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METALLURGY IN THE BRAZILIAN AMAZON: ALTERNATIVES FOR ACTIVITIES WITH SCARCE ECOLOGICAL PRUDENCE*

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Abstract:

The state strategic attempts at modernization in the Amazon during the 80's were of key importance for the launching of social actors in the region, among them the metallurgy industries. These producers — using charcoal as input and produce pig iron only — were relocated to the eastern Brazilian Amazon. Until then, such producers were almost exclusively located in the Brazilian southeast. They were called independent companies. They were different from the metallurgy companies called integrate, which operated in a larger scale manufacturing iron ore until the final product. In function of the high participation of the charcoal in the production costs, independent companies prefer to acquire charcoal originating from the native forest. As a consequence of this strategy, part of the biomass gathered in a deforested area of approximately 390 thousand hectares per year is carried to the metallurgy industry furnaces. Besides the pressure exercised on the forest, the implantation of these pig iron producers favoured the land concentration, contributes to the social dynamics reinforcing the chaos in the several urban spaces, the land conflicts, intensifying low wages and unhealthy working conditions. Such dynamics allows a cheap charcoal and pig iron production and represents a transfer of private costs to the society.

Keywords: Amazônia. Regional development. Metallurgy. Deforestation. Charcoal.

Resumo:

Na década 80, as tentativas estratégicas de modernização da Amazônia, concebidas pelo Estado nacional, foram decisivas para o lançamento de importantes atores sociais na região, dentre eles as indústrias siderúrgicas. Estas empresas — usam carvão vegetal como insumo e produzem tão somente ferro-gusa — foram deslocadas para a Amazônia Oriental brasileira. Até então elas localizavam-se quase exclusivamente no sudeste brasileiro. Tais indústrias são comumente chamadas de companhias independentes. Diferentemente das chamadas de integradas, que operam com grandes escalas de produção, partindo do minério de ferro até o produto final.

Em função da elevada participação do carvão vegetal nos custos de produção, as companhias independentes buscam adquirir carvão vegetal originário da floresta nativa. Como conseqüência desta estratégia, parte da biomassa retirada de uma área de aproximadamente 390 mil hectares é, anualmente, carreada para os alto-fornos das indústrias siderúrgicas.

Além da pressão exercida sobre a floresta, a implantação da produção de ferro-gusa favoreceu a concentração fundiária, contribuiu com dinâmicas sociais que reforçam a caotização de diversos espaços urbanos, os conflitos fundiários, e intensificam os esquemas de submissão da força de trabalho à baixa remuneração e a condições de trabalho insalubres. Dinâmicas estas que viabilizam a produção barata do carvão vegetal e ferro-gusa e representam uma brutal transferência para a sociedade de custos privados.

Palavras-chave: Amazônia. Desenvolvimento regional. Siderurgia. Desmatamento. Carvão vegetal.

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Introduction

Several pig iron industries have been installed in the eastern Brazilian Amazon during the last twelve years, as a result of governmental policies. Pig iron is an intermediate form through which the majority of iron compounds have to go before being transformed into steel.

Despite the constant increase of pig iron production, which was greater than 1.3 million tons in 1999, the effects resulting from such activity vis-à-vis regional development are very different than the official forecasts which justified the pig iron production. Up to present date, no industry has been installed to produce pig iron input within the region with higher aggregate value output.

Therefore, due to the low prices of pig iron, the low taxes paid by metallurgy companies, and the meaningless salaries generated by these companies, the changes that happened in the region as a result of the operation of these industries are mainly linked to the charcoal demand they generate.

The production of one ton of pig iron requires approximately 0.8 ton of charcoal as a reducer in the production process. This has resulted in a wide dissemination of charcoal production in the region, increasing forest exploitation with scarce ecological prudence, with employees working for low wages and under unhealthy conditions.

In view of the consolidation of pig iron production in the eastern Brazilian Amazon and that such production has not offered contributions for the sustainable development of the region, this study aims at reflecting on the elaboration and development of public and private agendas that are not totally marked by economic feasibility, but at the same time are marked by environmental prudence and contribute to social equity in the region.

The genesis of regional pig iron production has close liaisons with state intervention

Although the theories which supported intervention practices worldwide, linked to the so-called “development economy”, suffered increasing restrictions during the 80’s, the state perspective to transform the Carajas Railway Corridor into a giant mineral-metallurgical center at the beginning of that decade was still based on such theories, which have as central concepts the “unbalanced growth”, “chaining effects”, “motor complexes”, etc.

The document which served as the base for the most important federal intervention program in the region, called Great Carajas Program - GCP - pointed to a scenario where 3.5 million tons of pig iron, 10 million tons of steel, 550 thousand tons of iron alloys, and 30 thousand tons of metallic silicon would be produced in the eastern Brazilian Amazon in the year 2000, in the fields of metallurgy and others (Companhia Vale do Rio Doce, 1981).

In terms of planning, such vision wasn’t abandoned during the 80’s. The Directive Plan for the Carajas Railroad Corridor, dated 1989, indicated that the industrialization in the region was linked to the “implementation of a progressive and varied industrial park, regionally and nationally linked, to be

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initially enhanced by the export base", so that the region would not be transformed into a mere exportation platform for goods with low aggregate value" (Brasil, 1989: 7).

The official discourse announced the GCP as a program inserted within the regional development, which would industrialize and modernize the eastern part of the Brazilian Amazon due to the "dynamic chain effects" and the "internalization of revenues" as a result of the mineral product "export base". From such dynamics an "industrial metal-mechanics complex" would be created and its first stage would be the metallurgy industries. It was forecasted that the "forwarding motion set by metallurgic activities would propitiate the creation of a metal-mechanic park, which would be responsible for at least 44,000 new jobs in the year 2010" (Brasil, 1989: 19). The base of this industrial metal-mechanic center would be metallurgic activities.

Government plans recognized that such a huge metallurgy park would mean a significant consume of charcoal. It was forecasted that in the year 2000 1.4 million tons of charcoal would be consumed by the pig iron production (Brasil, 1989: 242). It was also recognized that that such a demand would mean an additional pressure on the forest. As an alternative, the *babacu* cocoa was indicated, as well as forest management and silviculture for biomass production, and carbonization methods using advanced techniques such as ovens that could recuperate tar instead of rustic ovens called "rabo-quente" (a kind of primitive clay oven).

In a smaller number and in a lower rhythm than that expected by the state planners, in the 80's and 90's some companies settled in the region, to produce pig iron - an intermediate form which the majority of iron components must go through before being transformed into steel. They were called independent companies. The investments and output of these companies are small when compared to those made by integrated industries. Pig iron produced by the smaller companies is sold as an input for integrated plants or iron manufacturers. They were different from the metallurgy companies called integrate, which operated in a larger scale working from iron ore until the final product, with all stages under their control, manufacturing steel products such as: dowels, plates, sheets, bobbins, bars and cables.

Integrated plants follow the technological route which dominates worldwide production of steel and is based on an industrial plant combining smelters for pig iron production and oxygen steel plant for steel production with machinery producing ingots and splinters. Such setup requires a minimum production of ten thousand tons per day, i.e. more than three million tons per year.

Nine independent pig iron companies have settled in the Eastern Amazon (Tab. 1). The settlement of these companies in the region is not a result of capitals invested in other activities in the region, but of corporate initiatives coming from other regions, mainly from the State of Minas Gerais.

Besides the possibility of easy and cheap access to biomass for charcoal production in the region, one of the things that made companies settled down in the region was the several credit, tributary and infrastructure facilities available. The major agents involved in the execution of public policies directed to industrial plants installation in the eastern Brazilian Amazon were the CGP and the following agencies: Development Superintendence for the Amazon – SUDAM and Development

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Superintendence for the Northeast – SUDENE. These two agencies had a major role in gathering the necessary financial resources to form the capital for the investment. This was mainly done through the Fund of Investment in the Northeast – FINOR and Fund of Investment in the Amazon – FINAM. The projects approved within the competence of GCP had immediate priority for approval by SUDAM and SUDENE. One of the program's goals was to ensure the approval for income tax exemption for the companies, for a period of ten years.

