benefits. There have been some empirical estimations of the impact of noise, air pollution on property values, among others.

Wage risk studies provide another illustration of how direct techniques can be used to assess the impact of environmental benefits. The wage rate reflects forces of supply and demand for a specific job with specific characteristics. The impact of the attribute safety on the wage rate has been the object of some empirical studies. If the market works freely and workers perceive the risks associated to activities, then we would expect that higher risk in occupations is compensated by higher wages.

The contingent valuation method (CVM) is another example of direct techniques put to evaluate environmental improvements. It consists of asking people what they are willing to pay for a benefit and/or what they are willing to accept as compensation to tolerate a cost. Asking may be either by using questionnaire/survey or it may be done in "laboratory" conditions. Basically, what is wanted is that people reveal their personal valuations about increases in environmental goods, if there are markets for these goods. A contingent market includes not only the provision of these goods but also the institutional context in which they would be financed.Two aspects make this approach particularly important: often this is the only technique available and it is potentially applicable to most contexts where there are environmental effects.

To avoid some biases, care must be taken in the design of the hypothetical market. If this is not done carefully, people will tend to not tell true valuations of the environmental goods being "hypothetically marketed". Strategic bias refers to the known example of the "free-rider", which arises when individuals are aware that in the case of public goods, their undervaluation will not mean their exclusion in the consumption of those goods. Design bias may arise from starting point bias, which is due to the influence of the first bid on the valuation of the environmental goods being marketed.Vehicle bias is due to the choice of the instrument of payment (changes in local taxes, entrance fees, surcharges or bills, higher prices for goods). Respondents may be sensitive to the choice of the payment instrument chosen. Information bias arise from the sequence of information supplied to the respondent. This leads to differences in the valuation of goods due to informational differences. Hypothetical bias arises from the nature of the experiment in itself. As long as individuals may act differently in the case of hypothetical and real payments, this bias is a possibility. Operational bias refers to the possible divergence between actual market conditions and actual operating conditions in the CVM.

CVM studies have shown that existence values may be very important. On the other hand, contrarily to what economic theory suggests, CVM studies have highlighted that willingness to pay and willingness to accept measures can differ significantly.

The travel cost method (TCM) approach is another method which is used to estimate the environmental benefits of recreational sites, such as parks, lakes, and so on. Travel cost methods have as an underlying idea that the money and time people spend to reach recreational places reveal their willingness to pay to enjoy environmental benefits.

TCM is an extension of the consumer theory in which the dimension of consumers' time value is introduced. In general, one can say that for workers the cost of getting to amenity places is the cost of travel, plus the entrance charge plus the foregone earnings. This would reflect their willingness to pay for each visit. Having information, we could plot the WTP and number of visits for many households. For similar households, we could derive a demand curve by varying the cost per visit (similarity here means income, preference for recreation and access to other recreational facilities). Given the demand curves, we could calculate the benefits of the site by taking the area under the these curves to obtain the consumer surplus. To obtain an estimate of environmental improvements, we need to know how much WTP would increase as response of environmental benefits due to a specific characteristic. By looking across sites, we will be able to trace out changes in this willingness to pay as facilities supply changes.

Although this technique has been used quite often, and, moreover, the TCM and CVM estimates tend to go together, there are a number of reservations about its applicability. It is a very demanding technique in terms of collection and codification of data. Also, it assumes that any travel undertaken to a site is solely for the purpose of visiting the site. On the other hand, the methodology has not yet reached a stage when one can rely on a standard technique to be used with confidence.

TCMs are useful for valuing recreational benefits in situations where sites are visited by a broad range of users specifically for recreational purposes and where adequated data on the characteristics of the site and the user are available.

Indirect valuation techniques

This kind of valuation method does not seek to measure environmental benefits by direct revealed preferences. Instead, it is estimated as a "dose-response" relationship between pollution, let's say, and some effect. Once we obtain this relationship, some measure of preference for that effect is estimated. The type of relationship may be the effect of pollution on health, on the physical depreciation of material assets such as metals and buildings, on aquatic ecosystems, on vegetation.

This approach is applicable to cases where people are unaware of the effects that pollution causes. Moreover, most of the environmental contexts can be properly dealt with. Once the dose-response relationship is established, indirect approaches then utilise valuations which are applied to the responses.

Basically, the steps to be followed can be summarized in the following way. First, the estimation of a physical damage function is required, that is:

R=R(P,other variables)

where R-physical damage and P-pollution

Once the coefficient of R on P is obtained, we have to calculate the change in AR due to an environmental policy. After that, we have to calculate AD=VAR, where V is the value placed to R and AD is the damage avoided by the environmental policy.

Some applications using this approach have been done. Many of them concentrated on health studies. A regression equation is formed which links health damage or mortality to factors such as income, race, diet, educatin, age, smoking habits.

Moreover, indirect procedures have been used in the case of materials corrosion. Air pollution affects exposed surfaces and causes corrosion of metals and deterioration of building surfaces. Data difficulties make the application of the method problematic.

It is important to distinguish between the standard housing stock and the stock of historical buildings and monuments. The indirect dose-response relationship is relevant to the former, because existence values far exceed user-values in the later case. It should be stressed that the estimated coefficients vary according to regions and are subject to large variations.

Another field in which this method has been applied is vegetation damage. It has been investigated the impact of increased ozone concentrations on agricultural products. Acid rain deposition and its effects on agricultural crops have also been studied. The influence of air pollution on forest damage has been investigated. Conversion processes during the transport of pollutants in the air play a role (formation of photo oxidants, strong acids, further oxidization of SO_2 into SO_4).

The simplest form to evaluate the economic value of the reduction of crops due to air pollution is to multiply the reduction in output attributable to the pollutant by the current price of that output. If the price is a market clearing one, still this way of calculation provides an approximation to the economic value of reduced output. This is because producers adjust their behaviour to higher levels of pollution, and so the impact of that pollution will have been mitigated. We need a model in which we could observe the producers' behaviour at varying levels of pollution.

In order to assess the impact of, for instance, a change in ozone concentrations or acid deposition, a model of the markets for the products affected is required, taking into account both supply and demand responses to varying levels of pollution. One can calculate the before and after pollution prices and quantities for each commodity. The change in the sum of consumer surpluses, plus the change in the profits of the producers, less any increase in government subsidies, is an approximation to the economic benefits of the change in pollution levels.

CHAPTER 8: AN EVALUATION EXERCISE TO VALUE THE AMAZON FOREST

8.1) Approach to Evaluating Environmental Costs of Deforestation in Amazonia

Forests, as suggested before, have economic value both as an stock and as a flow. As a stock, they are important in the performance of functions associated with the categories of use and non-use value. As a flow, the same is true. In Figure 8.1, we classify the potential uses of a forest mentioned in the last section according to being mainly associated with a stock or with a flow.

Figure 8.1

Classification of Forest Services According to Being mainly Associated with a Stock and/or a Flow.

	Stock	Flow
Direct Value	Non and timber products	Non and timber products
	Recreation	
	Medicine	Medicine
	Plant Genetics	Plant Genetics
	Education	
	Human Habitat	Human Habitat
Indirect Value	Ecological Functions (nutrient cycling, watershed protection, air pollution reduction)	
Option Price	Direct and Indirect Future Uses Cannot Take Place Without the Availability of a Minimum Stock	
Existence Value	Associated Mainly with a Stock	

Certainly that most of the direct uses of the forest associated with flows will be trivially associated with the availability of a stock. This classification is rather arbitrary because flows cannot exist without previous stocks and stocks today will generate flows tomorrow. However, this classification is useful to highlight the importance of holding tropical forests stocks today in a context of still imperfect understanding about the whole of functions performed by them. That is, if we are not able to assess all possible future flows derived from a forest, at least a value should be given to stocks today.

The assessment of the social cost of deforestation is an impossible task for the moment not only because of our limited knowledge as well as because of the lack of suitable methodologies. What is completely certain is that forests are being depleted at increasing rates and if policies are not changed towards them it won't take long before they will be exhausted. This fact seems to be of most importance in being incorporated in any evaluation exercise, which will be partial anyway, given our present state of knowledge. Moreover, in the specific case of the Amazon forest, an important factor to consider is that afforestation techniques are not successfully known up to the present.

Given these considerations, it seems sensible to treat tropical forests as assets which are being depleted at such rates that it won't take long to have them completely exhausted. This aspect is particularly true in what concerns the Amazonia. The evaluation of its stock value should receive some attention. A suitable framework to deal with the evaluation problem should include as preservation benefits not only use values but mainly the value of a forest as providing indirect value, option value and its existence value.

Some specific considerations further corroborate the interpretation of the Amazon forest as an stock which has to be evaluated. As mentioned in last sections, the uses that are being made in the Amazon have resulted in its partial depletion. It would seem meaningless to consider the environmental impacts of single projects and then sum them up because the environmental costs in a region of a certain pattern of development are not likely to be just the sum of environmental costs of single projects. There is likely to be an interaction effect. Moreover, we would be taking the risk to accept projects whose environmental costs seem to be low compared to the whole Amazon area. So, an attempt will be made here to analyse how preservation benefits from a stock evolve over time in a context of uncertainty, irreversibility and a positive rate of depletion. We will try to adapt the model formulated by Krutilla-Fisher (1975) and Pearce (1990) in which dynamic considerations are incorporated as well as the nature of preservation benefits is highlighted. In what follows, a brief description is given on the Krutilla- Fisher model (1975).

Krutilla and Fisher (1975) modelled the valuation and allocation of natural resources in a dynamic context in which there is irreversibility of investment decisions. They argue that irreversibility and uncertainty as a feature of the management of natural resources has to be considered where information about the costs and benefits of alternative uses is poor. Thus a dynamic framework has to be adopted when evaluating environmental resources. Basically, what they do is to contrast two alternatives: a) the development alternative; b) the preservation of environmental resources which, if so, would yield aesthetic and scientific benefits in perpetuity. Moreover, it is stressed the irreversible nature of development alternatives. Underlying the theory of exhaustible resorces, there is the idea that the resource has value only when extracted or when regarded as a store of future extractions. The conversion of natural resources can be treated as the extraction of a depletable resource, considering irreversibility at two levels: a) It gives rise to an user cost (foregone future extractive resource); b) the loss (in perpetuity) in value from the undisturbed environment. In the case of natural resources, the second loss may be more important than the first. This is because once an area is developed, there is irreversibility in the sense that particular patterns of geomorphology, weathering, and ecological sucession technology is not able to reproduce it in such a way that perfect substitution occurs. This is particurlaly true in what concerns the ecosystem constituted by tropical forests, about which the present scientific knowledge is limited.

The model is one in which planner is supposed to maximize net social returns from the use of the environment. The decision, or, in optimal control theory terms, the control variable, is the level of investment. Each increment in investment then adds something to the stream of discounted future benefits from the project while, at the same time, diminishing the returns from the natural resources. A brief outline of the referred model is provided, as well as its major results of interest here are presented.

<u>The Model</u>

Planner maximizes:

$$PV = \int e^{-\beta t} [\, b^d(S(t),t) + b^p(S(t), t) - C(I(t)) \,]\, dt \qquad (8.1)$$

subject to:

$$dS/dt = I$$

$$I \geq 0$$

$$S(0) = \overline{S}(0)$$

where:

β - the discount rate

t - time

$S(t)$- size of the project measured in physical units

b^d- net benefits from development(concave function)

b^p- foregone environmental benefits from preservation

$I(t)$- investment

$C(I(t))$- investment cost function

$\overline{S}(0)$- level of development at t=0

and $I>0$ stands for irreversibility in the model

The optimal solution is one which leads to "too little" development, that is, the time path of $S(t)$ will generally result in taking short-term losses, what means not undertaking current profitable projects whose net benefits are positive because a lesser level of development might be desirable in the future. This result is a direct consequence of the irreversible nature of the investment in this model.

The special case in which development returns are decreasing relatively to preservation benefits deserves further attention not only because it is likely to be applicable in empirical situations but also because important results arise in this context. Even not being able to estimate all components of the preservation benefits, the project-analyst may have the hunch that preservation benefits are increasing relatively to development benefits in a particular site of a project. This can be illustrated by constant net benefits from the project while the preservation benefits of its site are increasing due to the depletion of the stock of similar ecosystems in the world. A major result that arises in this context is that in order to determine whether or not to undertake a particular project, it suffices to compare its discounted net benefits with the discounted preservation benefits from not undertaking the project in question. The present value (PV) of project and no project cases over an infinite interval are given by :

Project case:

$$PV = \int e^{-\beta t} [\, b^d(S)\, e^{-rt} - C]dt \qquad (8.2)$$

No project case:

$$PV = \int e^{-\beta t} [\, b^p(S=0)\, e^{\partial t}]dt \qquad (8.3)$$

In the discrete case, we have:

Project case:

$$PV = \Sigma\, b^d (1+\beta)^{-t} (1+r)^{-t} - \Sigma\, C (1+\beta)^{-t} \qquad (8.4)$$

No project case:

$$PV = \Sigma\, b^p (1+\beta)^{-t} (1+\partial)^t \qquad (8.5)$$

where the variables are defined as before and r and ∂ stand for the rates at which project benefits are decreasing and preservation benefits are increasing, respectively.

In empirical situations, the decision rule should be to undertake a project only if the present value of its net benefits exceeds the present value of preservation benefits, as given by expressions 8.4 and 8.5, respectively. The outcome will depend not only upon the comparison of the magnitude of development with preservation benefits but also on the rate at which the latter are thought to be appreciating relatively to the former.

In our case, the model will be used in a slightly different version. As the analysis pursued here is of a "ex-post" nature, equation (8.5) will be estimated to evaluate the preservation benefits of conserving the Amazon forest as it stands presently. In our case, b^p would stand for indirect use, option value and existence value of the Amazon forest as well as the direct benefits from sustainable activities. ∂ is the rate at which the preservation benefits of conserving the Amazon forest are increasing, given the depletion of other tropical forests in the world. The present value of preservation benefits can be used to assess environmental costs due to deforestation assuming that there is a relationship between the stock of the forest and its value.

8.2) Use Values: Estimating Direct and Indirect Benefits

Direct Benefits

A brief outline of the characteristics of the Amazon economy is provided in order to calculate the net present value of its net income that can be generated on a sustainable basis. This last term will be made clearer later on, in the specific context of the Amazon region, but it can be advanced that, still, there are no clear rules of thumb to classify activities as being sustainable or not.

In Table 8.1, it can be appreciated the importance of the Amazon region in the Brazilian National Accounts.[113] Unfortunately, although more recent estimates of the Brazilian GNP exist, they are not disaggregated according to regions and so we have to rely on 1980 data.