COSIPAR, for instance, was partially financed by FINAM. According to the approved project, the FINAM fund would commit US$ 40.6 millions for the company capital. The company investments were only US$ 13.3 millions, in other words, only ¼ of the total resources needed to implement the project, the rest came from FINAM.

Therefore, these companies enjoyed financial aids from FINAM and FINOR. Once the project was approved, the signatories would receive 75% of the total amount indicated as necessary for the implementation of the industrial plants and for the purchase of rural areas for the forest management projects and reforestation. The resources were granted to the companies by the government agencies (SUDAM and SUDENE), which administrate the public funds for companies through the emission of shares and debentures by the companies.

The forms of federal mechanisms and intervention in the region have greatly changed during the past two decades. This was caused by the central authority lost by the military government, during the 80's, a process that culminated with the end of military governments, in 1985, and the promulgation of the 1988 Constitution. During this process, several mechanisms of intermediation between interests of several groups in the society have changed, as well as the relationships between States and Union. This had significant consequences for the conduction of policies regarding the mineral resources of the Amazon. The GCP, which had already endured objections by the society, lost its power and after that was terminated.

Therefore, modernization discourses, actions and strategies proposed for Amazonia were not the same ones that had guided the actions of the Brazilian National State, which formed the base for the implementation of metallurgy industries in the region. Such strategic changes in the state intervention are certainly linked to the changes caused by a new socially established force, together with worldwide accepted dynamics, which demanded new "models" of development.

TABLE 1: METALLURGY COMPANIES IN THE EASTERN BRAZILIAN AMAZON

Company	Location	Employees	Installed capacity (10^3t/year) [a]	Production (10^3t)	Ore Purchases (10^3t)
Maranhão Gusa S/A (MARGUSA) [b]	Bacabeira – MA	96	90	17[c]	23
Cia. Siderúrgica do Maranhão (COSIMA)	Santa Inês – MA	150	120	19[c]	30
Cia. Siderúrgica Vale do Pindaré [d]	Açailândia-MA	150	120	90	138
Viena Siderúrgica	Açailândia-MA	415	280	250	366
Gusa Nordeste S.A	Açailândia-MA	126	216	103	173
Siderúrgica do Maranhão S.A. (SIMASA)	Açailândia-MA	150	210	200	340
Ferro-gusa do Maranhão (FERGUMAR)	Açailândia-MA	170	130	93	151
Companhia Siderúrgica do Pará (COSIPAR)	Marabá-PA	260	320	200	291
Siderúrgica Marabá (SIMARA) [e]	Marabá-PA	100	90	40	103
Totais		1617	1576	1012	1615

(a) All data refer to 1997

(b) Belonged initially to the group Yanmar do Brasil, was shut down from January 1996 to April 1997, being then bought by a group from the State of Minas Gerais, Calsete, where the group was active as pig iron producer.

(c) In 1997 these companies worked only part time.

(d) Belonged to Construtora Brasil until May 1996, being then purchased by the Group Queiroz Galvão, which is also the owner of SIMASA. Together with Siderúrgica Viena, they form a trading company to market the companies' production.

(e) Belonged initially to a local group called Belauto, which has closed down due to the death of its major share holder, Mr. Jair Bernardino. The machines stopped in January 1989 and started to operate again only in December 1995, already under the control of a small metallurgy group from Minas Gerais.

Source: FIEMA (1995), FIEPA (1999), JUCEPA (1998), CVRD/RAL (1998) and research data.

The documents supporting federal intervention in the region are now in favor of a reduction of a direct state presence in economic initiatives, as well as reduced state control over such initiatives. According to official documents, this was emphasized, in the last decade, by the state financial crisis, mainly the Federal Union, which became incapable of managing with efficiency the majority of the economic projects mainly under its financial responsibility. On the other hand, the official discourse is now forecasting the increase of private initiative in the regional development process (Brasil, 1995a: 13). Within such context, Companhia Vale do Rio Doce – CVRD – responsible for the ore extraction in Carajas, was privatized.

Regarding regional development policies, the need to articulate the various regions between themselves and with the rest of the world, gains priority. State planners start to conceive the big national and international integration structures such as long distance transportation roads, of multimodal nature, marked by high capacity and low operational costs, enhancing the access to wider markets and improving the competitiveness of regional economic systems (Brasil, 1997: 17).

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Therefore, the metallurgy companies in the eastern Brazilian Amazon are presently facing the change in some aspects of important socio-economic agents, such as the National State. SUDAM and several other federal bureaucratic agencies, which used to have a prominent role in the state support for regional primary metallurgy, are now less important and part of the tributary exemptions is not anymore granted. However, certain instruments, which were and still are important for public policies supporting metallurgy industries, such as the access to funds as FINAM and FINOR, have been maintained and the previous tax exemptions were replaced by the alternative of reduced tax rates.

Independent metallurgy companies and their demand for charcoal extracted from the native forest

The state strategic attempts at modernization in the Amazon during the 80's were of key importance for the launching of social actors in the region, among them the metallurgy industries. The consequences for the region depend on which social groups have access to the natural resources and the way they do it, incorporating new dynamics and enlarging the structural diversity of the region. Independent pig iron producers, using charcoal as input, relocated to the eastern Brazilian Amazon. Until then, such producers were almost exclusively located in the Brazilian southeast, specially in the State of Minas Gerais, where iron ore extraction dates back to last century.

There too the metallurgy industry has widely used charcoal as a reducer for pig iron production. However, a trend to reduce charcoal consumption is already perceived. In 1988, more than 36.3 million cubic meters were consumed, and in 1998 it dropped to 24.49 million cubic meters (Anuário Estatístico ABRACAVE, 1999).

Charcoal has basically two origins: it is either produced from native forests, or comes from areas reforested exclusively for charcoal production. The charcoal from reforested areas has a significantly higher production cost than that coming from native forests. The greatest consumers of reforested areas charcoal are the big metallurgy companies, called integrated, with a vertical production. With all production stages under their own control, these companies can bear higher input costs, mainly that of charcoal coming from reforested areas.

Nevertheless, during the past decade the consumption of charcoal by these integrated companies has dropped. In 1988 they consumed 11.3 million cubic meters of charcoal; during the 90's the consumption was constantly reduced and in 1998 it dropped to 4.4 million cubic meters (Fig. 1). The reduction in charcoal consumption by the big integrated plants is linked to the increasing replacement of charcoal by coke as a reducer in the production process. The integrated plants using charcoal produced 3.1 million tons of pig iron, in 1988, and in 1998 this number was reduced to 1.7 millions. On the other hand, within the same period, pig iron production by integrated plants using coke increased from 15.6 million to 18.6 million tons (Anuário Estatístico ABRACAVE, 1999). This is a result of the changes undergone by big integrated metallurgy companies, such as Belgo-Mineira and Acessita, which have started to use smelters, where iron ore reduction is made through the use of coke, not charcoal.

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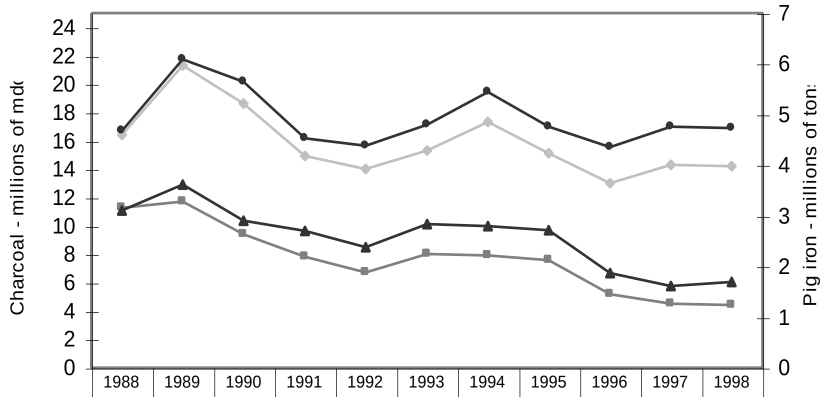
FIGURE 1: CHARCOAL CONSUMPTION AND PIG IRON PRODUCTION IN BRAZIL, BY INTEGRATED PLANTS AND INDEPENDENT PRODUCERS (1988-1998).



	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Charcoal consumed by integrated industries (millions of mdc)	11,30	11,70	9,40	7,80	6,70	8,00	7,90	7,60	5,20	4,50	4,40
Charcoal consumed by independent industries (millions of mdc)	16,40	21,30	18,60	14,90	14,00	15,30	17,30	15,10	13,00	14,30	14,19
Pig iron production by independent industries (millions of tons)	4,68	6,09	5,64	4,53	4,38	4,80	5,44	4,76	4,35	4,76	4,73
Pig iron production by integrated industries using charcoal (millions of tons)	3,11	3,61	2,90	2,70	2,38	2,84	2,80	2,72	1,87	1,61	1,69

Source: Anuário estatístico ABRAVACE (several years). Elaborated by the author.

The independent pig iron producers are, therefore, responsible for the maintenance of the high charcoal consumption as pig iron production reducer in Brazil. In 1998, these companies consumed 14.1 million cubic meters of charcoal, representing 58% of the total charcoal consumed by Brazilian industries.

It is evident that integrated plants tend to replace charcoal by coke and independent plants tend to maintain the use of charcoal as a reducer in their production processes. The problem is that, as opposed to integrated plants, the so-called independent plants produce only pig iron and because charcoal is a considerable item on their production costs they try to acquire charcoal from native forests in order to decrease the costs of their inputs.

Such trends were decisive in the past decade’s size reduction of reforested areas for charcoal production, in Brazil. In 1990, there were 125 thousand ha, but in 1998 there were only 30 thousand ha (Anuário Estatístico ABRACAVE, 1999).

Pig iron production shows a steady growth in Amazon

Currently, independent pig iron producers, in Amazon, have a total output capacity of over 1.5 million tons/year (Tab. 1), a potential production linked to the existent 18 smelters. In the State of Minas Gerais the output capacity is 5 million tons/year (Anuário Estatístico ABRACAVE, 1999). The

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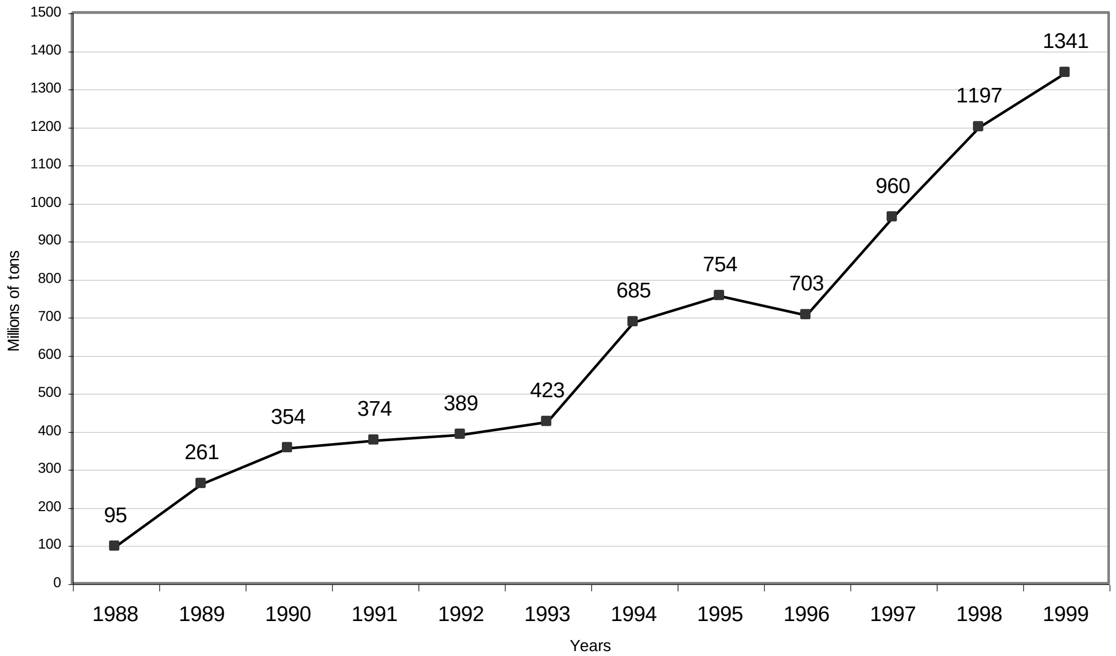
pig iron output capacity currently in existence in the Amazon represents over 20% of the total independent plants output capacity in Brazil.

There is now a situation in the eastern Brazilian Amazon, where the pig iron production has increased year by year and this is very significant (Fig. 2). This also means a considerable charcoal annual consumption of at least 1.3 million tons. In terms of iron ore, however, the demand of these plants is residual when compared to the annual output of Serra Carajas. In 1997, for example, the pig iron companies located in the eastern Brazilian Amazon consumed 1.6 million tons (Tab. 1), which corresponded only to 3.7% of the total iron ore extracted from Carajas in the same year (CVRD/RAL, 1998).

FIGURE 2: VOLUME OF PIG IRON PRODUCED IN THE EASTERN BRAZILIAN AMAZON.



Source: Research data obtained from the Carajas Railroad Superintendence.

The regional production of pig iron will be increased in the next years with the installation of new smelters in the companies already in operation. To this will be possibly added the beginning of operations of a new metallurgy plant, in 2001, the Usina Siderúrgica do Maranhão – USIMAR, linked to the Group WHB, in Sao Luis, MA. Its production will not be limited to pig iron, but also pig iron processing, with production of iron pieces and components for plants. The operation of its high furnace and other facilities will represent an additional demand of 130 thousand tons of charcoal, which means a 10% increase on the current demand.

We cannot overlook a possible scenario where the plans of CVRD to be installed in Maraba, PA or in Acailandia, MA, will have 5 smelters for pig iron production, with capacity to produce 197,000 tons per year, each. These smelters will use the iron ore from Carajas as a reducer and charcoal combined with coke (20%). According to the company, the first of these smelters may start operating in 2003, using charcoal coming from areas reforested by Celulose do Maranhão – CELMAR, which has not been able to produce cellulose from those forests. According to the company's plans, as of 2005, reforestation will begin in new areas in order to guarantee charcoal for the enterprise.

Charcoal production: main link between pig iron production and regional economy

After almost one decade of operations, the primary metallurgy production is almost entirely sold in the international market. In 1999, 92% of the regional pig iron production was exported mainly to the USA, because the European Union applies taxes of 51.3% on all Brazilian pig iron imports, allegedly due to *antidumping* rights. And even the small part which is sold in the national market is processed in other regions and not in the eastern Brazilian Amazon. Therefore, until present date, the forecasts about these industries and their dynamic factors over the regional economy and that they would serve as a base of a diverse industrial park, have not been fulfilled.

Regarding direct jobs, according to the characteristics of the capital composition, the number of new jobs is small compared to the populations of the cities where the companies are located and there are no significant changes in the job market for these cities. The generation of 1.6 thousand jobs (Tab. 1) is far from what had been forecasted in the Directive Plan for the Carajas Railroad Corridor: 21,658 direct jobs in the year 2000 in the metallurgy and iron alloy sectors (Brasil, 1989: 392).

The wages generated by the operation of the companies have not been able to alter the income in the region. The salaries paid by metallurgy companies, besides being not in great number, are low; the average monthly salaries for the jobs created by these companies is US$ 200 (Monteiro, 1998: 126).

Another key aspect of pig iron producers and regional economy is the taxes that could be generated by the operations. However, the tributary exemptions of the profits generated by the trading of their products have significantly reduced taxes paid by these companies. In 1996, aiming at turning Brazilian products more competitive in the external markets, the federal government exempted several export products - among them pig iron - from the Merchandise and Services Tax – ICMS.