Table 8.1

Gross National Product-Brazil- 1980- Cr$ 10^9 (Value in 1985 US$ 10^9)

	Brazil (1)	Amazon Region (2)	(1)/(2) % (3)
Total	12281(230)	782(15)	6.4
Agriculture and Cattle Ranching	1232(23)	174(3)	14.1
Industrial Activities	4700(88)	225(4)	4.8
Services	6349(118)	383(8)	6.0

Source: IBGE(1987)

[113] Here we are considering what is called the "Legal Amazonia", which comprises the states of Amapa, Para, Roraima, Maranhao, Goias, Acre, Rondonia, Mato Grosso, Amazonas.

The figures above are indicative of the contribution of the Legal Amazon region to the Brazilian GNP. Its overall 6.4% participation contrasts heavily with such a large part of the national territory. Except for agricultural and cattle ranching activities, whose participation is 14.1%, all the other remaining activities contribute very little to the generation of Brazilian output. The situation for the period 1980-90 is likely to be very close to the data shown in Table 8.2. Not only has the Brazilian GNP stagnated but also the Amazon region has not been able to increase its share of the GNP.

This result is surprising, considering that the Brazilian government has been taking a series of measures to promote the region since 1964. As was reviewed in Chapter 2, a whole package of incentives as well as direct governmental intervention in the region through large scale projects has been taken in the Amazon area. After all, it could be expected a better performance of the region towards contributing to the generation of the Brazilian output. This is especially true if we recall that the process of industrialization in Brazil really started in the beginning of the 1950s, just fourteen years earlier.

We can see in Table 8.2 the main products produced in the region. As long as there are no available statistics of the net income generated at that level of disaggregation, production value figures are provided in a first instance.

Table 8.2

Main Agricultural Products Produced in the Amazon Region-1986.

Product	Quantity(T)	Value(US$$10^6$) *	% of Total National Production
Rice	3,958,663	666	38.0
Bananas	107,198	79	21.3
Cocoa	49,636	76	10.8
Sugar Cane	10,789,914	112	4.5
Beans	235,757	76	10.6
Guarana	895	---	65.0
Jute	27,857	---	100.0
Mallow	35,840	---	100.0
Manioc	6,422,365	243	25.0
Corn	3,698,400	327	18.0
Black Pepper	42,068	---	93.0
Oranges	560,425	8	1.0
Tomatos	74,524	10	4.1
Soybeans	1,934,934	280	14.5

Source: Constructed by the author from original data in IBGE (1986), and IBGE (1987).

--- not available

The share of some Amazonian agricultural products in agricultural GNP is significative for the cases of rice, manioc, and, as expected, for exotic products such as pepper, guarana,jute and so on.

The composition of the vegetable production as well as its value and quantity are shown in Table 8.3.

Table 8.3

Main Vegetable Products Produced in the Amazon Region -1985.

Product Production	Quantity(t)	Value(US $ 10^6)	% of Total National
Acai	126,531	27.0	100.0
Buriti	903	0.6	76.0
Brazil nuts	45,020	9.2	100.0
Caucho	124	0.2	100.0
Copaiba	36	0.03	100.0
Cumaru	434	1.2	100.0
Hevea latex	40,895	48.0	100.0
Hevea liquid	1,581	0.8	100.0
Jatoba	17	0.04	74.0
Licuri	6,599	0.9	43.0
Macaranduba	364	0.01	100.0
Mangue	25	0.01	89.0
Palmito	126,040	4.0	95.0
Sorva	2,455	0.8	100.0
Timbo	25	0.01	100.0
Ucuruba	12	0.01	100.0
Urucu	66	0.01	8.0
Babassu	206,257	44.0	93.0
Jaborandi	1,990	0.5	92.0
Timber	22,320,020(a)	422.0	52.1
Charcoal	596,298	30.0	17.0
Fuelwood	41,650,135(a)	60.0	29.8
Total		650.5	

Source: Constructed by the author from original data in IBGE(1986).
(a) in m^3

As can be seen, the region is characterized by the presence of unique vegetable products, found only there. The total value of vegetable production (excluding timber, charcoal and fuelwood) is low, US$ 137.5. million These three last account for US$ 512.0 million.

The animal production in the Amazon region can be seen in Table 8.4.

Table 8.4

Animal Production in the Amazon Region-1985

Product	Quantity (t unless otherwise indicated)	Value(US$ 10^6)	% of Total National Production
Eggs	137,349(10^3 dozens)	75	6.4
Milk	1,530,120(10^3 liters)	245	12.7
Honey	137,768 (in Kg)	0.4	1.1
Bee wax	10,864 (Kg)	0.04	1.1
Fishes	195,940	92.0	23.0
Crustacean	30,873	34.0	27.9
Mollusc	2,916	0 3	35 8
Total		447.0	

Source: Constructed by the author from original data in IBGE(1986).

Looking at the figures and bearing in mind that 26%[114] of the livestock is in the Amazon region, it comes out that the productivity in the eggs and milk production is very low compared to the other regions of the country. Only 12.7% of milk and 6.4% of eggs are produced there.

114 Source: IBGE(1986)

Mining and extractive activities are presented in Table 8.5.

Table 8.5

Mining and Extractive Activities in the North Region -1985

Product	Raw(t)	Processed(t)	Value(US$ 10^6)	% of National Production
Aluminium	6,358,555	4,206,369	119.0	70.0
Calcareous	4,261,624	3,128,365	33.0	9.0
Caulim	565,931	221,158	21.0	29.4
Diamonds	92,007	136,913	0.1	4.8
Tin	21,234	42,746	503.0	95.4
Iron	1,671,100	1,285,000	12.0	1.0
Manganese	2,208,733	1,503,161	57.0	65.0
Gold(in Kg)	4,750,355	22,710	176.0	77.0
Tungstenio	---	22	0.02	1.0
Dolomita	173,635	325,047	1.8	8.7
Nickel	1,303,200	560,610	17.0	81.0
Total			940	

Crude Oil 9633760(m^3)

Natural Gas 2100558(103 m^3)

Source: Constructed by the author from original data in IBGE(1986).

On the other hand, the participation of the region in the industrial sector is almost negligible, as can be seen in Table 8.6.

Table 8.6

Industrial Sector- Amazon Region-1985

Product	Quantity (t)	Value(US$ 10^6)*	% of National Production
Raw Steel	8,789	1.6	0.04
Steel Laminate	7,988	1.3	0.1
Paper	36,557	17.7	0.9
Cellulose	212,646	102.9	6.3
Total		123.5	

Source: Constructed by the author from original data in IBGE(1986).

(*) Prices used as an sectoral average from BCB(1987)

Looking at the overall figures, we see that, still, the largest sector in the Legal Amazonia ranked by production value is the agricultural sector[115]. Mining and mineral processing activities contribute very little to the output value generated in the region(US$ 1,063.5 million). The temptation that large-scale projects as CIOP posed to the Brazilian government is high in this context: for instance, CIOP at full operation was thought to add US$ 700 million, almost the production value of the whole mining and mineral processing sector of the region. As CIOP is just one project, four or five other similar projects were thought capable of moving the Amazon region towards generating quick export- earning value in a region that was responsible for only 2% of the total Brazilian exports in 1985 and 5% of total imports (IBGE, 1986). However, as suggested in the economic appraisal of CIOP, there is a high cost to obtain

[115] Although production value is not an ideal measure to rank sectors by importance, there are no available net statistics at the necessary level of disaggregation

such large revenues, and it is just a question of comparing costs and benefits to realize that such projects are not necessarily so profitable as they may appear at first sight.

A figure that expresses the value of the economic activities that can be developed in the region on a sustainable basis is needed. In order to achieve it, first we need to discuss the nature of sustainability in the specific context of the region.

If sustaintability is interpreted strictly, it would mean the lack of deforestation as an input to the production processes of the several economic activities. This concept could be made more flexible to allow techniques of afforestation to be implemented: that is, certain economic activities could take place provided that environmentally compensating projects are undertaken. However, afforestation techniques have not been successfully implemented in the Amazon region, as suggested in the last chapter. Thus, the sustainability concept applied to the region cannot for the moment encompass the case of compensating projects in the case of deforestation. Moreover, technological considerations have to enter the analysis to determine whether or not certain economic activities can take place there. Furthermore, the sustainability concept to be properly applied requires an integrated approach. In these two last aspects, the CIOP case is very illustrative. While, in itself, CIOP could be considered as an example of a project which had no significant environmental impacts, the induced development along the corridor, especially that through the settlement of pig-iron industries, is a major threat to the Amazon forest, because of the required charcoal industry. So, to consider mining activities as sustainable or not, we have to introduce two dimensions in the analysis: the technology to be used and an integrated approach to assess what forward linkages are likely to occur as a result. The same is true about agricultural and industrial uses:

the sustainability concept has to be applied in a multi-sector framework as well as taking into account the technologies to be used.

To further illustrate the above, in the past, forest dwellers have exploited the forest in a way to guarantee a "balance" between the use of forest resources for economic activity and sufficient preservation to ensure ecological stability and sustainability. Hunting, fishing, growing of crops, food gathering and the use of trees to produce homes and canoes have been developed with minimal deforestation and degradation. Important cultural mechanisms have been employed to prevent this livelihood being threatened by overpopulation (Pearce, Markandya and Barbier, 1990). The same economic activities taking place there could have led the forest to its fate, if the intensity of their exploitation was enough to lead to such a dramatic result.

As we want a preliminary figure for the direct net benefits of the region, we take its GNP in 1980, US$ 15 billion from Table 8.1 . This is so because this includes activities that are sustainable by their very nature (as such vegetable production) and also other activities that, although not sustainable for the whole region, can be for a small part of it. In 1980, large-scale GCP projects hadn't been implemented and the rate of deforestation could be considered small (about 10%). A good strategy for the conservation of Amazonia is to release it from the export revenue generation function that the Brazilian government wants to assign to it. What has already been done in the region is irreversible and what will happen next depends on Brazilian governmental policies.

The Legal Amazonia's GNP in 1980 is taken as a proxy for the direct benefits in the empirical application of this study. We concentrate on suggesting ways to ensure that, in the future, sustainable methods are used to guarantee the generation of that value on a sustainable way.

Pearce, Markandya and Barbier(1990) suggest the establishment of zones according to their high protection, conservation value and economic use value in the sense of settling economic activities. This caveat is important because the three kinds of zone have economic value. High protection zones are those that have important ecological functions to perform.[116] High conservation value zones include forests with notably high concentrations of biodiversity.[117] The remaining Amazonian land could then be allocated to the best economic value (timber production, agricultural activities and so on). So, instead of trying to stop the development that is already there, which would inevitably lead to resistance, the Brazilian government should concentrate on managing it in an organized way.[118] For this, it is also required that the "mega" strategy for Amazonia is abandoned and creative mechanisms are devised to charge the rest of the world for the existence and option values as well as indirect ecological benefits. Moreover, tourism values could add significantly to the direct value component. Out of about two million visitors in 1985, only 2% went straight to the Amazon region, while 46% went first to Rio de Janeiro and Sao Paulo (IBGE, 1986). As conservation strategies for the Amazon forest are extremely important for securing it functionally intact, Section 8.5 sets some guidelines with that end.

[116]It includes areas that form important watershed functions, especially the regulation of water flowing to the highly productive alluvial plains and swamplands.

[117]High conservation value forests could be divided into those in which recreational tourism is allowed and those that are purely conservation reserves(protected area which could also include the livelihoods of indigenous forest-dwelling communities)

[118]See Hall(1989) for sustainable policies for the Amazon region. See also Hecht and Cockburn(1990) for a skeptical view on the zones proposal. These last authors think that there are no easy solutions: without the legitimation and participation of the communities involved towards finding solutions, it is unlikely that any technocratic proposal will effectively work out.

Indirect Benefits- Carbon Credits

Tropical forests are associated to several ecological functions. Watershed effects, nutrient cycling, carbon cycling, sulphur cycling are all examples of ecological functions which depend on the existence of forests to be properly performed. Valuation techniques, as Pearce (1990) highlights, tend to concentrate on either "damage done" or "cost of replacement". For instance, the removal of a tropical forest that protects a watershed can result in soil erosion,downstream sedimentation and increased floods. A measure of the value of the watershed protection function would be the damage done if there is forest removal, or alternatively, the cost to substitute the affected area. It has to be stressed that the whole of ecological functions credited to the existence of forests is still imperfectly understood. Yet, there has been some progress towards a better understanding on the nature and extent of ecological functions attributed to forests.

Watershed effects of forests have been related to maintaining rainfall levels, water supplies and floods as well as preventing soil erosion and sedimentation. Myers (1989) points that in the Ganges river system, deforestation of the Himalayan catchments territories has contributed to flood-and-drought regimes for 500 million smallscale farmers in India and Bangladesh, with costs in India alone worth over US$ 1 billion a year. In several other river systems of tropical Asia, such as Salween, Irrawaddy, Chao Phrayaand Mekong, there are similar deforestation-related problems of breakdown in hydrological functions, although in not such a large scale than in the Granger river. This claim is, however disputed by others. Yet, still there is uncertainty on the extent to which deforestation results in significant watershed effects. Hamilton and King (1983) provide a survey of claimed watershed effects and the empirical evidence for their existence. Basically, they suggest that results have to be qualified: impacts are conditional upon the use to which deforested land is put. The argument is that the subsequent land use is what matters, that is, the nature of the agricultural system, the nature of the logging system and so on. [119]

Nutrient cycling basically refers to the ability of forests to stock chemical elements such as nitrogen, phosphorus, potassium and calcium and, through litterfall, to cycle these elements avoiding them to pollute river and coastal ecosystems.

One of the most important ecological functions attributed to forests is carbon cycling, indirectly contributing to containing the greenhouse effect[120]. In the process of photosynthesis, forests "fix" carbon dioxide and give off oxygen. Deforestation, in its turn, releases CO_2 into the atmosphere and, thus, increases the level of the greenhouse effect.[121] The option to conserve a forest precludes the damage arising from putting the land to other uses and thus releasing carbon. In this sense, forests should be given a " carbon credit" equal to the damage avoided. Mature tropical forests are, however, in equilibrium and so they have a zero net carbon fixation.

The net amount of carbon accumulating annually in the global atmosphere can presently be reckoned to be around 4.0 billion tonnes (4 gigatonnes-GT). This figure is obtained through the difference between what is globally emitted (8 billion tonnes[122]) less what is absorbed by the oceans and other "sinks"(half of the emisions) (Houghton and Woodwell, 1989). Afforestation practices could be used to counter the

---

[119]See Pearce and Warford(1990), pp 42-44.
[120]See Pearce and Warford(1990), pp 46-50.
[121]See Myers(1989) for the greenhouse effect feedbaks on forests.
[122]2.4 GT from tropical forests and 5.6 GT from fossil fuels.

building up of carbon dioxide in the global atmosphere. According to preliminary estimates, 1 million km^2 of tree plantations could serve to absorb 1 GT of carbon per year throughout the period of major tree growth extending several decades. So, 4.0 million km^2 of reforestation would be needed to absorb the entire 4.0 GT of carbon dioxide built up each year. (Myers, 1989).