The main socio-economic changes in the region, caused by the operation of these companies, are linked one way or the other to operation inputs, namely charcoal. Therefore, the main link between the industrial plants and the regional socio-economy is the charcoal demand, not only due to the amounts operated - it is estimated that pig iron producers will buy approximately US$ 54 millions of charcoal in the year 2000 - but also due to the creation of several mechanisms for charcoal production, involving several social structures and relations.

Such demand changes the regional scenario; one of the changes is the formation of groups of workers dedicated to charcoal production. The monthly income of charcoal production workers ranges from US$ 52 to US$ 113 per month, corresponding to at least eight hours per day of work (usually 10-11 hours per day). According to work condition criteria, stability, and the salary paid, there is no doubt

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that the jobs generated by charcoal production are very low quality ones; the working and housing conditions are extremely uncertain, jobs are temporary, there are no social or fringe benefits attached, the monthly wages are hardly higher than the national minimum salary, and workers are subject to coercible working capacity immobilization. Besides that, in most cases, workers get paid by the amount they produce; this induces workers to employ their families as helpers, sometimes even children, thus establishing a socially undesirable working relationship for these children, although this is not always perceived by the workers. Moreover, the extension and consequences of such unhealthy working conditions and the future effects on their health are not realized by the workers in its whole extent. One can add to this that even those family members who are not involved in the charcoal production are affected by it because the family houses are usually located near the ovens and all those who live there are impacted by the pollution originating from charcoal production (Monteiro, 1995: 89).

Metallurgy and the trend to consume native forest charcoal

In the 80's, the cost of one ton of charcoal from reforested areas in the eastern Brazilian Amazon was estimated around US$ 60 and US$ 75, excluding the charcoal transport to the plants (Brasil, 1989: 308). However, technicians of Camargo Correa Metais – CCM –, a company which produces metallic silicon, has been reforesting, and has produced splinter and charcoal in the region for its own consumption, with wood originating from silviculture, indicate that in 1997 the production cost of one ton of timber from silviculture was around US$ 20 (Tab. 2) and that the cost of one ton of charcoal from the same biomass would come to US$ 100.

TABLE 2: PRODUCTION COST OF ONE TON OF TIMBER COMING FROM SILVICULTURE IN AMAZONIA.

Cost items	US$/t of timber
Land cost	1.9
Preparation, plantation	7.1
Forest maintenance	6.3
Conduction of *rebrota* and reform	2.2
Administration	2.1
Total	19.6

Source: Research data obtained from CCM in 1997.

The production cost of US$ 19.6 per ton of timber, which is closer to the data provided by CVRD, means that even using an excellent conversion rate (2.7 t/timber for 1 t of charcoal), the cost of timber – excluding cut, transportation, carbonization, maintenance, etc., – represents, in the cost of one ton of charcoal coming from reforested areas, US$ 52.92/t. This cost item alone is higher than the regional price of one ton of charcoal coming from the native forest, which is around US$ 45/t.

The acquisition of charcoal is the most representative cost item in the pig iron production, being approximately 40% of total costs. In the eastern Brazilian Amazon, the production cost of one ton of pig iron, before taxes, comes to US$ 107 (Tab. 3). Therefore, we can safely indicate that charcoal is the main input in pig iron production and the independent companies try to control their profit margins through it.

TABLE 3: PRODUCTION COST OF ONE TON OF PIG IRON IN THE EASTERN BRAZILIAN AMAZON.

Item	Unit	Cost (US$)	Consumption	Cost (US$)
Iron ore [(a)]	T	9.4	1.5	14.10
Mine/plant [(a)]	T	2.55	1.5	3.85
Charcoal	T	45.00	0.875[(b)]	39.37
Chalk	T	15.00	0.05	0.75
Dolomite	T	25.51	0.06	1.53
Quartzite	T	13.55	0.1	1.35
Electricity	MWh	40	0.1	4.00
Other inputs	-	-	-	2.53
Labor force	M/h	2.50	-	6.37
Maintenance	-	-	-	4.27
Administration	-	-	-	4.50
Transport and shipping	T	12.5	1	12.50
Capital costs	-	-	-	12.00
Total	-	-	-	107.12

(a) Items that the CVRD offers to independent plants, called “pig iron package”.

(b) Exclusive loss of charcoal, in an average of 15%.

Source: Monteiro (1998: 133), modified.

Therefore, the price of charcoal produced from reforested areas, over US$ 100/t, is significantly higher than that of charcoal produced from native forests. The charcoal from reforestation is not compatible with the cost structure of pig iron production in the independent companies. Since one ton of pig iron is sold, in average terms, for US$ 125 (Fig. 3), the use of charcoal coming from silviculture would increase the production costs of pig iron and this could not be absorbed by these companies, and would be contrary to their economic logic, which is to try to acquire charcoal at the lowest price.

Therefore, both in southeastern Brazil and in the Amazon, independent companies turn to charcoal from native forests pressed by economic factors. This is the reason why the discourses of the companies and the polemic issue of big reforested areas in the region, to meet the demand for charcoal, was buried during the first decade of operation of the metallurgy projects in the Amazon. The metallurgy industries in the region have not accomplished any of the Integrate Plans Forest/Industry – PIFI’s –, where directions and goals were established regarding the origin of the material to be carbonized, mainly the implementation of silviculture. According to official reports, in the southeast of the country, the demands of the Brazilian Institute of the Environment and Natural

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Resources – IBAMA – requiring metallurgy companies to assure that until 1992 70% of charcoal should come from reforested areas and that until 1995 this ratio should be 100%, were totally disregarded (Brasil, 1995b: 25).

The biomass used to supply the pig iron producers in the eastern Brazilian Amazon comes almost entirely from the native forest. The portion coming from silviculture or from babacu cocoa carbonization is not significant. The timber which feeds the thousands of smelters where charcoal is produced has several origins: deforestation for pasture or farming purposes; leftovers from sawmills; and the so-called sustainable forest management.

For charcoal production, a varied social relation network is created; in general terms, it has the following path: when the timber comes from deforestation for pasture or farming purposes, the land owners do not charge for the timber taken, asking only that the charcoal producers render the area "clean" for planting almost always grass.

That is why it is not possible to establish an equality between small charcoal producers and small farmers or squatters because in most of the cases the charcoal suppliers use timber from different landowners. Therefore, a small charcoal supplier almost always uses timber coming from a big estate and not necessarily from a small farm.

When the biomass to be burned comes from sawmill leftovers, the sawmill owner usually allows the ovens to be installed within the sawmill premises and gives away the leftovers, asking that the sawmill staging area be cleaned. In some cases, the sawmill owners get 10 or 20% of the amount of the charcoal produced.

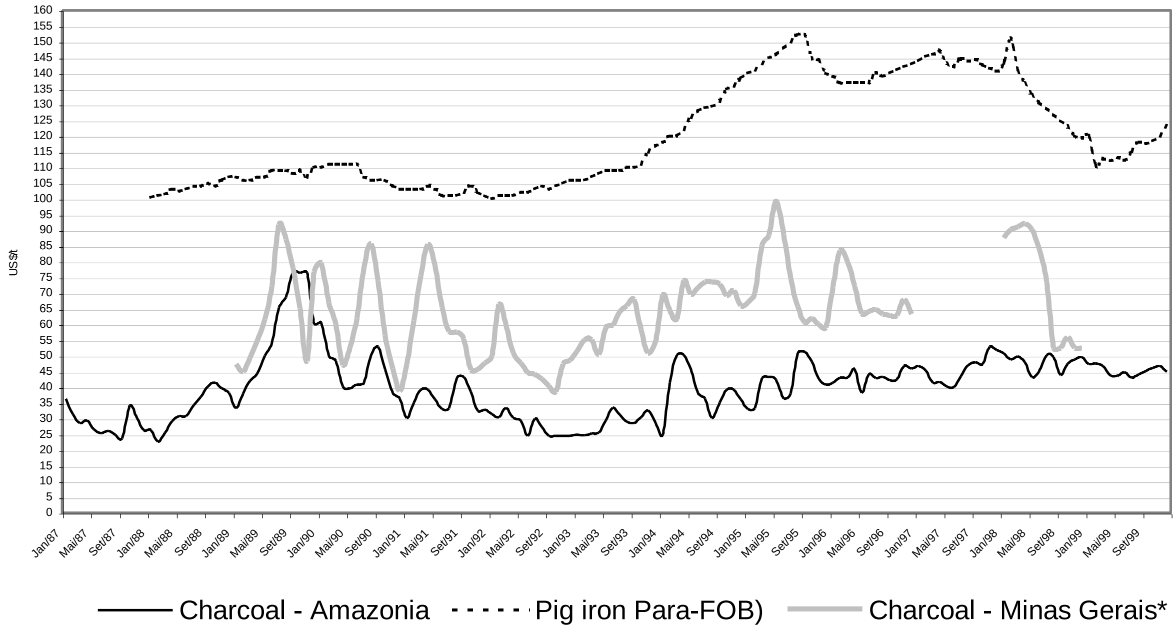
In some cases, the large estate owners or the sawmill owners are directly in charge of the charcoal production, but this is not the usual pattern.

In July 1995, Monteiro (1998: 149) estimated that the operation costs – excluding capital costs – involved in the production of one ton of charcoal supplied by sawmill leftovers were around US$ 30 and the production costs of those who used timber from deforested areas were around US$ 36. Such cost composition resulted in the establishment of a charcoal market in the eastern Brazilian Amazon where prices were lower than those in the State of Minas Gerais, where pig iron industries are located (Fig. 03).

Besides that, the charcoal consumed in the southeast of the State of Para and in the east of the State of Maranhao comes from places near the industries. In the southeast of the country the charcoal is usually transported across distances of more than 800 kilometers.

A study which analyzed the formation of charcoal markets and which encompassed more than 800 suppliers of COSIPAR in the years 1989, 1990 and 1991, indicated that around 2/3 of the charcoal consumed by the company came from sawmill leftovers and that 70% of the charcoal made from deforestation timber came from charcoal factories located no more than 80 km from COSIPAR and that approximately 50% of all charcoal supplied came from charcoal factories located around the same area (Monteiro, 1993: 16). However, during the 90's, two trends were leading the process: the proportional reduction of charcoal production coming from farms and the proportional increase in the charcoal coming from sawmill leftovers; and the longer distances between biomass for charcoal production and the industries.

FIGURE 03: PRICE OF CHARCOAL IN THE EASTERN BRAZILIAN AMAZON AND IN THE STATE OF MINAS GERAIS.



* Converted at the rate of 3.5 mdc equivalent to 1 t.

Sources: Anuário Estatistístico Abracave (several years), Abracave (1996) and research data.

The first trend seems to result from the higher costs of charcoal produced with timber from deforested areas when compared to costs of charcoal produced with timber from sawmill leftovers, but it is linked to the charcoal demand, which became higher than the pasture area capacity. This becomes less important, however, due to the reduction of land prices during the past decade, the monetary stabilization in Brazil, as well as due to the constant occupation threats suffered by big estate owners, diminishing the role of land as a valued reserve.

Regarding the distance between charcoal production areas and the industries, this is also a trend in the independent industries in the southeast of Brazil. The National Program for the Environment indicates that the State of Bahia is presently the biggest charcoal producer and supplier for the metallurgy industries in the State of Minas Gerais, using timber extracted from the Atlantic Forest existent in the southwest parts of Bahia. This emphasizes, in southeastern Brazil, the increasing distances between biomass sources and metallurgy industries (Brasil, 1995b: 53).

In the eastern Brazilian Amazon, it is already common place to see charcoal transported across distances over 300 km. Therefore, charcoal production is not anymore under the direct influence of the Carajas Railroad and extends itself along the northern Tocantins State as well as all the southeast

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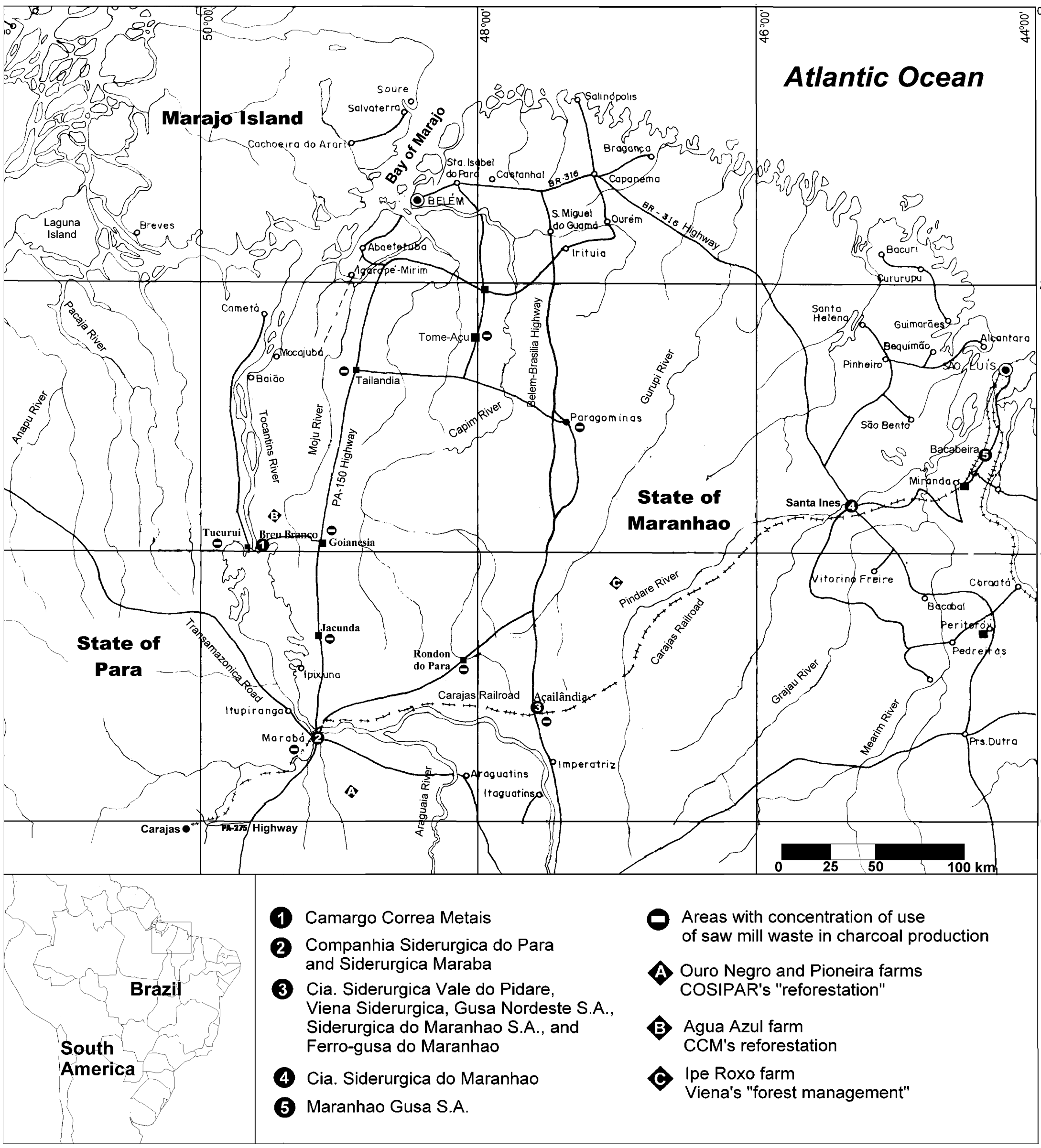
region of the State of Para. In the State of Maranhao, there's a lot of pressure on the pre-Amazon forest as well as on large savannah areas in that state (Fig. 04).

FIGURE 04: LOCATION OF PIG IRON PRODUCTION ENTERPRISES IN THE BRAZILIAN EASTERN AMAZON.