As long as the carbon cycling effect is, given the present level of knowledge, the best understood and the one which seems to be the largest, we will concentrate in this effect in the estimation of the value of ecological functions of forests.

For tropical forests two issues arise: a) what "carbon credit" should be given to tropical forests to avoiding the global warming impacts of deforestation; b) what contribution could afforestation make to containing the greenhouse effect. Pearce (1990) also proposes that a "damage avoided" approach to value the forests both as a carbon credit as well as to evaluate the monetary value of afforestation programmes.

The damage avoided approach to valuation results in an estimate of US$ 13 per tonne of carbon (Nordhaus, 1990). For such figure, Nordhaus (1990) estimated the cost of global warming on the American economy in 1981. Economic activities were classified according to their sensitivity to climate impacts. The impacts of a $3^{\underline{0}}$ C warming on the sensitive sectors were estimated for selected variables.[123] The damage effects from that warming effect was estimated to be 0.25% of the US National Income. This estimate was "ad hoc" adjusted to 1% to incorporate neglected impacts of the warming effect on variables such as human health, recreation, biological diversity, environmental quality, water systems and so on. Assuming that doubling CO_2 concentrations

---

[123]Variables such as lower yields in crops, sea level rise affecting land use and land values, increased demand for space cooling and space heating.

imposes costs on the order of 1% of world output, a value of US$ 13 per tonne of CO_2 equivalent emissions is estimated.[124]

On average, deforestation of one ha of land contributes some 100 tonnes of carbon to the atmosphere in a single year. [125] At some US$ 13 per tonne damage, it follows that deforestation causes damage at a rate of some US$ 1,300 per ha. If applied to the Brazilian Amazonia, this would result in a total value of US $ 71.5 billion.[126]

Following the estimates of Myers(1989) previously mentioned that 1 GT of carbon per year requires 1 million km^2 to be absorbed, or 10 tonnes of carbon per ha per year, the carbon value of afforestation programmes can be calculated. According to the previous estimate of US$ 13 per tonne, the value of the carbon credit in the context of afforestation programmes would be around US$ 130 per ha per annum.

---

[124]The concept of CO_2 equivalent emissions of a greenhouse gas(GHG) converts the amount of a GHG in the quantity of CO2 that would lead to the equivalent amount of total warming, incorporating the aspect that this last has lasting effects over the indefinite future. See Nordhaus (1990) for a more detailed explanation.

[125]See Pearce(1990, p.48) adapted from Houghton(1989). This estimate is based on a sample of 34 countries in which rates of deforestation are associated with the amount of carbon released , what depends on the uses put to land after deforestation.

[126]The assumptions are that the storage of biomass equivalent is some 50 billion tonnes; 11 billion tonnes of carbon would be released if the Brazilian Amazonia forest was burnt(Fearnside, 1985); half of this carbon emission would be absorbed by other sinks, thus 5.5 billion tonnes would be emitted and to offset it, it would be necessary to invest £ 93.5-115.5 billion

8.3) Non-Use Value: Existence Value

8.3.1) The Contingent Valuation Approach Framework and Possible Applications

In contingent valuation experiments people are asked what they are willing to pay for a benefit or what they are willing to accept to tolerate a cost. The contingent valuation method is based on market creation techniques designed to reproduce the relevant conditions as if a market existed. Respondents are asked their personal valuations for increases or decreases in the quantity of some good, in particular in the case of environmental improvements or decreases in environmental quality, if a market existed. It could also be the case that individuals are asked whether they are willing to pay (WTP) or willing to accept (WTA) a particular figure.[127] It should be stressed that a contingent market includes not only the good in itself whose value is sought but also the institutional framework in which the good would be financed. The contingent valuation method (CVM) has been applied to a variety of situations, in particular improvements in water and air quality, to value the option and existence values of species and sites, and, increasingly, theoretical efforts have been devoted to find other situations where the method could be successfully applied. For instance, in developing countries the method promises to be a way of assessing how far individuals are willing to pay for infrastructure projects whose benefits will accrue to them. Moreover, in the next subsection it is shown the

[127]There are variations of the method, in particular, contingent ranking, in which respondents are asked to rank outcomes consisting of different combinations of goods and forms of payment.

potential application of the method to the up to now new situation of tropical forests.[128]

Some issues arise in the context of the CVM. As suggested, the aim of the CVM is to elicit valuations which are close to those that would be revealed if an actual market existed. So, great care is needed to design and simulate the conditions of the hypothetical market. The first issue is that respondents should have a kind of "full information" on the good in question. If the good is improved scenic visibility, for instance, this could be achieved by displaying photographs of the view with and without particular levels of pollution. If the good is conservation of a tropical forest, a film could be used to show the exuberance of such ecosystem. Moreover, other issues arise that have to be dealt with if the responses are to be given any credibility: what form the survey should take to avoid intrinsic biases of the method.

In general, it is believed that a personal interview is the best way of survey, although mail surveys and telephone interviews have also been used.[129] The problem with personal interviews is that they may be quite expensive to undertake, what might impose a limit on the survey sample size. The second important consideration is the way in which the change will be undertaken: this concerns not only if a particular agency will be responsible or not for the provision of the good but also how the "project" will be financed. In this last connection, it could be the case of voluntary contributions, increases in income tax rates, introduction of charges and so on. The third important issue is the method by which the WTP or WTA is measured. Basically, there are

---

[128] For a good introduction to the CVM as well as its applications, see Cummings et. al. (1986); Mitchell and Carson (1989); Markandya (1991) for a brief introduction to the method as well to a comparison to other possible methods of evaluating environmental benefits.

[129] See Markandya (1991).

three methods that have been used to enquiry the WTP or WTA of respondents. They are described in what follows.

The first method consists of a simple question: what is your maximum WTP or minimum WTA? The second is the use of an iterated procedure, where the interviewer starts with a given value and asks whether the WTP differs from that value. If it is more the interviewer increases the figure and if it is less the figure is decreased. This iterative technique, called bidding games, is carried on until the desired answer is reached, but rarely extends beyond three questions in order to avoid respondent objections to repeated questions. The third method consists of asking respondents whether they are willing to pay or to accept a determined sum for the effects of a determined action. The answer, which could be yes or no, is recorded and no further question is asked. This last method has the disadvantage of conveying less information on the true WTP or WTA of respondents but it presents the advantage that the responses can be analysed using discrete data techniques. On the other hand, the literature has identified sources of errors in the estimates obtained from the CVM, which can be broadly classified as hypothetical context bias, information bias, strategic bias, and vehicle of payment bias. Each of these will be treated in what follows.

Hypothetical bias arises because of the inherent nature of the method: as the situation being described is hypothetical, the WTP and WTA figures are not actually paid or received. Clearly, this presents a risk in the application of the CVM: answers may not correspond to the amounts that individuals would be willing to pay when the time comes to express "real" values.[130] Yet, there are ways through which this source of bias can produce errors considered acceptable. A first

[130]Analysts discuss hypothetical bias in terms of content, criterion and construct validity. See Mitchell and Carson (1989).

requirement to minimise hypothetical bias is to present choices as close as possible to actual choices. Another point is to pass information regarding the choices in terms that are comprehensible to the respondent. Finally, the respondent has to be given enough time so that to formulate the response. In order to assess the extent to which hypothetical bias affects valuation estimates, some empirical works have been undertaken based on the comparison of estimates obtained through the CVM and from other methods where actual payments were involved.[131] Generally speaking, the results showed that the WTP estimates obtained from CVM and from experiments where actual payments ocurred did not differ significantly. However, for WTA estimates the figures may differ substantially between actual and hypohetical payments methods. [132]

Design bias, or sometimes called information bias, is similar to hypothetical bias. Yet, this bias refers rather to the CVM format design than to the context in which choices are to be made. For instance, in bidding games where respondents are given a preliminary figure, it may happen that what is called the starting point bias arises: responses are influenced by that figure. Clearly, if the mean maximum WTP is close to the questioner's starting point, this is a sign of potential starting point bias.[133] On the other hand, another source of design bias, sometimes called more specifically vehicle bias, may arise from the method of payment being proposed in a determined survey: surcharges, fees, taxes

---

[131] In this connection, see Johansson (1987).

[132] See Markandya (1991) for an explanation on why there is such divergence. Psychological factors have been pointed out as possible determinants of the difference in estimates of WTP and WTA as long as people need more in the way of compensation for lost things than they are willing to pay for what they may get. This is because what matters is is not the final set of goods that a person has but the changes in that set relative to some reference point.

[133] This can be avoided by adjusting the design through some pretesting of the questionnaire.

and so on. Responses should not get affected by the method of payment being proposed. Information or design bias may also be associated with the agency that is identified as undertaking the improvements. One possible way to correct for format design bias is to adopt the discrete "accept-reject" format, in which a bidding procedure is eliminated. Moreover, this last has the advantage that, once it has been decided that an improvement project will be undertaken, people will be paying the same amount of money, what makes things easier to implement once it has been decided so.

The last important source of bias is what is called strategic bias, by which responses may be affected by the self interest of respondents. This is related to the incentive to give undervaluations of a public good which, if provided to one person is provided to all. Incentives for truth telling have to be incorporate in any CVM design The empirical evidence shows that even with weak incentives for truth telling, the presence of strategic behaviour can be overcome.[134] So, this source of bias should not be seen as a major hindrance to the proper application of the CVM, if precautions are taken in the design format of such studies.

CVM has been used to value environmental improvements as less air pollution, better water quality, as well as to elicit preferences for the option and existence value components of species and sites. It should be stressed that most of those studies have been undertaken in developed countries, independently on the object of valuation being in developed or in developing countries. More recently, this technique has been increasingly used in developing countries to value the provision of water, sewerage and other infrastructural facilities. As the urbanization process in most developing countries is taking place at very high rates,

---

[134]See Pommerehne et. al (1982); Coursey et. al. (1987); Randall et. al. (1985)

official financing agencies as the World Bank and IDB have increasingly relied on CVM tecniques to test the possibility that the own beneficiaries of many infrastructure projects are willing to finance them. As official sources of financing seem to be of inadequate size to meet the forecast needs of urban populations in developing countries, and, on the other hand, governments in those countries are severely constrained by budget problems and structural programmes, there seems to be no other way to finance important projects other than by local populations themselves. Studies have shown that, in fact, the CVM technique can provide a valuable tool for enquiring local populations in developing countries on the extent to which important projects can be financed by them.[135]

The application of CVM techniques is not problem free, as suggested before. However, there are ways of overcoming the limitations inherent to the method, as also suggested before. The main advantage of the method is its versatility: a variety of different situations can be properly dealt with if the precautions to avoid the biases are taken. As the method can be easily applied to the context of developing countries, one would expect that its use will be increasingly done in the valuation of environmental benefits in those countries.

---

[135] See Whittington et. al. (1991), Briscoe et. al. (1990) for the application of the CVM in developing countries

8.3.2) The Contingent Valuation Approach Applied to the Existence Value Component of the Amazon Forest

In principle, the contingent valuation method could be used to find the existence value of preserving the Amazonian forest. A proper questionnaire to avoid the intrinsic biases of the process should be designed. Both developing and developed countries would have to be enquired about their willingness to pay for preserving the Amazon region. Up to now, no study has been carried out for tropical forests' evaluation.

One aspect that should be given enough care would be how to make respondents become aware of the whole Amazon forest in its exuberance. Photographs are not completely suitable because they can only partially show the largest tropical forest of the world. Ideally, respondents should see a film on the Amazon forest to realize what is involved when it comes the time to value the existence component of this forest. This is a major problem in using the CVM in the context of the Amazon forest. Certainly, such problems could be overcome with enough resources. However, theoretically speaking, this problem does not eliminate the possible application of the CVM in this context. Alternatively, more practical solutions as showing photos to the respondents as well as describing what is the Amazon forest could be taken in the absence of the huge resources needed, as would be the case in the ideal way of people becoming familiar with the whole ecosystem in question.

Bearing in mind the biases that arise in the CVM context outlined in the last Subsection, it seems that the one which could arise in the context of the Amazon forest is information bias. Strategic bias does not seem applicable to this case because of the own definition of the problem: there is no reason to expect that people will behave in their self interest in evaluating the existence value component of the Amazon forest. Yet, it is the case that information bias might affect the results. For instance, respondents in developed countries could be affected by the way the existence value component was to be secured: if this is left only to the Brazilian government, without any international agreement on it, the WTP could be underestimated because of credibility problems. Moreover, the method of payment chosen in such a survey could affect the WTP of respondents. Another important point is that estimates of respondents in developed and developing countries could differ substantially just because of the different socio- economic characterists prevailing in these two groups of countries.

In order to illustrate the method, a simple questionnaire was designed (see Annex 8.1) and applied to a limited sample.[136]Specific care was given to avoid starting point bias through the provision of wide value ranges to respondents. The results suggest that, still, people feel unable to give meaningful answers to questions 1 and 2, that is, the world willingness to pay for the preservation of the Amazon forest. On the other hand, most answers to question 3 indicate a value of US$ 2 per week, what would result in a value of US$ 96 per year to pay for the existence of the Amazon forest on a personal basis. Considering the adult population of the OECD members (500 million), this would give a value of US$ 48 billion per year. However, this figure is likely to be overestimated because of the fact that the sample was constituted by

---

[136]The size of the sample is 50. The sample only included people familiar with the concepts involved.

environmental economists, who might have a higher willingness to pay for natural resources.

8.4) A Model to Evaluate the Preservation Benefits of the Amazonian Forest

As already said, preservation benefits have an important dynamic nature, because the problem of allocating environmental resources is essentially of a intertemporal nature. Conservation of the Amazonian forest should begin with an appreciation of its value as an economic asset, endowed by nature. The Amazon can generate benefits in perpetuity. A dynamic framework to evaluate the total economic value of the Amazonian forest is suitable, and in which we can allow an appreciation rate. The rationale for allowing an appreciation rate to be applied over the preservation benefits of the Amazonian forest lies not only because of its nature as an economic asset but also because forests all over the world are being depleted and, so, the remaining stock is to become more valuable to society with the increase in their scarcity.

Here, an attempt will be made to integrate the Krutilla-Fisher (1975) approach outlined in Section 8.1 with the framework provided by Pearce (1990), which gives important insights about the nature of preservation benefits of forests. This way, we can calculate the total economic value of the Amazonia forest so that we can assign environmental costs to CIOP.