Source: Monteiro (1998: 88). Modified.

Therefore, because of lack of pressure on the part of government agencies, the companies tend to consume charcoal coming from the native forest, being an additional element of pressure on the several ecosystems in the region.

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The "sustainable forest management" as a strategy for large deforestation

The charcoal production is based on supplies from native forest biomass. The independent pig iron producers have resorted to several artificial means, which allow them to gain access to forest reserves with almost no trace of ecological prudence and at low costs. All this with the blessing of the public administration, which is the central piece to guarantee the economic coherence of the enterprises. Among these artificial means is the *sustainable forest management*, which is seen as ecological. This strategy was probably copied from the timber businessmen in the region, who are used to take advantage of this means in order to gain access to large forest areas. According to IBAMA's regional superintendence, only in the State of Para, they registered 1,300 projects of *sustainable forest management* in the years between 1995 and 1999.

The sustainable forest management is a tool to manage the extraction of timber from the forest in such a way that the area can be reforested. Such strategy involves many kinds of forest treatments.

The studies on the production of timber through sustainable management in the Amazon region are scarce and recent. The main experiments are made by the Agro-Forestry Research Center of the Eastern Brazilian Amazon, of the Brazilian Farming Research Company – EMBRAPA – in Belterra, PA, in the National Forest of Tapajos; by the National Institute of Research in the Amazon - INPA, in the Negro River region; by SUDAM/Agricultural Sciences Faculty of the State of Para – FCAP; in a study series located in the west of Para. In the Carajas Railroad Corridor, in the cities of Buriticupu and Santa Luzia, State of Maranhao, the researches are conducted by Rio Doce Forests S/A – FRDSA, a CVRD subsidiary.

The Directive Plan for the Carajas Railroad Corridor mentioned the experiments conducted by FRDSA, indicating that the prescribed treatments "would not assure the proper regeneration within the forecasted 20 years [...] and the forest consultants who were hired do not believe in the success of the sustainable management experiment in the long run", based on the treatments prescribed by FRDSA (Brasil, 1989: 268).

Fearnside (1988), by the end of the 80's, indicated that the strategy for charcoal production through forest management is not efficient. He said that "the experiences include treatments such as shallow cut and heavy exploitation, leaving only a few trees scattered over a bare field. [...] It is doubtful to call forest management something that certainly removes the whole forest" (Fearnside, 1988: 20).

Besides ecological prudence, he questions the economic feasibility of such strategy saying that "the big cost and the various biological problems associated with the production of managed forests make us think that the native forest will probably be cut before the investment becomes real" (Fearnside, 1989: 54).

An IBAMA report on the forest management projects by Maranhao Florestal – MARFLORA –, an affiliated company of the group then associated with MARGUSA, indicated the areas are subject to constant fires and the company does not try to avoid them; the cutting restrictions made by the

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approved management plans are not observed; cutting is made in consecutive years “razing almost everything, leaving a naked area”; there is no technical follow up of the project; the enrichment of the area with new seedling has been presently forsaken; and several other irregular practices were equally indicated (Hass *apud* Andrade, 1995: 31).

All the available information corroborates the forecasts that the strategies for extracting timber through *sustainable management* are only a disguised way to deforest with legal support. The forest management may be extended to 100% of the property.

Babacu cocoa as a source of biomass for charcoal production

Since the beginning of metallurgy implementation in the eastern Brazilian Amazon, the biomass of babacu cocoa had been indicated as an ecologically prudent alternative for charcoal supplying to the pig iron industries of the region (Brasil, 1989: 77). The use of charcoal made from this fruit is an old alternative, as per a report made in 1953. This report indicated that the charcoal made from babacu was technically acceptable (Leite, 1953: 43-48). Regional initiatives in carbonization of babacu cocoa have confirmed the quality of this input to be used in smelters.

Government forecasts - currently outdated - indicated that in the early 80’s there was an area of over 4.7 million of hectares covered with babacu palm trees in the State of Maranhao, producing an average of 1.6 tons of cocoa per hectare. This meant a potential volume of 7.7 million of vegetal biomass, which could be burned (Brasil, 1982).

Metallurgy companies in the eastern Brazilian Amazon include in their PIFI that one of the biomass sources to produce charcoal is the babacu cocoa. Besides including this source of energy in their PIFI they disseminate the idea that it will be a significant source of charcoal for their smelters. This is not true and is a way to diminish the pressure over the native forest in the eyes of the control agencies and public opinion.

The newspaper “Correio do Tocantins”, in June 1994, published an article saying that “COSIPAR will inaugurate, by the end of the month, its first ecological charcoal station. The charcoal feeding the ovens will be produced from babacu cocoa. [...] Within three years, the company will install ‘twelve ecological charcoal stations’. With this, thousands of trees will be spared from the blade and fire” (A Voz do Povo: 3, 1994). The article referred to a *carbonization center*, located in Sao Domingos do Araguaia, which started operating 1994.

In the following years, Luis Carlos da Costa Monteiro, President of COSIPAR, stated that “from 1996 on, COSIPAR will invest in the installation of food centers and charcoal production centers [...], a complex project, which may represent significant enhancement in the income and occupation for the population in the babacu areas” (Informativo ABRACAVE, 1996: 7).

Once more, words were not put to practice. Regarding the *ecological carbonization station*, there are actually 12 ovens in the city of Sao Domingos do Araguaia, specially designed for carbonization of babacu cocoa, but apparently babacu cocoa is burned only during IBAMA’s inspections. What is usually burned in these ovens are the leftovers from the sawmills near the so-called *ecological carbonization station*.

Therefore, up to now, charcoal produced from babacu cocoa to supply metallurgy companies in the region is extremely residual. They are limited to a few pilot programs, such as the one managed by Mr. Luiz Amaral, which supports the State Government in the southwest of the State of Maranhao. The Pro-Natura Institute proposes that this experience should get institutional support in order to become a general activity, receiving credit for carbon sequestration (Instituto Pro-Natura, 2000: 5).

A study by SUDAM/PNUD states that supplying charcoal industries through carbonization of babacu cocoa “is not free of rather political than natural problems”. According to said document, “in the babacu cocoa process there is an archaic social relation which some political segments would like to preserve” and concludes that “the use of babacu cocoa in the pig iron production is merely a matter of political and corporative initiative” (SUDAM/PNUD, 1997: 94-5).

This is not a good explanation for not using babacu cocoa to produce charcoal. The reasons for not using it are probably different, possibly purely economic. Both in the leftover carbonization and the carbonization of timber coming from deforestation, the costs for gathering, preparation and transportation of biomass are the highest ones. In the case of timber from deforestation, it is over 50% of the total operational costs involving charcoal production (Monteiro, 1998: 154). When using babacu to produce charcoal, the great dispersion of biomass - only 1.6 t/ha - dramatically increases the costs of gathering and transportation to the carbonization site. Apparently, this does not make babacu competitive in view of the low prices of charcoal produced from sawmill leftovers or from deforestation.

The use of babacu as biomass source for charcoal production has not become popular, although it is an ecologically prudent alternative, mainly because pig iron producers induce their suppliers to use the less expensive biomass, disregarding social and ecological concerns. Therefore, environmental prudence is relegated to a mere rhetorical element.

Charcoal production and pressure on the Amazon primary forest

It is estimated that from 1999 on, 1.3 million tons of charcoal will be consumed and supposing that 40% of it is produced with timber coming from deforestation or with timber coming from sustainable forest management - remembering that big metallurgy companies use this label only as a means to obtain legal authorization to deforest large areas - and that 60% is produced with timber coming from sawmill leftovers (as other biomass forms, in practical terms, do not exist), we can roughly deduct that part of the biomass gathered in a deforested area of approximately 425,000 hectares per year is carried to the metallurgy industries smelters. Even considering that there might be an intersection between areas where timber is extracted by sawmills and areas deforested for farming purposes, in both cases what is carried to charcoal production comes from areas reaching a total of 390,000 hectares (Table 4). Certainly, in the process of forest destruction in these areas, charcoal is a secondary drive, but its importance can never be over emphasized.