An important conditioning factor to develop the model is the Brazilian governmental policy towards Amazonia that will prevail in the future. This is because the economic value of this environmental asset depends on the present and future uses that will be made of it. Two radical assumptions turn out: a) the Brazilian government will maintain and intensify the economic activities taking place there which would lead to its complete depletion in a finite period of time and, so fully "developing" Amazonia; b) the Brazilian government will be concerned with the sustainability of economic activities to take place there and will only allow those activities that can be managed without harming further the forest. In the first case, we know from Pearce and Myers's (1989) remarks that we could not sum the different components of the total economic value of the Amazonia because, for instance, existence value is incompatible with user-values. So, we would have to concentrate mainly on the estimation of the present value of direct use values. Existence and option values would clearly tend to zero in terms of an existing forest stock. In the second case, user and non-user values should be summed up: direct, indirect, option and existence values should enter into the calculation. As it is likely that the second estimation leads to a higher figure than in the first case, and, on the other hand, the features of irreversibility and uncertainty are present in our analysis, it seems more sensible to follow the second alternative, thus assuming that all economic activities that have negative environmental effects will be halted. In this case, the following equation stands for the total economic value in a given period of time (TEV_t), once it has been decided that the Amazon forest will be conserved as it is presently:

$$TEV_t = \text{Use Value}_t + \text{Non-Use Value}_t \qquad (8.a)$$

where: Use value $_t$ stands for: a) direct use value net income generated by sustainable activities in a period of timet (DV_t)

b) Indirect value- value attributed to the ecological functions performed by forests, mainly the carbon credit value in a period of time t (IV_t)

c) option value- by its own definition is a function (g) of future direct (DV_{t+i}) and future indirect values (IV_{t+i})

Thus, we have: $-g(DV_{t+i}, IV_{t+i})$

$i=1,2,3......$

<u>Non-use value$_t$</u> refers mainly to existence value(EV_t)

Equation (8.a) broken down into its components becomes:

$$TEV_t = DV_t + IV_t + g(DV_{t+i}, IV_{t+i}) + EV_t \quad i= 1,2, 3,........ \quad (8.b)$$

DV_t was estimated in section 8.2 and was found to be a value of US$15 billion in 1985 prices[137]. The indirect value can be estimated in a first instance by carbon credits as undertaken by Pearce (1990). Accordingly, an annual value of US$ 71.5 billion in 1990 prices was found. Option value is a function of both direct and indirect use values and its form depends on intertemporal preferences of society as well as on how society reacts to leaving or not options open for the future. At this stage, it seems difficult to rely on specific forms to model the option value. Finally, existence values could be estimated using survey techniques, so that people can reveal how much they want to pay to have that environmental asset preserved either for themselves or for future generations. As was suggested in section 8.3, a limited step was taken in the sense of asking people about their willingness to pay for the preservation of the Amazon forest. The personal valuation of environmental economists who felt able to reply resulted in an aggregate value of US$ 48 billion per year for the existence value component. Given the expected upward bias, given that those people are supposedly more concerned with environmental matters, we set the annual existence value for the Amazon as US$ 30 billion. So, except for the option value, the total economic value of the Amazonia would be on the order of US$ 120 billion in 1990 a year.[138]

---

[137]See section 8.2 for the assumptions required to arrive at that value.
[138]DVt has been inflated to 1990 prices.

Another approach to find the total economic value for Amazonia is proposed here, in which we define exogenous values for the components of the TEV_t as being those for which there is a market or a market can be simulated (basically, direct and existence values). Endogenous values for the components of TEV_t would be those for which their determination would depend on the determination of the total economic value. This could be thought for indirect use value and option price. This is not only an analytical devise but also it can be rationalized in the following way. In the case of indirect use value, we can think that the existence of forests should be subsidized, following the analogy with taxing products environmentally damaging.[139] So, carbon credits would add to the total economic value of forests. Moreover, it is likely that option prices depend on the total economic value of forests, both trivially, through the future components of direct and indirect values and on the existence value, and through the bequest motive for future generations.

So, DV_t, EV_t are determined outside the model, by either market or simulated markets, and indirect and option values (IV_t and OV_t, respectively) by:

$IV_t = a\,TEV_t \qquad 0<a<1$ (8.c)

$OV_t = b\,TEV_t \qquad 0<b<1$ (8.d)

It follows that equation (8.b) becomes:

$TEV_t = DV_t + a\,TEV_t + b TEV_t + EV_t$ (8.e)

Solving, we get:

$TEV_t = (DV_t + EV_t) / (1 - a - b)$ (8.f)

---

139 See Pearce, Markandya and Barbier(1989) where the authors propose to tax commodities whose production and/or consumption induce the release of greenhouse gases.

Maintaining the values for DV_t, EV_t previously found and assuming a=b=0.15, we get a figure for the total economic value of the Amazonia in 1990 of the order of US $ 70 billion. The parameter "a" stands for the rate of "subsidy" given to the Amazonian forest as a carbon credit. Ideally, its value should be equal to the tax applied to greenhouse releasing commodities. Supposing that such tax is 0.15, this same value, 0.15, is used here to stand for the rate of "subsidy" given to the Amazonian forest as a carbon credit. The parameter b represents the social preferences for leaving future options open. Ideally, we should know the extent to which people are willing to assign value and to pay for conserving the Amazonian forest to future uses, either through a better knowledge on their preference maps or through directly enquiring them. The value of 0.15 should be interpreted as a lower estimate: people want to increase the Amazonian forest TEV by 15% , representing their preferences for the future direct and indirect functions to be performed by such asset.

On the other hand, we need to integrate the two approachs. The present value (PV) of preservation benefits (TEV) of the Amazonia is given by:

$$PV = \int \frac{TEV_t(1+\delta)^t dt}{(1+r)^t} \qquad (8.g)$$

where δ is the rate at which the Amazonia forest is appreciating, r being the rate of discount.

The next step is to estimate δ. It seems sensible to use as a proxy the rate of depletion of other forests all over the world, reflecting the fact that, as forest stocks are being reduced, one would expect that the price of the remaining forests increases.

Estimation of the Parameter ∂

Recent estimates[140] point to a global deforestation magnitude of the order of 142,200 km^2 per year, an area equivalent to almost 60% of Great Britain or West Germany. Considering that the remaining world stock of forests comprises 7,783,500 km^2, the global deforestation rate amounts to 1.8% per year. On the other hand, the total deforestation for 1979 was estimated to be around 75,000 km^2, which means that there has been an acceleration in the annual deforestation rate of 67,200 km^2, an increase of almost 90%. (Myers, 1989).

In the Latin America scenario, Brazil is responsible for holding 54% of the region's forests, while this figure is reduced to 28% if we consider the whole stock of forests. This country has the highest rate of deforestation per year (around 50,000 km^2 since 1987), although still a low proportionate rate (2.3% per year), given its largest forest stocks.

The ten leading countries in deforestation values are: Brazil, Burma, Colombia, India, Indonesia, Malaysia, Mexico, Nigeria, Thailand and Zaire. These countries are collectively loosing their forests at a figure of 106,300 km^2, what makes 77% of the total world deforestation. On the other hand, three countries (Brazil, Indonesia, Zaire) hold 52% of tropical forest stocks, corresponding to 4,012,000 km^2.

Patterns and trends of deforestation are extremely varied across continents and countries. In Southeast Asia, it is likely that all forest will be eliminated by the end of the century in countries such as Thailand, Vietnam and virtually all primary forest in Philippines and Burma. It is also expected that, little forest of whatever sort will remain in 20 years'

---

[140]Figures that are presented, unless indicated explicitly, refer to forests destruction, not including degradation.

time in most of Malaysia and Indonesia outside the Kalimantam and Iriara Jaya. The situation is quite different in Papua New Guinea with its low population pressures: sizeable tracts of forest are believed to remain for several decades into the next century.

In Africa, if recent patterns and trends in deforestation are maintained, countries as Madagascar, East Africa and West Africa will reach the end of the century without any forests, due to the pressures of population growth and impoverished peasantry. However, in the Zaire Basin comprising Gabon, Congo and Zaire, population pressures virtually do not exist what, combined with the endowment of mineral resources, result in that forest stocks are little exploited.

The overall situation in Latin America is dominated by what will happen in Brazil concerning the vast Amazonian forest. Yet, it is expected that very little forest will persist long into the next century in Mexico, Central America, the Atlantic coast sector of Brazil and Amazonian Ecuador. The Amazonian sectors in Colombia, Peru, and Bolivia are also likely to be eliminated by that time, differently from the Venezuelan sector. As mentioned before, Brazil holds 54% of the region's forests. The vast area of Brazilian Amazonia forest opens the possibility that Latin America will contribute to the world forest stocks by the end of the century in a significant way, depending on what will be done there.

Although not consensual, there is reason to suppose that deforestation rates will grow not in a linear manner, but rather in an exponential way. In the 1980s, there has been a 90% increase in the annual deforestation rate. The 1990s could well see that rate be as high as 150%.

We want, at this stage, a value that stands for the appreciation rate that Brazilian forest would have if the Brazilian government took measures to stop deforestation while other countries' policies stayed the same. Also supposing that the overall rate of annual deforestation will increase to 159% in the next decade, this means that the forest stock will be disappearing at a rate of almost 240,000 km^2 a year, which, in the year 2000 would leave only about 6,000,000 km^2 of forests. A loss in the year 2000 of 240,000 km^2 of forest per year would work out at 4% as deforestation per year of remaining forests. Considering the impact of Brazil stopping deforestation, this would result in a 3% deforestation rate per year of remaining forests.[141]

Estimates for the Amazonian forest.

Thus, setting r=10% and using ∂= 3%, we can find values for the present value (in perpetuity) of the Amazonia in the framework designed before, which is summarized by:

$$PV = \sum_t TEV_t \, (1+\partial)^t / (1+r)^t \qquad (8.h)$$

Using the value of US$ 120 billion for TEV_t, the present value is US$ 1,715 billions. Using the other estimate for the TEV_t = US $ 70 billion, the present value for the Amazonian forest is US$ 1,000 billion.

With an approximate area of 3.6 million km^2, the economic value per km^2 would be US$ 476 thousand and US$ 278 thousand or, in ha terms, US$ 4760 and US$ 2780, respectively. These figures are extremely conservative insofar as they embody the negligence in the calculation for potential sustainable uses in the region, recreation, medicine applications and other ecological functions performed by the largest forest in the world. However, the analytical framework is suitable

[141]This would mean an annual deforestation rate level of 190,000 km2 and a stock of forests by the year 2000 of 6,500,000 km2.

to dealing with the evaluation problem and estimates can improve with the better understanding of that forest. Anyway, the values so far found will be applied to the deforestation induced by CIOP.

8.5) Guidelines for the Conservation of the Amazon Forest

One lesson that can be learnt from the whole Carajas Programme is that policies to preserve the Amazon forest functions intact should be devised and implemented with urgency. This is because it may be the case that areas being lost now due to the present pattern of development taking place in the Amazon forest may have high protection or conservation value, which means that an irreversible loss might be occuring. The meaning of high protection and conservation value is as given in Section 8.1.

To illustrate the above said, it is worth analysing the changes that have been associated to the Carajas undertaking on the area of the project. Although, as suggested in Chapter 6, there are other investments being implemented in that region that also affect the speed at which the environment is being degraded, it is clear that a large share of this degradation can be attributed to CIOP. Ideally, to know the exact extent to which CIOP is responsible for adverse environmental effects would require that we undertake a kind of with/without project analysis for the area of CIOP's influence. As in practice this is an impossible task, at least we should try to understand the links between the project and the physical environment.

The Carajas Project has had, directly and indirectly, serious environmental effects. In addition to the land clearing required for the installation of mining, ore processing, transport and urban facilities at or near the mine and port sites, construction of the Carajas railway directly involved deforestation of an 80 m strip along most of its length of 890 km. This area of 72 km^2 was opened exclusively by CIOP: originally, that area was covered by dense tropical forest. Moreover, directly, the other major source of deforestation was the selective extraction of high quality timber for the fabrication of railroad ties. CVRD estimates point to a figure of at least 50,000 ha of forest that were selectively cut in order to produce the ties required by the Carajas railroad.

Indirectly, as suggested in Chapter 6, in the larger area of influence of CIOP, almost completely deforested areas can now be seen, which in the 1960s and until mid 1970s remained as untouched forest. The attraction of migrants to the area, private land speculation, improved access to inacessible parts of the region due to improved road and railroad infrastructure, the use of fuelwood to produce charcoal for the pig iron smelters along the railway corridor are factors that have been pointed out as indirectly associated with CIOP' implementation. Deforestation in the project's area of influence has increased significantly over the past decade and a half. Data to show this is given in what follows.

Studies undertaken by SUDAM based on image satellites reveal that the deforested area in the state of Para has increased from some 25,000 km^2 in 1978 to about 115,000 km^2 in 1986.[142]The large majority of the areas cleared were originally in forest. Much of this deforestation has occurred in the the southeastern part of the state, where deforestation rates have considerably exceeded the average of Para as a whole. The city of Maraba is very illustrative in this sense: in 1986, nearly 20% of the total area had been cleared while the same figure in the early 1970s was only 0.4%. In Maranhao, deforestation has also accelerated in the past decade. The total area cleared in this state has increased from some 2,940 km^2 in 1975 to 50,670 km^2 in 1988, what means deforestation rates of 1.1% and 19.7%, respectively. The same tendency of concentration in deforestation rates in specific cities

[142] This means a deforestation rate of 2% in 1978 and a 10% in 1986.

seems to be true for the Maranhao state, although there are no available statistics of deforestation according to cities in this state. Certainly, as pointed out in Chapters 6 and 7, other factors such as unsustainable agricultural techniques, cattle ranching ventures, among other factors, have been contributing factors to explain deforestation rates in the states of location of CIOP. As it becomes impossible to separate the effects of CIOP from other economic activities simultaneously taking place in the region on deforestation rates, at least we should be aware of the effects of the project in its larger area of influence.

Retaking the starting point of concern of this section, we should try to answer how the Carajas project helps us in the design and implementation of policies intended to preserve the Amazon forest's use and non-use functions. The Carajas project helps us to highlight the fact that effective policies to introduce a pattern of sustainable development in the Amazon will have to take into account: a) the broader area of influence of any project; b) the Amazon forest as a whole ecosystem. Here, the idea that a system shock (Pearce and Markandya, 1989) can have cumulative impacts is very useful in highlighting the fact that well demarcated zones according to "high protection", "high conservation" and "economic use" are established in a such way that their existence is assured as such in the process of sustainable economic development.