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TABLE 4: ESTIMATED AREA WHERE BIOMASS FOR CHARCOAL PRODUCTION IS EXTRACTED IN THE EASTERN BRAZILIAN AMAZON

Origin	Timber used for carbonization (t/ha)	Charcoal produced (t/ha)	Charcoal demand (in thousands of tons)	Dimension of the originating area (thousands of hectares) [(a)]
Sawmill leftovers	6 [(b)]	2	780	390
Deforestation	44 [(c)]	14.6	520	35
Total			1300	425

[(a)] There is a possibility of juxtaposition of areas.

[(b)] An average of 30 tons of timber which can be used by sawmills is extracted in one hectare of forest; an average of 2/3 of this timber is considered leftover. From the 20 tons of leftovers, an average of only 6 tons is used for charcoal production.

[(c)] An average of 44 tons of dry timber which can be used for carbonization is extracted from one hectare of forest, due to current techniques of burning only logs with over 5 cm and less than 50 cm.

Source: Monteiro (1998: 114) modified.

The pressure over the primary timber, the industries installed in the eastern Brazilian Amazon have also favored the onset of huge land properties through two ways: one is that charcoal production significantly reduces costs with cleaning the areas for pasture use; the other one is that all companies acquired large estates for their sustainable forest management projects or reforestation.

A partial list of estates acquired by metallurgy companies, including CCM, indicates a total of over 130,000 hectares. This reinforces the land structure distortions in the region and establishes a highly conservative relationship between metallurgy companies and regional social segments, which derive their power from ownership of large land areas (Monteiro, 1998: 207). Many land acquisitions by metallurgy companies are made through a process called *grilagem* (Shiraishi Neto, 1995: 68) and with violence against landless people occupying the areas, causing deep social tension in the areas (Carneiro, 1995: 210).

What’s even worse is that the whole process is financed by public funds through FINAM and FINOR, since the industrial enterprise projects presented to the financial agencies include the need to allocate funds for rural land acquisition.

Besides that, in certain areas where wood resources are scarce due to predatory use (as in the city of Rondon do Para), charcoal production in sawmills has become an important factor in the maintenance of sawmill activities. In the last decade, revenues coming from charcoal production formed a significant portion of the sawmill workers wages. Therefore, one cannot say that “charcoal producers serve as mere recyclers or down-cyclers”.

Outsourcing in charcoal production

Pig iron producers have been using several different strategies to build and maintain a regional charcoal market to supply their needs. We can see a common logic pattern in their strategies: all of them transfer to third parties the responsibility of charcoal production, even when the charcoal production facilities and the timber used belong to them or come from an area within a so-called

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sustainable forest management. Different denominations are attributed by metallurgy companies to those who carry the burden of charcoal production: suppliers, contractors, partners, etc.

MARGUSA has used different strategies and mechanisms all the time, aiming at mobilizing small farmers to produce charcoal. At first, the company installed its furnace banks within its own areas and used several means to convince small farmers to reduce the time used to work in their own lands and occupy their time with charcoal production. Such strategy caused part of small farmers to reduce or abandon their planting areas. In a second moment, as of April 1992, MARGUSA started to install its furnace banks within the small farmers' lands and later sold them the equipment. Therefore the farmers started to manage and became entirely responsible for charcoal production; the company then outsourced all charcoal production. In a third moment, part of the farmers who became "entrepreneurs" started to abandon the furnace banks and went back to farming activities (Andrade, 1995: 57).

Since the beginning, the strategy used by COSIPAR to build up a charcoal market in the region was to transfer control and responsibility over charcoal production to third parties. In order to implement such strategy, COSIPAR provided financial aid, involving brick supply and monetary funds, for those who wanted to produce charcoal for the company. The debts would be converted into tons of charcoal, paid through successive discounts with charcoal supplied by the debtor, who was also obliged to sell all his charcoal exclusively to COSIPAR. Also, COSIPAR bought the charcoal right there where the ovens were installed and thus the producers did not have to buy a truck for transportation of their merchandise.

Such strategy was successful because in the southeast of the State of Para there were already many farmers who came from the States of Minas Gerais, Espirito Santo and Bahia, where charcoal production was already very popular. It was not, therefore, a totally new activity for part of the social actors in the region. Many charcoal producers coming from the southeast of the country came to the region attracted by COSIPAR expecting to engage in charcoal production in lands belonging to third parties, or even acquired land for charcoal production and then re-sold the land. Additionally, such reality was possible due to the fact that the company had teams of furnace builders who helped those who did not dominate the technique and this resulted in a quick spread of charcoal activities. In 1989, the company had already more than 800 charcoal suppliers (Monteiro, 1993: 14).

This is how both types of charcoal production became so popular in the eastern Brazilian Amazon: charcoal production supported by deforestation and charcoal production supported by sawmill leftovers.

An interesting example of the generalization of charcoal production from sawmill leftovers is observed in the results of a survey on the destination of leftovers in the city of Jacunda, located along the PA-150 road, 100 km north of the city of Maraba. In March 1994, 36 out of the 47 sawmills operating in the area had charcoal production facilities attached to them; six of the remaining 11 sawmills gave their leftovers to charcoal producers in nearby areas; and only five sawmills were not linked to charcoal production. This can be extended to other cities with a great number of sawmills (Monteiro, 1998: 181)

The existence of charcoal production facilities within sawmills located in urban areas and charcoal facilities near such areas indicate a logical pattern: timber transportation costs to the ovens are a very significant part in the total cost of charcoal production, although this means more pollution in urban areas.

Opposition on the part of people living near sawmills started right after the beginning of operations of the first ovens to produce charcoal from sawmill leftovers. In the States of Maranhao and Para, organized groups started to demand the deactivation of ovens burning timber in urban areas (Carneiro, 1995: 128; Monteiro, 1998: 183).

Due to the social pressure, some metallurgy companies interested in maintaining charcoal production from sawmill leftovers started to build in certain localities the so-called “carbonization stations”. In these areas, distant from urban settlements, a great number of ovens was installed for burning sawmill leftovers. Such stations built by the metallurgy companies were then sold to third parties, who became responsible for that sort of business. In this case, 10% of the charcoal sale price is deducted as payment for the infrastructure.

Despite the risks, the population near heavy concentrations of sawmills is still exposed to the damaging effects of the pollution caused by charcoal production, which is still present in urban areas in several cities of the region.

Energetic inefficiencies and transfer of private costs to society

It seems rather evident that alterations in the regional scenario as a result of metallurgy plants are very significant and very different from official estimations. Such changes are mainly linked to the production structure of the companies, marked by charcoal demand and low energetic efficiency. The production of 16 tons of pig iron implies the destruction of one hectare of forest, the dispersion of huge quantity of gases, the destruction of parts of the flora and fauna, etc., and this is not included in the economic analyses.

When we include elements of the energetic-material dynamics to the metallurgy industry analysis, we notice that to produce one ton of pig iron, 875 kg of charcoal is needed (CEMIG, 1988: 150) which requires at least 2,600 kg of dry wood, with an average density of 360 kg/m³. In other words, if we use wood from native forests, we need to deforest at least 600 m² considering that the forest has around 120 *estereos* per hectare (st/ha) of useful wood potential for carbonization. The production of the amount of charcoal needed for the industrialization of one ton of pig iron uses the wood contained in at least 600 m² of native forest.

There may be significant variations in the cited parameters. Literature indicates different wood potentials useful for carbonization in one hectare of forest, and this is more so due to the different kinds of tropical forests in Amazonia (SUDAM, 1974: 36). We are assuming that one hectare yields and average of 44 tons of dry timber for carbonization. Another parameter refers to the proportion of the

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conversion of timber into charcoal, which is linked to the humidity of the timber – with up to 25-30% of humidity, the wood has a calorific power of 3.5 Mcal/kg, while dry wood may reach 4.7 Mcal/kg (Martins, 1980: 20) – as well as the type of furnace used for carbonization. The type of furnace has a direct influence in the energetic efficiency of the carbonization process. There is a great number of ovens. However, there is no doubt that the most widely used furnace in the region is the "rabo-quente".