The first step in any strategy designed to maximize the net social benefits from the Amazon forest should be the <u>identification</u> and <u>demarcation</u> of areas so that to ensure that its main functions are performed and are consistent with the uses being made: ecological functions, provision of biodiversity, sustainable economic activities. This task is not an easy one because not only has science been unable to give a definitive answer on the extent to which certain ecological functions depend on the existence of a minimum forest stock, but it has limited guidelines to offer on the size of this stock. Possible threshold effects introduce uncertainty in this process. Moreover, as the forest characteristics vary a lot across the whole area, and, still, most of the forest has not been properly exploited nor documented, a lot of research on site would be needed for the proper land use planning of the Amazon according to land-use categories. Additionaly, there are no clear rules of thumb to determine what are the possible sustainable activities. In this connection, it is not only the nature of the economic activities that matters but also their location considering the specific soil and the type of forest characteristics. And to make things more complicated, technologies and the manner of management of large projects can be an important dimension to determine whether or not specific economic activities can be classified as sustainable or not. What matters here is that such land demarcation according to land use categories is an urgent need and different actors can be very important in such research: the Brazilian government, local populations, the international community. Once this step is complete, different tools could be used to ensure that the main forest functions are performed and that social net benefits are being maximized.

The first policy strategy towards the Amazon forest is the elimination of policy distortions which create artificial incentives to convert forest to other uses. As Chapter 7 observed, the Brazilian government has played a major role in the promotion of the development pattern presently taking place there, through not only the provision of generous financial incentives for cattle ranching, agriculture, mining projects and so on but also through direct action to develop the region, mainly through the provision of roads (See Tables 7.3 and 7.4). As said before, most of those projects would not have been attractive from a financial point of view if incentives had not been available.

Moreover, reducing migratory pressure to the Amazon forest is also a very important point to be noted because it is very unlikely that the mounting social problems from other parts of Brazil can be solved through the introduction of sustainable economic activities in the Amazon.

Another important factor which the Brazilian government is to play a major role is the design and implementation of a careful plan of transportation infrastructure. Still, this is the major determinant of the opening of new lands. The provision of roads in the past and the Carajas railway have been factors that have resulted in developmnet patterns in the Amazon forest inconsistent with any criterion of sustainability. In this connection, the Brazilian government can play an active role in inducing and enforcing an specific land use plan through the tranportation infrastructure component. Once is has been delineated which areas are to be preserved almost intact for purposes of high protection and conservation, this information should be used for the consistent provision of transportation infrastructure.

In the areas destined for settling of the best economic activities, an effective environmental policy should make individuals making land use decisions pay the full social costs of environmental externalities. The opportunity cost of converting forest is not costless and so individuals making such decisions should have in mind the full environmental consequences of different economic activities. One possibility is to make companies or individuals pay a tax for the externalities produced and, for that, it is necessary the knowledge of the likely environmental damage that would follow as the changed land use takes place. Still, research is in need to answer this question because the environmental damage from the same activities varies with location and with techniques employed. In the absence of such information, environmental taxes could be devised based on activities.

Another very important point to receive attention from the part of the Brazilian government and official financing agencies is the introduction of truly sustainable agricultural techniques in the Amazonia. In eastern Amazonia, there exists a subsistence farming population of some five million. Growing practical experience shows that the agronomic potential for Amazonia exists. The potential for sustainable agriculture, both on the alluvial foodplains and on the uplands, has been shown to exist as long as certain basic principles are observed concerning integration with the forest, crop diversity, nutrient recycling, weed and pest control and adaptation to local conditions. Gradwohl and Greenberg (1988) have stated that "the intensive use of small plots can be applied to almost any tropical environment". Sustainable agriculture in Amazonia can be achieved through adapting techniques to a broad range of agro-ecosystems, which involves shifting cultivation and sedentary methods, annual and perennial crops, silvicultural plantations and extractivism.

The opportunity cost of stopping development in the Amazon forest now is very low: as said before, the most recent net income statistics for the region is on the order of US$ 15 billion. However, this figure should not be seen as definitive since many projects, especially mineral and related processing projects, are planned to be implemented soon and they are expected to generate foreign exchange. Moreover, as the Amazon forest is thought to be a resource rich area, further exploration and exploitation could change the opportunity cost estimate. Anyway, it is worth stressing here that the areas which are found to have high protection and conservation value should be financed by both the domestic and international communities, as long as important benefits are derived by the world population through the existence and option value components. Once the demarcation of such areas is undertaken, the opportunity cost of stopping development there should be estimated and appropriate mechanisms should be devised so that the rest of the world compensate the loss in income that would follow in those areas. The creation of environmental funds in developed countries to be passed to the Brazilian government, for instance, would be a feasible option to finance the maintenance of such areas.

CHAPTER 9- CARAJAS: AN INTEGRATED ASSESSMENT

9.1) An CIOP's Extended Cost-Benefit Analysis to Environmental Effects

As suggested in chapter 6, a host of social and environmental problems were created or greatly exacerbated by the Carajas undertaking. Ideally, we would like to consider all of them in our analysis and, better still, we would like to put a monetary value on them to reflect society's preference for each consequence of the project. This ideal solution being not possible in practice, either because of present methodological limitations or because of lack of data, the analysis here will concentrate on the CIOP's environmental costs, in particular with those associated with deforestation. The pig-iron and the steel industry constitutes a major threat to the Amazonia forest, especially at a time when steel industries in the South are loosing competitiveness and face the situation of a stagnated demand.

We have to consider the likely scenario that the pig-iron and steel industry is transferred to the north of the country because of the subsidies implicit in the cheap supply of charcoal. Moreover, we have to consider the situation that developed countries pressed by their populations and environmental organizations stop buying iron-ore or any further processed iron-ore product to express commitment with a kind of "morality" towards environmental resources. Even not following this line of reasoning and accepting that there is a retraction in the world iron ore market, thus creating a excess supply for the CIOP's output, this may encourage and stimulate the pig-iron and related activities to supply either the external or domestic markets.

The above considerations are realistic and have to be taken into account in an "ex-post" analysis of CIOP. For purposes of evaluation, it is imperative that the close forward linkage between CIOP and the pig-iron industry is considered, and, thus internalising partially some of the CIOP's environmental costs. Moreover, in proceeding so, we have to stress that the limits to the growth of this industry are given by the stock of the iron ore (about 18 billion tonnes) and the supply of charcoal, very large considering the whole Amazon forest. In what follows, a forward linkage model pig iron- iron ore is developed so that the net benefits of the joint iron ore - pig iron complex can be compared to the costs of deforestation associated to this complex. This seems a sensible way to internalize costs of deforestation induced by CIOP without penalizing it, as long as the net benefits of the iron ore processing are being considered.

Forward Linkage Model between CIOP and the Pig-Iron Industry along the Carajas Corridor.

To produce one unity of pig-iron, it is necessary iron ore and charcoal, this, in turn, requiring deforestation. Here, we wish to establish the technical relationship between the iron ore and the induced deforestation, so that we can assign environmental costs to each unity that goes to supply the pig-iron industry.

It is assumed that 1 unity of pig-iron requires 1.7 unities of iron-ore, that is:

$$y = 1.7x \qquad (9.a)$$

where: x - level of pig- iron production

y - level of iron ore production

First of all, it is necessary to establish the relationship between the production of pig-iron and the necessary deforestation in area unities. According to CVRD estimates: 3.5 m^3 of wood are necessary to produce 1 tonne of charcoal, 0.8 tonnes of charcoal are required to produce 1 tonne of pig-iron, 1 ha of forest results in 100 m^3 of wood. This means that to produce 1 tonne of pig- iron, it would be required a deforested area of 0.03 ha. So, the relationship between deforestation(z) as area in ha and pig-iron production (in tonnes) is expressed by:

$$z = 0.03\, x \qquad (9.b)$$

And as y = 1.7 x, the same expression can be written as:

$$z = 0.03\, y / 1.7 = 0.02\, y \qquad (9.c)$$

To assign environmental costs (EC) to each unity of iron ore that is destined to supply the pig-iron industry, we need to rely on the concept of price of deforestation (P) per ha previously found. This can be expressed as:

$$EC = P\, z \qquad (9.d)$$

Or substituting:

$$EC = P\, 0.03\, x = P\, 0.02\, y \qquad (9.e)$$

The above expression assumes that all the iron ore production goes to supply the pig-iron industry. Making it less pessimistic and more flexible, let's suppose that ax unities ($0 < a < 1$) of iron ore are destined to supply the pig-iron industry. Or:

$$EC = P\, 0.03\, a\, x = a\, P\, 0.02\, y \qquad (9.f)$$

So the above expression establishes the relationship between the iron ore production (y) in tonnes and the environmental costs (in 1989 US$) to be internalized to CIOP. P, we should recall, was estimated to be US $ 4,760 and US$ 2,780, both per ha using the two approaches.

Possible Scenarios

We here want to deal with cases that range from the actual scenario to possible outcomes, given only the availability of resources: iron ore and charcoal.

The first case to receive some attention is the actual scenario. CIOP produces about 30 million tonnes, most of the production is exported and only a very small fraction is destined to the pig-iron industry(less than 1 %). As the fraction is still very small, we assign no environmental costs to CIOP.

The second case is a more radical one: all the CIOP's production goes to supply the pig-iron industry. This is the scenario dealt with in Section 3.6, when it was analysed the joint profitability iron ore- pig iron industry. It could be argued that the pig-iron industry capacity is not prepared to process such a large quantity of iron-ore. However, given that the region increasingly offers infrastructural facilities, it can be realistically assumed that the necessary capacity can be quickly installed. The rationalization for this may be the introduction of legislation in developed countries that forbid at all the consumption of iron ore from CIOP and so, CVRD would destiny all its production to the internal market.

The third case refers to the decision of the Brazilian government to transfer all the iron ore metallurgic industry to the Carajas corridor. Here, we could think in CIOP's replication so many times as necessary to meet the total sectoral capacity of the Brazilian industry.

The three scenarios are realistic because they just magnify real aspects of the iron ore and steel market. First, CVRD strategy has as one guideline the progressive transfer of its Minas Gerais mines to Carajas. Moreover, the loss of competitiveness in the steel industry in the south of the country further contributes to this possibility as being very "real". Secondly, pressed by environmental groups, EC countries in 1989 have attempted to cut contracts from CVRD. As a demonstration effect, contracts were temporarily stopped. Thirdly, cheap supply of charcoal and iron ore could mean that, on purely financial grounds, it is profitable to concentrate all the iron ore and steel making industry in the Carajas region. Only a decisive governmental action could stop that, what, up to now, has not emerged as a feature of Brazilian environmental policy.

The second scenario, that is, that associated to all iron ore being destined to the pig-iron industry, has been calculated using the approach above described. In this case, the environmental costs (EC) of producing 30 million tonnes of iron ore and thus 17 million tonnes of pig iron would amount to US$ 2,856 million and US$ 1,949 million, considering, respectively, the prices of deforestation of US$ 4,760 and US$ 2,780 per ha previously found in section 8.4 (1989 prices). If we look at the net income generated by the joint project iron ore-pig iron (see Annex 3.6), the net income generated is on the order of US$ 748 million from the activity of selling pig iron in international markets in 1980 prices, or US$ 1,003 million at 1989 prices (US$ 135 per tonne for the period 1987-1990). The comparison of the environmental costs and the net income generated by CIOP-pig iron leads to the result that the joint project has a negative rate of return introducing environmental costs. Moreover, this conclusion could be extended to the case in which all the pig- iron industry of the country was to be transferred to the Amazon area: that is, environmental costs would exceed the production net benefits. If environmental taxes were introduced by the Brazilian government, on purely financial grounds the joint operation iron ore -pig iron would not be profitable.

In an extended cost-benefit analysis to the environmental effects, our case study was made easier for the low CIOP-pig iron economic profitability. Only deforestation costs were incorporated in the analysis in a quantified way, what was enough to turn the CIOP-pig iron economic rate into a negative one. Conventional cost-benefit techniques, if properly applied at the appraisal stage, could have rejected the project on efficiency grounds. An apparently contradictory lesson emerges from that: expected highly profitable projects should be subject to more rigourous analysis at the pre-appraisal stage with respect to the environmental and social components, because many of these are simply missed at that phase. If these factors cannot be given any meaningful monetary estimate, as will often be the case, they should, at least, be recorded as such and so, society is made more conscious of the effects involved.

An analysis of the CIOP's economic and social profitability is very unfavourable to the project. First, on purely efficiency grounds, the project profitability is under the capital cost required to finance it. So, even if development is synonymous of growth, CIOP wouldn't be recommended on purely economic considerations. Secondly, the project has had serious external effects, both environmental and social, which, although not fully quantified, would contribute to further decrease its economic and social profitability. The project, as was dealt in Chapter 6, is not compatible with the traditional government goals as better income distribution and environmental care on a regional perspective. Local populations, especially the most vulnerable group of landless farmers, were made worse-off and the project has contributed to further degrade the environment, mainly through its indirect effects. If development is to be understood as a process that incorporates those social goals, the project has not been able to contribute to improve the income distribution neither the goal of improving the relationship between the environmenmt and economic activities taking place in the region.

9.2) The Carajas Iron Ore Project: Some Lessons

The main lesson to be learnt from the CIOP's case study is that projects should be assessed in a way as integrated as possible. Integration here means broadening a specific project's area of location to the human and physical region where the project is to be located. This requires widening the spacial project's area of influence as well as it imposes understanding the social process taking place in such a broader area. The appraisal and selection of projects should be done in a regional approach to evaluating the social profitability of projects, especially those large-scale projects with infrastructural components to be implemented in frontier regions and in fragile ecosystems, as is the case of the CIOP's undertaking in the Amazon forest.

The need to understand the linkages between economy and ecology in the region of a project's area of influence is a first step to record social costs and benefits of any undertaking. Integrating succesful environmental management to economic development in such sensitive ecological and social areas imposes selecting projects whose environmental and social effects will contribute to a pattern of sustainabable growth in the largest perceived economic and environmental area of influence of any undertaking: it is required that projects do not have harmful effects on the natural resource base of that larger area and, moreover, projects should contribute to the improvement of social indicators of the populations directly or indirectly affected. As a minimum requirement, if development in Amazonia is to be sustainable, the needs of local populations have to be taken into account in any programme. Projects especially designed to provide these populations the access to land with the introduction of sustainable agriculture techniques is in need. Missing this point in whatever development plan can turn these victim populations into agents of destruction of the Amazon forest.

The Greater Carajas Programme has been an anti-example of such integrated social assessment. CIOP is a good example, on the other hand, of the social and environmental disasters that may arise when such an integrated assessment is missed at the planning stage. CIOP has greatly deteriorated the environment and the social indicators of populations directly and indirectly affected. As a practical lesson, it emerges that any GCP project has to be assessed in what concerns its social benefits and costs taking into account its effects at least in the Greater Carajas Area.

The above statement, if extended to the whole ecosystem represented by the Amazonian forest, highlights the need that potential projects in the region be assessed in terms of the fundamental social objectives towards that area: a) generating income in an efficient way; b) integrating local populations to the regional economy on a sustainable way; c) preserving the Amazon forest functionally intact. A programme of projects for the region has to be constrained by, for instance, the establisment of zones designed to create a balance between developing economic activities, and conserving and protecting the forest ecologically intact. In particular, projects to maintain the ecological functions of the Amazon forest such as preservation benefits in containing the greenhouse warming effect, maintaining an yet unknown genetic resource, should be designed with the participation of the international community both at the scientific and financial levels.

Given the not yet exploited mineral resources of the Amazonia, estimated to be on the order of US$ 3 trillion, it would be simplistic to conclude this thesis by simply stating that mineral projects should be stopped in the name of the preservation benefits from the Amazon. However, the main lesson from the present study is that the decision framework in which those projects are to be evaluated has to change. The idea that the access to extensive available land is synonymous of cheap land should be completely abandoned as a starting point in any serious cost-benefit analysis. It is recommended that projects in the Amazon, in particular mining projects, should only be implemented under a special set of conditions: a) as a first step, a careful economic analysis, with realistic price projections, should be done to all potential projects; b) once the potential project has passed this later step, a detailed analysis of its direct and indirect effects, both social and environmental, should be undertaken. The negligence of the project's interactions with the physical and social environment can result in true disastrers from these standpoints. In the case that the project produces negative externalities, then it is the case to record them as such at least. The still lack of knowledge of the precise effects of deforestation as well as the absence of suitable methodologies to fully assess social and environmental externalities should not be a reason enough to ignore them in any cost-benefit analysis. Rather, these scientific and methodological limitations should be a challenge to environmental economists. On the other hand, introducing the conditionality to undertake compensating projects to offset negative environmental and social externalities produced by large-scale projects such as CIOP is a practical way of reassessing the social profitability of projects. In this case, any project with negative externalities has to be reassessed in light of the required costs to undertake the necessary compensating projects. This would turn the social profitability of many projects unacceptable. In this connection, if all the charcoal consumed by the pig iron industry industry was to be obtained from afforested areas, the internal rate of return of the joint activity iron ore -pig iron would decrease from to 9.3% to 4.2% per year, as can be seen in Annex 3.6. If compared to the capital cost required to finance the project on the order of 6.5%, the joint operation pig iron -iron ore would not be financially atractive when charcoal is used from afforested areas.

Cost- benefit analysis, for large-scale projects located in sensitive areas from an ecological and social standpoints, has to be adapted if this tool is to help project decision-making. In particular, a regional approach to identify costs and benefits of a project has to be adopted. Cost-benefit techniques can help in the measurement of such broader benefits and costs and in the weighting- up process.

Annex 3.1 - CIOP FINANCIAL ANALYSIS(US$ 1,000,000 AT DECEMBER 1980 PRICES)

(ONE DOLLAR= 65.5 CRUZADOS)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
QUANTITY (MILLION TONNES)	15	25	35	35	35	35	35	35	35	35	35	35
SALES REVENUE	279	465	652	652	652	652	652	652	652	652	652	652
TOTAL OPERATING COSTS (a)	111	144	173	173	173	173	173	173	173	173	173	173
MINE	22	32	39	39	39	39	39	39	39	39	39	39
RAILWAY	58	75	93	93	93	93	93	93	93	93	93	93
PORT	12	16	18	18	18	18	18	18	18	18	18	18
ADMINISTRATION	19	21	23	23	23	23	23	23	23	23	23	23
TOTAL OTHER EXPENDITURES	389	412	420	411	399	321	295	274	253	233	233	199
DEPRECIATION	126	132	133	133	133		133	133	134	139	141	143
FINANCIAL COSTS(b)	192	197	196	188	175	158	137	118	96	75	69	34
LOCAL TAXES (IUM & PIS) (c)	10	17	24	24	24	24	24	24	24	24	24	24
AMORTIZATION OF PRE-OPERATING EXPENSES		6	6	6	6	6						
AMORTZATION & INTEREST DURING CONSTRUCTION	60	60	60	60	60							
NET INCOME BEFORE TAX	-221	-91	58	67	80	157	184	205	226	246	245	279
DEPLETION COST												
AMORTIZATION PAST LOSSES			311	253	185	91						
TAXABLE INCOME	-221	-91	-253	-185	-105	87	184	205	226	245	245	279
INCOME TAX							3	3	3	4	4	4
NET INCOME AFTER TAXES	-221	-91	58	67	80	156	181	202	222	242	242	275
DEPLETION COST (d)	22	37	52	52	52	52	52	52	52	52		
FISCAL EXEMPTION (e)						19	52	58	64	70	70	80

(a) CVRD estimates based on its Minas Gerais mines
(b) It includes financial charges of foreign and domestic loans
(c) It includes Mineral Extraction Tax(IUM) and Social Integration Program(PIS)
(d) Depletion cost allowances as they are generated with the income of the project
(e) SUDAM incentives

Annex 3.1 - CIOP FINANCIAL ANALYSIS(US$ 1,000,000 AT DECEMBER 1980 PRICES)

(ONE DOLLAR= 65.5 CRUZADOS)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	TOTAL (1985-2009)
QUANTITY (MILLION TONNES)	35	35	35	35	35	35	35	35	35	35	35	35	35	345
SALES REVENUE	652	652	652	652	652	652	652	652	652	652	652	652	652	15734
TOTAL OPERATING COSTS (a)	173	173	173	173	173	173	173	173	173	173	173	173	173	4237
MINE	39	39	39	39	39	39	39	39	39	39	39	39	39	947
RAILWAY	93	93	93	93	93	93	93	93	93	93	93	93	93	2262
PORT														
ADMINISTRATION	23	23	23	23	23	23	23	23	23	23	23	23	23	579
TOTAL OTHER EXPENDITURES	180	173	180	196	200	200	200	201	204	197	195	195	192	6354
DEPRECIATION	143	144	158	172	176	176	176	176	180	173	171	171	168	3783
FINANCIAL COSTS(b)	13	4												1650
LOCAL TAXES (IUM & PIS) (C)	24	24	24	24	24	24	24	24	24	24	24	24	24	589
AMORTIZATION OF PRE-OPERATING EXPENSES														29
AMORTIZATION & INTEREST DURING CONSTRUCTION														302
NET INCOME BEFORE TAX	299	306	298	282	278	276	276	276	274	281	283	284	286	5142
DEPLETION COST					278	198								476
AMORTIZATION PAST LOSSES														839
TAXABLE INCOME	299	306	298	282		80	278	278	274	281	283	284	286	3827
INCOME TAX	4	5		4		28	97	97	98	98	99	99	100	755
NET INCOME AFTER TAXES	294	301	298	278		52	181	181	178	183	184	184	186	3911
DEPLETION COST (d)														476
FISCAL EXEMPTION(e)	85	87	89	80										751

(a) CVRD estimates based on its Minas Gerais mines
(b) It includes financial charges of foreign and domestic loans
(c) It includes Mineral Extraction Tax(IUM) and Social Integration Program(PIS)
(d) Depletion cost allowances as they are generated with the income of the project
(e) SUDAM incentives

ANNEX 3.2

CIOP CAPITAL COST ESTIMATES (END 1980 BASE COST ESTIMATES)
US$ 1000(DECEMBER 1980)

	TOTAL	1980	1981	1982	1983	1984	1985	1986	1987
MINE	463231	33794	77339	64897	115848	80198	49022	33768	8365
CIVIL WORKS	101087	2354	18332	16557	21143	19965	11028	8423	3285
EQUIPMENT	184482	1159	2501	30379	62807	33425	28045	22287	4059
ENGINEERING	22204	30281	---	100	8279	7014	3543	2247	1021
INFRASTRUCTURE	143090	---	56506	16560	3312	---	---		
FREIGHT AND ERECTIONS	12368	---	---	1301	3748	3414	3094	811	---
PORT	233264	10671	31604	63396	52959	38763	22299	12125	1567
CIVIL WORKS	81059	1262	3490	24458	26809	14298	7047	2951	744
EQUIPMENT	84813	---	13258	15783	17219	18798	12126	7129	500
ENGINEERING	13094	---	---	1973	2623	4289	2276	1620	313
INFRASTRUCTURE	49815	9409	14756	20521	5129	---	---	---	---
FREIGHT AND ERECTIONS	4483	---	---	661	1179	1368	850	425	---
RAILROAD	1690368	83760	214194	595766	389028	219370	112482	60027	15731
CIVIL WORKS	237936	14859	34036	96555	45249	19220	8399	16084	3444
EQUIPMENT	588879	---	67795	115637	146824	137039	86120	25071	10391
ENGINEERING	85908	---	---	20588	22437	18666	7950	14371	1896
INFRASTRUCTURE	719559	68901	112363	351093	159646	26504	1054	---	---
FREIGHT AND ERECTIONS	58076	---	---	11893	14872	17941	8969	4601	---
TOWNSITES	168185	15	7299	26910	47933	43728	28591	11773	1936
PROJECT MANAGEMENT	326508	101026	30119	67407	68961	39517	11272	6565	1641
PRE-OPERATIONAL EXPENSES	29112	---	4092	4307	5168	11574	3971	---	---
MINE	18024	---	4092	4307	5168	2704	1753	---	---
PORT	2366	---	---	---	---	1893	473	---	---
RAILROAD	8722	---	---	---	---	6977	1745	---	---
PHYSICAL CONTINGENCIES	312605	---	36172	99330	81427	51200	26622	14470	3384
ENGINEERING	141322	59398	7509	34447	25553	11831	2279	305	---
INSTALLED CAPITAL	3364585	288664	408228	956460	786877	496171	256538	139033	32614
WORKING CAPITAL	99206	---	---	---	---	---	51698	23886	23622
INTEREST DURING CONSTRUCTION		---	6787	40322	114154	168671	---	---	---
TOTAL FINANCING REQUIRED	3793725	288664	415015	996782	901031	664842	308236	162919	56236

Annex 3.3- Iron Ore Prices/1950-2000

US$/tonne

Year	Current	1985 Constant US$*
1950	12.4	52.3
1951	16.3	59.7
1952	22.3	78
1953	20.1	72
1954	17.1	62.9
1955	18.2	65.7
1956	21.4	74.6
1957	22.5	76.8
1958	21.5	72.2
1959	17.1	58.2
1960	17.1	56.8
1961	17.8	58.2
1962	16.8	54
1963	15.7	51.3
1964	15.7	50.3
1965	15.7	50
1966	15.3	46.9
1967	13.5	41
1968	12.6	38.6
1969	11.8	34.4
1970	15.2	41.6
1971	13.5	35
1972	12.8	30.6
1973	17.1	35.2
1974	19	32.1
1975	22.6	34.4
1976	21.9	32.8
1977	21.6	29.5
1978	19.4	23
1979	23.3	24.4
1980	26.7	25.5
1981	24.3	23.1
1982	25.9	25
1983	24	23.8
1984	23.2	23.4
1985	22.7	22.7
1986	22	19.5
1987	21.8	18.7
1988	21.7	18.4
1989	21.4	17.9
1990	21.2	17.5

Source: World Bank(1987)
* Deflated by the Manufacturing Unit Value Index(MUV)

Annex 3.4

Cost-Benefit Stream to Calculate the internal rate of return(values US$ 1,000,000)-
- Scenario A

	Capital Costs [1]	Net Income[2]	Financial Net Income[3]	Financial Net Income[4]
1980	238			
1981	339			
1982	794			
1983	653			
1984	412			
1985	212	-102.8	102.8	102.8
1986	115	15	15	15
1987	27	147	147	147
1988		237.8	237.8	237.8
1989		237.8	237.8	237.8
1990		237.8	237.8	218.8
1991		237.8	234.8	182.8
1992		237.8	234.8	176.8
1993		237.8	234.8	170.8
1994		237.8	233.8	163.8
1995		237.8	233.8	163.8
1996		237.8	233.8	153.8
1997		237.8	233.8	148.8
1998		237.8	232.8	145.8
1999		237.8	237.8	148.8
2000		237.8	233.8	153.8
2001		237.8	237.8	237.8
2002		237.8	209.8	209.8
2003		237.8	140.8	140.8
2004		237.8	140.8	140.8
2005		237.8	140.8	140.8
2006		237.8	140.8	140.8
2007		237.8	140.8	140.8
2008		237.8	140.8	140.8
2009		237.8	140.8	140.8

The internal rate of return is 4.4%, the financial one including SUDAM incentives is 3.55% and that one excluding them is 2.15%.

---

[1] From the table of capital cost estimates.

[2] The price used for the period 1989-2009 is US$ 16.2 in 1985-88 terms, which deflated by the US GNP to be compatible with 1980 estimates is US$ 13.7 Net income from the CIOP income statement.

[3] Net of income taxes but it includes SUDAM incentives

[4] Net of income taxes and SUDAM incentives

Annex 3.5

Cost-Benefit Stream to Calculate the internal rate of return (Values US$ 1,000,000)- Scenario B

	Capital Costs[1]	Net Income[2]	Net Income[3]	Net Income[4]
1980	238			
1981	339			
1982	794			
1983	653			
1984	412			
1985	212	-102.8	102.8	102.8
1986	115	15	15	15
1987	27	147	147	147
1988		237.8	237.8	237.8
1989		237.8	237.8	237.8
1990		165.9	165.9	146.9
1991		165.9	162.9	110.9
1992		165.9	162.9	104.9
1993		165.9	162.9	98.9
1994		165.9	161.9	91.9
1995		165.9	161.9	91.9
1996		165.9	161.9	81.9
1997		165.9	161.9	76.9
1998		165.9	160.9	73.9
1999		165.9	165.9	76.9
2000		165.9	161.9	81.9
2001		165.9	165.9	165.9
2002		165.9	137.9	137.9
2003		165.9	68.9	68.9
2004		165.9	68.9	68.9
2005		165.9	68.9	68.9
2006		165.9	68.9	68.9
2007		165.9	68.9	68.9
2008		165.9	68.9	68.9
2009		165.9	68.9	68.9

The internal rate of return is 2.2%, the financial one including SUDAM incentives is 0.82% and that one excluding SUDAM incentives is - 1.20%

---

[1]From the table of capital cost estimates

[2]The price used for the period 1989-2009 is US$ 11.3 in 1980 terms. Net income is taken from the CIOP income statement.

[3] Net of taxes but including SUDAM incentives.

[4] Net of taxes and SUDAM incentives

Annex 3.6

Cost Benefit Stream to Calculate the Internal Rate of Return of the Joint Project Iron Ore- Pig Iron (US$ 1,000,000)

	Capital Costs	Net Income[1] (charcoal from native forest)	Net Income (charcoal from afforested areas)
1980	2,108		
1981	339		
1982	794		
1983	653		
1984	412		
1985	212		
1986	115		
1987	27	748	361
1988		748	361
1989		748	361
1990		748	361
1991		748	361
1992		748	361
1993		748	361
1994		748	361
1995		748	361
1996		748	361
1997		748	361
1998		748	361
1999		748	361
2000		748	361
2001		748	361
2002		748	361
2003		748	361
2004		748	361
2005		748	361
2006		748	361
2007		748	361
2008		748	361
2009		748	361

The internal rate of return is 9.34% per year if all consumed charcoal is from native forest and 4.24% per year if charcoal is from afforested areas

[1] It is assumed that the price of a tonne of pig iron will remain stable at US$ 135 in 1987 prices, or, deflated to be compatible with 1980 estimates of CIOP means a price of US$ 102 per tonne and a net income of US$ 44 per tonne of pig iron. This net income stream is based on the assumption that all charcoal consumed comes from native forest.

Commodity	SPI	SP2	Classification
Charcoal	0.833	0.832	X
Forestry	0.552	0.544	X
Cocoa	1.02	1.02	X
Rice	1.388	1.388	M
Wheat	0.989	1.605	M
Soybean	1.043	1.041	X
Fruits	2.962	2.87	X
Tobacco	2.661	2.661	X
Beans	1.297	1.16	M
Corn	0.792	0.791	X
Vegetables	1.54	1.495	X
Tubercles and roots	1.879	1.875	X
Raw vegetable fibers	0.584	0.584	X
Oil seeds	0.539	0.539	X
Other agricultural products	1	0.989	X
Birds	0.944	0.943	M
Eggs	1.309	1.305	M
Livestock and Poultry	1.097	1.089	M
Iron ore	0.494	0.438	X
Other metallic minerals	1.28	1.114	X
Non-metallic minerals	1.092	1.009	M
Petroleum and natural gas	1.022	1.017	M
Mineral coal	1.58	1.396	M
Cement	0.963	0.867	X
Glass	0.753	0.648	X
Glass recipients	0.2325	0.222	X
Other glass products	0.647	0.616	X
Cement and concrete products	0.861	0.708	X
Earthenware and chinaware for construction	0.807	0.67	X
Earthenware and chinaware for domestic use	1.048	0.861	X
Other non-met allic mineralproducts	0.754	0.667	X
Iron alloys	0.848	0.848	X
Steel lingots	0.573	0.573	X
Steel plates	0.673	0.665	X
Steel coils and sheets	0.541	0.505	X
Thin steel sheets	1.068	1.049	X
Special steel sheets	1.044	1.019	M
Steel rods	0.306	0.304	X
Steel profiles	0.774	0.739	X
Iron and steel round bars	1.047	0.905	X
Machine wire	1.219	1.215	X
Steel sheets, non flat	0.426	0.366	X
Other steel sheets,nes	0.671	0.627	X
Scrap iron	0.11	1.11	M
Iron and steel smelter products	0.513	0.49	X
Iron and steel forger products	0.741	0.702	X
Copper and copper sheets	0.89	0.878	M
Aluminum anf aluminum sheets	0.669	0.668	X
Other non-ferrous metals	0.755	0.708	X

Screws	0.535	0.473	X
Steel wire	1.119	1.045	X
Other wired products	0.432	0.38	X
Metallic structures	0.582	0.465	X
Sawed products	0.648	0.553	X
Metal products	1.069	1.04	X
Metalllic wrappings	1.042	1.018	X
Non-electrical ovens	0.826	0.78	X
Knives,forks and others	0.752	0.671	X
Steel tubes	0.501	0.44	X
Other metallurgic products	0.613	0.568	X
Pumps and motors	0.876	0.785	X
Rollers and others	0.669	0.66	M
Industrial tools	0.812	0.812	X
Other equipment parts	0.757	0.744	X
Turbines and steam generators	1.378	1.358	M
Machines to work metal	0.799	0.799	M
Machines for transport	1.02	0.844	M
Tool-machines and others	0.785	0.777	X
Machines for agricultural production	1.065	1.025	X
Bulldozres	0.955	0.928	X
Bulldozer parts	0.645	0.618	X
Office equipment	0.502	0.502	X
Refrigerators and other domestic machines	0.962	0.96	X
Generators	0.82	0.804	X
Transforms	0.826	0.824	M
Equip. for electrical energy	0.596	0.508	X
Electric wire and cable	0.691	0.601	X
Electric equipr ent,except for vehicles	0.495	0.449	M
Electric equipment for vehicles	0.67	0.604	X
Electric motors	1.109	1.089	X
Apliances for domestic use	0.646	0.565	X
Electric equipment	0.644	0.585	M
Material eletronic	0.539	0.535	M
Electronic equipment	0.335	0.335	M
Communication equipment	0.9	0.898	X
Parts for communication equipment	0.609	0.569	M
Televisions	0.973	0.973	X
Radios and sound equipment	0.453	0.448	X
Automobiles	1.534	1.538	X
Trucks and buses	1.024	1.024	X
Vehicles motors	1.639	1.637	X
Vehicles parts	0.733	0.694	X
Shipbuilding	0.752	0.752	X
Motors and parts for vehicles	0.881	0.817	M
Railway equipment	0.763	0.763	X
Parts for railway equipment	0.268	0.254	M
Other vehicles and parts	1.05	0.97	X
Wood not processed	1.243	1.113	X
Prepared wood	0.557	0.494	X
Wood structures	0.838	0.694	X
Other wood products	0.978	0.949	X
Wood furniture	0.604	0.592	X

Metal furniture	0.645	0.633	X
Wood pulp	1.235	1.217	X
Paper for impression	0.831	0.825	X
Paper for wrapping	0.885	0.867	X
Other types of paper	0.884	0.872	X
Paper wrappings	0.535	0.512	X
Other paper products	1.117	1.009	X
Tyres and camaras	0.789	0.671	X
Rubber	0.811	0.81	X
Rubber products	0.569	0.543	X
Leather and leather products	0.701	0.697	X
Sodium hydroxide	0.558	0.558	X
Soda-ash	0.637	0.629	M
Phosphoric acid	0.741	0.733	M
Other chemical elements and compounds	0.856	0.842	M
Alcohol	0.601	0.599	X
Petrol	0.543	0.399	X
Diesel fuel	0.782	0.629	M
Fuel oils,except diesel	0.631	0.599	X
Lubrificating oils	0.889	0.757	X
Naphta	3.226	3.226	M
Gas petroleum refining	1.765	1.672	M
Asphalt	1.128	0.98	X
Other petroleum refining products	0.981	0.915	X
Basic petrochemical products	1.042	1.024	X
Intermediate petrochemical products	0.756	0.757	X
Coke and coal derivations	0.777	0.769	M
Poliethylene	0.73	0.728	X
PVC	0.61	0.605	X
Other chemical resins	0.556	0.551	X
Artificial fibers	0.513	0.51	X
Elastic fibers	0.697	0.691	M
Soybean oil	0.84	0.84	X
Vegetable oilseed products	1.093	1.081	X
Other edible vegetable oils	0.872	0.872	X
Other nonedible vegetable oils	0.703	0.702	X
Pigments	0.295	0.294	M
Paints	0.739	0.641	X
Nitrates and phosphates	1.289	1.4	M
Fertilizers	1.121	1.58	M
Pesticides	0.253	0.245	M
Chemical products for cleaning	0.644	0.608	X
Other chemical products	0.634	0.602	X
Non-dosed pharmaceutical products	0.905	0.894	M
Dosed pharmaceutical products	0.357	0.322	X
Perfumery	0.611	0.46	X
Soaps	0.886	0.773	X
Plastic threads	0.59	0.565	X
Plastic products for industrial use	0.478	0.445	X
Plastic tubes	1.119	0.928	X
Plastic wrappings	0.337	0.306	X
Other plastic products	0.182	0.163	X
Cotton wool	0.606	0.603	X

Cotton stone	0.597	0.597	X
Other processed textiles fibers	0.731	0.73	X
Cotton threads	0.768	0.784	X
Cotton fabrics	0.456	0.454	X
Other natural textile threads	0.73	0.725	X
Other natural textile fabrics	0.592	0.59	X
Synthetical fiber threads	1.045	1.04	X
Synthetical fabrics	0.412	0.408	X
Mail fabrics	0.72	0.719	X
Mail apparel	0.6	0.607	X
Tissue bags	0.671	0.616	X
Table and bed cloths	0.589	0.518	X
Treads to sew	0.441	0.441	X
Special fabrics	0.55	0.525	X
Apparel	0.412	0.371	X
Other textile products	0.646	0.608	X
Footwear	0.589	0.522	X
Coffee beans	1.755	1.752	X
Processed coffee	2.008	1.827	X
Processed rice	0.812	0.753	M
Wheat flour	0.73	0.726	M
Fruit juices	0.971	0.9	X
Canned vegetables and fruits	0.485	0.46	X
Cocoa butter	0.241	0.239	X
Manioc flour	1.25	1.217	X
Other flours	1.078	1.072	X
Other processed vegetable products	0.94	0.926	X
Meat	1.037	0.994	X
Pork meat	1.026	0.989	X
Prepared meat	1.495	1.415	X
Raw leather	1.568	1.559	X
Birds	0.422	0.408	X
Milk	0.806	0.788	M
Other dairy products	0.716	0.708	M
Cristal sugar	0.211	0.208	X
Demerara sugar	0.195	0.193	X
Other sugar products	0.37	0.368	X
Processed sugar	0.293	0.268	X
Bakery and pastry products	0.963	0.911	X
Processed soybean oil	1.111	1.053	X
Other processed vegetable oils	0.948	0.915	X
Margarine	0.882	0.86	X
Animal food	1.096	1.088	X
Prepared fish	0.797	0.79	X
Other food products	0.567	0.53	X
Wines	0.737	0.577	M
Beers and malts	1.334	0.905	M
Other alcoholic beverages	0.736	0.54	X
Refreshments	0.544	0.43	X
Processed tobacco	1.333	1.333	X
tobacco products	8.333	8.334	X
Books	0.833	0.824	X
Newspapers and magazines	1.401	1.286	X

Other printing products	1.13	1	M
Toys	0.354	0.354	X
Other products	0.676	0.579	M

Source: Seroa da Mota (1988)

Hunting and fishing	0.89
Coffee crops	1.042
Sugar cane	1.01
Cattle raising	0.994
Machines maintenance and repair	0.834
Electric utilities	0.967
Water supply	0.899
Civil construction	0.741
Distribution	0.928
Trade	1.002
Rail transportation	1.519
Maritime transportation	0.933
Air transportation	0.891
Road transportation	0.79
Communications	0.919
Financial services	0.949
Leasing of machines	1.024
Hotels and restaurants	0.85
Repair services	0.928
Vehicles maintenance	0.891
Other services	0.944
Hospitalar assistance	0.805

Source: Seroa da Mota (1988)

Annex 8.1

Questionnaire on the Amazon Forest

The Amazon forest is the world's largest tropical forest and is located mainly in Brazil but it extends to other countries. Apart from being a source of hardwood timber, tropical moist forests also supply other "minor" products such as nuts, resins, and latex. They are a rich source of biological life, much of it unrecorded and unstudied, which has scientific value and which is also valued for its existence, independently of any use to which mankind may put the forest. Moreover, important ecological functions are associated to tropical forests.

Amazonian deforestation appears to be accelerating. Perhaps 10% of the total area has already been lost and further development is likely to increase this proportion.

Please answer the questions below.

1) At the moment, the Amazon forest area contributes some US$ 15 billion to the Brazilian GDP(around 6%). What do you think is the maximum that governments worlwide would be willing to yearly pay Brazil for not pursuing unsustainable development in the area?

US$ 5 billion
US$ 10 billion
US$ 15 billion
US$ 20 billion
US$ 30 billion

US% 40 billion

US$ 50 billion

Other value

[As a guide, the GNP of the USA is US$ 4500, the UK is US$ 575 billion, France is US$ 870 billion, Germany is US$ 1100 billion, Norway is US$ 830 billion]

2) What do you think is the maximum amount your government would be willing to pay to prevent further deforestation in the Amazon area?

Please state the country where you live- ________________

US$ 1 million

US$ 20 million

US$ 50 million

US$ 500 million

US$ 1 billion

US$ 5 billion

US$ 10 billion

US$ 20 billion

Other value

3) If individuals were to be taxed specially to provide funds to conserve the Amazon forest, what is the maximum amount you would be willing to pay in increased income tax to secure this benefit?

US$ 1 per week

US$ 2 per week

US$ 5 per week

US$ 10 per week

US$ 20 per week

US$ 30 per week

US$ 40 per week

Other value

4) In light of your answer to 3 above, would you prefer to pay your contribution through a special environmental fund?

Yes/No

5) Have you ever been to the Amazon?

Yes/No

6) If the answer to question 5 is no, do you think you are likely to visit the Amazon:

once?

more than once?

never?

Bibliography and References

Amaral et. al. "Projeto, Estudo e Preservacao de Recursos Humanos e Naturais da Area do Projeto Ferro-Carajas". CVRD Report. Rio de Janeiro,1988.

Anderson, A. "The Carajas Iron Ore Project: Assessment of the Environmental Components". Mimeo, 1989.

Bacha,E.L., et al. Analise Governamental de Projetos de Investimento no Brasil:Procedimentos e Recomendacoes . INPES/IPEA, Rio de Janeiro,1971.

BCB-Banco Central do Brasil-Series Historicas do Setor Externo-1971-1985. Banco Central do Brasil, 1987.

Bergstrom,J. et al. "Economic Value of Wetlands-Based Recreation" Mimeo,1988.

Binswanger, H. P. Brazilian Policies that Encourage Deforestation in the Amazon. Environment Department, World Bank, Washington, D. C., 1989.

BNDES. O Projeto Carajas. Project Report, 1980.

Bonelli,R and Cunha,P.V. "Mudancas nas Estruturas de Producao, Renda e Consumo e Crescimento Economico no Brasil no Periodo de 1970/75". Pesquisa e Planejamento Economico, vol. 12, no 3, December 1982.

Braga, H et al. Incentivos Efetivos as Exportacoes e as Vendas no Mercado Interno. FUNCEX, Rio de Janeiro, 1987.

Branford, S, and Glock, O. The Last Frontier: Fighting Over Land in the Amazon., Zed Books, London, 1985.

Briscoe, R. et al. "Towards Equitable and Sustainable Water Supplies: A Contingent Valuation Study in Brazil". The World Bank Economic Review, vol.4, 1990.

Browder, J. "Public Policy and Deforestation in the Brazilian Amazon" in Repetto, R. and Gillis, M.(eds). Public Policies and the Misuse of Forest Resources. Cambridge University Press, Cambridge,1988.

Cagnin, J. U. "Programa Grande Carajas- Perspectivas do Parque Siderurgico a Carvao Vegetal". Mimeo. Belem, 1988.

Coursey, D. L. et. al. "On the Supposed Disparity Between Willingness to Pay and Willingness to Accept Measures of Value". Quarterly Journal of Economics. vol. 102, 1987.

Cummings, R.G. et. al. Valuing Environmental Goods: An Assessment of the Contingent Valuation Method. Rowman and Alanheld, Totowa, New Jersey, 1986.

CVRD. "Iron Ore Pricing". Mimeo. 1990.

CVRD. Impacto Ambiental e Desenvolvimento Socio-Economico ao Longo da Estrada de Ferro Carajas. CVRD, 1987.

CVRD. "Amazonia Oriental: Plano Preliminar de Desenvolvimento". Mimeo, 1981.

Dasgupta, A. K. and Pearce, D. W. Cost -Benefit Analysis: Theory and Practice. Macmillam Education, London, 1978.

FAO. Tropical Forest Resources. FAO, 1981

Falesi, I. " Solos na Area de Influencia de Carajas" in SEMA/ IWRB/ CVRD. Desenvolvimento Economico e Impacto Ambiental em Areas de Tropico Umido Brasileiro: A Experiencia da CVRD. CVRD, Rio de Janeiro, 1987.

Fearnside,P. M. "The Charcoal of Carajas: A Threat to the Forests of Brazil's Eastern Amazon Region". Ambio, vol 18, no 2, 1989

" Deforestation in Brazilian Amazonia: The Rates and Causes of Forest Destruction". The Ecologist, vol 19, no 6,1989.

"Deforestation and Agricultural Development in Brazilian Amazonia". Interciencia, vol 14, no 6, 1989.

"Causas do Desmatamento na Amazonia Brasileira" Para Desenvolvimento. no23, jan-jun1988.

"Jari at Age 19: Lessons for Brazil's Silvicultural Plans at Carajas". Interciencia , vol 13, no 5, 1988.

"Human-Use Systems and the Causes of Deforestation in the Brazilian Amazon". Paper presented at UNU International Conference on Climatic, Biotic and Human Interactions in the Humid Tropics. Sao Jose dos Campos, SP, Brazil, 1985.

Fearnside, P. M. and Rankin,J.M. "The New Jari: Risks and Prospects of a Major Amazon Development". Interciencia . vol 7, 1982.

" Jari and Development in the Brazilian Amazon" Interciencia, vol 5, no3, 1980.

"Jari Revisited : Changes and the Outlook for Sustainability in Amazonia's Largest Silvicultural Estate". Interciencia, vol 10, no 3, 1985.

Freitas, M. L. D. "A Politica Ativista da CVRD" in SEMA/IWRB/CVRD, Desenvolvimento Economico e Impacto Ambiental em Areas de Tropico Umido Brasileiro: A Experiencia da CVRD. CVRD, Rio de Janeiro,1987

"Brazil's Carajas Iron Ore Project: Environmental Aspects" Mimeo, Rio de Janeiro, 1986.

Garcia, Gasques, J. and Yokomizo, C. "Avaliacao dos Incentivos Fiscais na Amazonia". Mimeo, IPEA, Brasilia, 1986

Gistilink, F. "Carajas, Usinas e Favelas". Mimeo, Sao Luis, 1988.

Gittinger, J. P. Economic Analysis of Agricultural Projects. John Hopkins University Press, Baltimore and London, 1982.

Goodland, R. " Environmental Reconnaissance of Tucurui Hydro Project" ELETRONORTE, Brasilia, 1987.

Goodland, R. J. A. "Brazil's Environmental Progress in Amazonian Development" in Hemming, J. (ed), Change in the Amazon Basin(voll Man's Impact on Forests and Rivers. Manchester UniversityPress, Manchester,1985.

Gradwohl, J. and Greenberg, R. Saving the Tropical Forests. Earthscan, London, 1988.

Guimaraes, E. P. "Recent Trade Policy in Brazil". Kiel Working Papers, Kiel, August 1989.

Hall, A. Developing Amazonia: Deforestation and Social Conflict in Brazil's Carajas Programme. Manchester University Press, Manchester, 1989.

Hamilton, L. and King, P. Tropical Forest Watersheds: Hydrology and Soils Response to Major Uses or Conversions. Westview Press, Boulder, 1983.

Harberger, A. C. "Three Basic Postulates for Applied Welfare Economics". Journal of Economic Literature, vol 9, September, 1971.

Hecht, S. " The Sacred Cow in the Green Hell: Livestock and Forest Conversion in the Brazilian Amazon". The Ecologist, vol 19, no6, 1989.

" Environment, Development and Politics: Capital Accumulation in the Livestock Sector in Eastern Amazonia". World Development, Vol XIII, no6, 1985.

Hecht,S. and Cockburn, A. The Fate of the Forest: Developers, Destroyers and Defenders of the Amazon. Verso, London and New York, 1989.

Helmers, F. L. C. H. Project Planning and Income Distribution. Martinus Nijhoff Publishing, Boston, The Hague and London, 1979.

Hirschman, A. The Strategy of Economic Development. Yale University Press, New Haven and London, 1958.

Houghton, R. A. "The Future Role of Tropical Forests in Affecting the Carbon Dioxide Concentration of the Atmosphere". Ambio, vol. 19, no 4, 1990.

Houghton, R. A. and Woodwell, G. M. "Global Climatic Change". Scientific American, no 260, pp 36-44, 1989.

IBASE. Carajas: O Brasil Hipoteca seu Futuro. Achiame, Rio de Janeiro, 1983.

IBGE. Sistema de contas nacionais consolidadas. IBGE, Rio de Janeiro,1989.

IBGE. Estudo Integrado de Recursos Naturais em Areas Especificas do PGC-Nucleo de Maraba.IBGE, Rio de Janeiro, 1987.

IBGE. Matriz de Relacoes Intersetoriais.IBGE, Rio de Janeiro,1987.

IBGE. Estatisticas Historicas do Brasil. IBGE, Rio de Janeiro, 1987.

IBGE. Anuario Estatistico do Brasil.IBGE, Rio de Janeiro, 1986.

IBGE. Censo Demografico.IBGE, Rio de Janeiro,1980.

IDESP. "Impacto de Implantacao do Polo Siderurgico na Estrutura Produtiva e no Movimento Migratorio em Maraba".Relatorio de Pesquisa no12. IDESP, Belem, 1988

INPA. "Estudos da Ecologia e Controle Ambiental na Regiao da UHE Tucurui". Relatorios Setoriais. Manaus, 1982.

Johansson, P. O. The Economic Theory and Measurement of Environmental Benefits. Cambridge University Press, Cambridge, 1987.

Krutilla, J. and Fisher, A. C. The Economics of Natural Environments. Resorces for the Future, Washington, D. C., 1975.

Langoni,C. G. As Causas do Crescimento Economico no Brasil. APEC,Rio de Janeiro, 1974.

Little, I.M.D. and Mirrlees,J.A. Project Appraisal and Planning for Developing Countries.Heineman Education Books,1974.

Mahar, D. J. Government Policies in Brazil's Amazon Region. The World Bank, Washington, D.C., 1989.

Malingreau, J. and Tucker, C. "Large Scale Deforestation in the Southearstern Amazon Basin of Brazil". Ambio, vol 17, no1, 1988 .

Margullis, S. "Desempenho do Governo Brasileiro e do Banco Mundial com Relacao a Questao Ambiental do Projeto Ferro Carajas". Texto para Discussao no 193.IPEA, Rio de Janeiro, August 1990.

Markandya, A. The Economic Appraisal of Projects: The Environmental Dimension. Prepared for the Inter-American Development Bank, Washington D. C., 1991

Markandya, A. and Richardson, J. The Environment and Structural Adjustment. Prepared for the World Wildlife Fund, Washington D. C., 1990.

MIRAD. Conflitos de Terra. Coordenadoria de Conflitos Agrarios, MIRAD/INCRA, Brasilia, 1987.

Mishan, E. J. Cost Benefit Analysis. Allen and Unwin, London, 1982.

Mishan, E. J. Elementos de Analise de Custos -Beneficios. Zahar, Rio de Janeiro, 1975.

Mitchell, R. C. and Carson, R. T. Using Survey Methods to Value Public Goods: The Contingent Valuation Method. Resources for the Future, Washington D. C, 1989.

Myers, N. Deforestation Rates in Tropical Forests and Their Climatic Implications. Friends of the Earth Report, 1989.

Nordhaus, W. "To Slow or not to Slow: The Economics of the Greenhouse Effect". Mimeo. Department of Economics, Yale University, 1990

Novaes, F. "Vertebrados Terrestres da Serra Norte/ Carajas" in SEMA/IWRB/CVRD. Desenvolvimento Economico e Impacto Ambiental em Areas de Tropico Umido Brasileiro: A Experiencia da CVRD. CVRD, Rio de Janeiro, 1987.

Oren, D. "A Avifauna da Canga Ferrifera " in SEMA/IWRB/CVRD. Desenvolvimento Economico e Impacto Ambiental em Areas de Tropico Umido Brasileiro: A Experiencia da CVRD. CVRD, Rio de Janeiro,1987.

Pearce, D. W. " Economic Values and Tropical Forests" in Pearce, D. W. and Warford, J. (eds). Environment and Economic Development in the Third World. forthcoming., 1990.

"An Economic Approach to Saving the Tropical Forests" in Helm, D.(ed). Economic Policy Towards the Envionment. Backwell, Oxford, forthcoming.

. Economic Values and the Natural Environment. The Denman Lecture, University of Cambridge, February 1987.

Cost- Benefit Analysis. Macmillam Education, London, 1983.

Pearce,D. W. and Markandya,A. "Marginal Opportunity Cost as a Planning Concept" in Scharamm, G. and Warford, J.(eds). Environmental Management and Economic Development. Published for the World Bank, John Hopkins University Press, Baltimore and London, 1989.

The Benefits of Environmental Policy. OECD, Paris,1988

Environmental Considerations and the Choice of Discount Rate in Developing Countries. Environment Department, World Bank, Washington D. C., 1988

"Shadow Prices in Pakistan". Report prepared for the World Bank. 1987.

"The Economic Benefits of Environmental Improvement". Paper prepared for the Environmental Research Trust. Romford, Essex, 1986.

Pearce, D. W., Markandya, A, and Barbier, E. Sustainable Development: Economics and Environment in the Third World. Edward Elgar Publishing Limited, 1990.

. Blueprint for a Green Economy. Earthscan, London, 1989.

"Sustainable Development and Cost-Benefit Analyis", LEEC Paper. London, 1988.

Pearce, D. W. and Myers, N. "Economic Values and the Environment of Amazonia" in Goodman, D. and Hall, A. (eds). The Future of Amazonia: Destruction or Sustainable Growth? Macmillam Press, London, 1989.

Pearce, D. W. and Nash, C.A. The Social Appraisal of Projects - A Text in CBA. Macmillam, London, 1981.

Peters, C. et. al. "Valuation of an Amazonian Forest". Nature, vol. 339, 1989.

Pezzey, J. Economic Analysis of Sustainable Growth and Sustainable Development. Environment Department, The World Bank, Washington, D.C., 1989.

PGC. "Relatorio de Desempenho". PGC Report, 1988.

Pommerehne, W. et. al. "Economic Theory of Choice and the Preference Reversal Phenomenon: A Reexamination". American Economic Review, Vol. 72, 1982.

Powers,T.A. (ed). Estimating Accounting Prices for Project Appraisal. Interamerican Development Bank,Washington D.C.,1981.

Randall, A. et al. National Aggregate Benefits of Air and Water Pollution Control. University of Kentucky, 1985.

Ray,A. Cost-Benefit Analysis:Issues and Methodologies.The John Hopkins University Press, Baltimore, 1984.

Redclift, M. Sustainable Development: Exploring the Contradictions. Methuen, London, 1987.

Repetto, R. World Enough and Time.Yale University Press, New Haven, 1986.

Ruitenbeck, H. J. Evaluating Economic Policies for Promoting Rainforest Conservation in Developing Countries. Ph.D Thesis, London School of Economics and Political Science, University of London, 1990

Scohl,W. W. "Estimating Shadow Prices for Colombia in an Input-Output Table Framework, World Bank Staff Working Paper No 357,World Bank, Washington D.C.,1979.

Secrett, C. "Greater Carajas: Sustainable Development or Environmental Catastrophe.in Treece, D. Bound in Misery and Iron:the Impact of the Grande Carajas Programme on the Indians of Brazil. Survival International, London,1987.

Seroa da Mota,R. "Estimativas de Precos Economicos no Brasil". Texto para Discussao no 143, IPEA/ INPES, Rio de Janeiro,1988.

"Um Estudo de Custo-Beneficio do PROALCOOL". Pesquisa e Planejamento Economico, vol 17, no1, 1987.

. Alcohol as Fuel: a Benefit-Cost Study of the Brazilian National Alcohol Programme- Ph.D Thesis, University College London, University of London,1985.

Shabman,L. and Bertelson,M. "The Use of Development Value Estimates for Coastal Wetland Permit Decisions". Land Economics, 55, 2, May 1979.

Silva, M. "Estudos Botanicos em Carajas" in SEMA/IWRB/CVRD. Desenvolvimento Economico e Impacto Ambiental em Areas de Tropico Umido Brasileiro: A Experiencia da CVRD. CVRD, Rio de Janeiro, 1987.

Simons, M. "The Smelters' Price: a Jungle Reduced to Ashes".The New York Times, 28 May 1987.

Squire,L. and Van der Tak, H. Economic Analysis of Projects.The John Hopkins University Press, Baltimore,1975.

Tundise,J. et al. "Caracterizacao dos Ecossistemas Aquaticos na Area de Influencia da Ferrovia Sao- Luis Carajas" . Mimeo, CVRD, Rio de Janeiro, 1986.

Turner, R. K.(ed). Sustainable Environmental Management Belhaven Press, and Boulder, Col: Westview Press, London, 1988.

UNIDO. Guidelines for Project Evaluation.United Nations, New York,1972.

Whittington, D. et. al. Willingness to Pay for Improved Sanitation in Kumasi, Ghana: A Contingent Valuation Study. Report Prepared for the World Bank, 1991.

World Bank. Project Completion Report-Carajas Iron Ore. Confidential Report. 1989.

Word Bank. Iron Ore and Steel Market Trends and Outlook. Confidential Report, 1987.

World Bank. Carajas Iron Ore Project-Staff Appraisal Report. Confidential Report, 1982.

World Commission on Environment and Development. Our Common Future. (The Brundland Report), Oxford University Press, Oxford,1987.

World Resources Institute. World Resources 1990-1991. WRI, Oxford University Press, 1990.