The parameters adopted herein were obtained from various interviews made in factories using charcoal, in forest areas, and supported by related literature. According to the adopted techniques, only logs with diameters between 5 and 50 cm can be used for charcoal production. Such limitations are due to the fact that trees with more than 50 cm of diameter are difficult to transport and to cut into smaller pieces; this would consume energy and would make it too expensive. We have to keep in mind that all timber which may be useful for sawmills have been previously extracted from these areas.

Regarding the sawmill waste, we can say that the production of $100m^3$ of processed wood generates up to $24.7m^3$ of waste (Vidal *et. al*., 1997: 15), considering that only pieces of more than 5cm can be used to produce charcoal.

However, in both cases the main method of carbonization is based on the use of the so-called "*rabo-quente*" ovens, which means 3 t of wood for 1 t of charcoal.

Basically, charcoal production implies in large dispersion of material and energy, beginning with deforestation and continuing during the carbonization process, taking into consideration that the existent facilities are projected to use only charcoal, wasting the volatiles. During carbonization, the wood is decomposed, by the action of the temperature, in a solid product: the charcoal; plus volatile gases compounded by a fraction which can become liquid, and in a non-condensable fraction. Therefore, from the whole carbonization process, only the charcoal is used, and gases, water steam, organic liquids and tar are wasted (6,5 Mcal/kg).

This process of carbonization is marked by the low energetic efficiency, with significant losses of energy equivalent to 2.6 Gcal per ton of dry wood, for an average of 30% of charcoal (Martins, 1980: 20).

The energetic inefficiency of pig iron production is especially high due to its direct linkage to the charcoal production, which is also marked by the low energetic efficiency and the dispersion of huge amounts of material and energy. The production technology is similar in all plants of the region. The most remarkable difference is that some metallurgy companies installed in the region have an injection system of fine charcoal in the smelter, but the majority of the companies do not have this system.

The process is mainly based on the use of a smelter, where iron ore is reduced, together with the reduction agent: the charcoal. The melting products are loaded in the upper part of the smelter, leaving the device as a metallic alloy (Fe-C), in liquid state, used to produce solid pig iron. Through the lower part, the slag (sub-products generated by the process, mainly melting impurities) is drained.

To initiate the charcoal combustion, which furnishes the necessary energy to the process, air is injected laterally in the lower part of the smelter while the gas formed during combustion leaves the furnace through the top, and is partially used (60%) for pre-heating. The charcoal has a double function: as chemical agent, eliminating oxygen from the iron oxides; and as thermal agent, providing heat to the process. Charcoal represents 99% of energy consumption in independent plants (CEMIG, 1988: II). Some companies operating in the eastern Brazilian Amazon, however, use also mineral coal in the high furnace, but this is a residual participation when compared to charcoal. The coke importation is presently around 20,000 tons per year.

During the charcoal combustion, energetic losses are very high. The energetic content of the liberated gases is higher than the sum of the energy consumed in the chemical reactions plus the heat absorbed by the pig iron and the slag (CEMIG, 1988: 157). The amount of energy actually used for iron reduction and fusion does not reach 40% of the total energy amount provided by the charcoal to the system (CEMIG, 1988: 187). Such process provides pig iron and slag as final commercial products. The pig iron produced with charcoal has an advantage: (as opposed to the pig iron produced with coke): the quantity of sulfur is residual. It may be therefore added as part of the input needed to produce some types of steel, which require low levels of sulfur, reducing or even avoiding the use of secondary refinement to obtain low sulfur steel. This quality of the pig iron produced from charcoal will possibly compensate the energetic losses incurred by independent producers.

This production process is marked by an intense use of natural resources and by the transfer of energy and material from the natural Amazon environment to other regions, in the form of charcoal/pig iron production, which results in the consumption of great amounts of vegetal biomass from the native forests (from sawmill leftovers or from deforestation).

Evidently, there are losses caused by dissipation in all energetic-material transformation processes. However, the dimension of such losses depends on the intelligence of the system, on the degree of efficiency in the transformation processes and on energy use. The production of pig iron requires the consumption of 5,688 Mcal included in 875 kg of charcoal, which in turn requires 12,200 Mcal bounded in the used wood. Including the big quantities of energy lost in non-carbonized wood, due to the technical limitations, we can show that the industrialization process implemented in the region is, from an energetic-material point of view, highly entropic. Taking into account the whole production process we find out that 12,200 Mcal are needed to produce one tone of pig iron. Despite of extremely low energetic-material efficiency of this production process, one ton of pig iron is sold for an average price of US$ 125 (Fig. 2).

Nevertheless, the low energetic efficiency does not seem to be in contradiction with the so-called “economic efficiency” of the process. The reason is that the production of pig iron and charcoal is based on the transference of costs to the society, making a highly energetically inefficient process “efficient” from the traditional economic point of view.

One cannot state that great part of the wood used in pig iron production is not wanted because there is a social manifestation, expressed in the legislation, restraining the percentage of the land used

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for deforestation in private estates in Amazonia. This is a clear indication that the majority of the society does not want the vegetation and ecosystems depleted in such areas. Actually, when deforestation is made aiming at private benefits, private costs are transferred to the society.

Private costs are also transferred to the society when ovens for charcoal production are installed in urban areas and when the pollution caused by them compromises the health and quality of life of the workers in the charcoal production and of the nearby population; this cost, in the bottom line, is also transferred to the society.

Possible alternatives for the metallurgy production in the Brazilian Amazon

The main problem involving iron production with charcoal as primary input is of a social and environmental nature. The pressure caused by the demand of this input on the native forest results in imprudent environmental practices as well as in charcoal production supported by precarious labor conditions, unhealthy working environment and low wages.

One of the indicated solutions to solve the problem is silviculture. However, the plantation of forests to produce biomass for charcoal production requires a cycle of at least two decades. The first cut is generally made in the seventh year, followed by *rebrota* and eventual re-planting of part of the areas. The second cut is made in the 14^{th} year and the last one in the 21^{st} year. It is therefore a long-term investment, requiring great amounts of capital. The investment of great amounts of capital for such a long time and mainly - as already indicated - the high costs of charcoal production with timber coming from silviculture is not assimilated by pig iron companies.

A study made by the Ministry of Environment of Brazil (Brasil, 1995b: 53), referring to charcoal supply for pig iron industry in the State of Minas Gerais, recognizes that the custom of using biomass from native forests without ecological prudence, existent for decades, tends to remain so in that region. According to this study, things have remained so because charcoal from native forest biomass is significantly less expensive than that from reforested areas, and also because control mechanisms are inefficient. Such statements are correct and very similar to what's happening in the eastern Brazilian Amazon.

Even the applications for non-refundable public financing to buy land to be used for reforestation to supply the metallurgy industry in the eastern Brazilian Amazon, as suggested by CVRD, would not solve the case. As already mentioned, it is not only the high cost of the land which makes charcoal from reforestation so expensive, and not able to compete with charcoal illegally extracted from native forest. This is mainly caused by society's incapacity to stop illegal deforestation, which is even more dramatic when it happens in ecosystems not very well known, such as those in the Amazon.

The document issued by the Ministry of Environment of Brazil (Brasil, 1995b: 25), based on experiences in the southeast of Brazil in a pilot program, suggests that changes in technology - with more sophisticated processes to carbonize wood, capable of using pyrolysis gas, methanol, tar and acetic acid - would make biomass from reforested areas economically feasible for charcoal production.

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This was also present in the government plans, in the 80's, for charcoal production in the eastern Brazilian Amazon (Brasil, 1989: 272). Despite the existence of more advanced technologies, which add efficiency and re-usage of several wood carbonization by-products, the unsophisticated carbonization methods are still used both in Amazonia and in the southeast of Brazil. Such outdated techniques seem to be still in use due to the strategies of pig iron industries, which transfer the charcoal production to a wide network of hundreds of suppliers lacking capital to invest in carbonization equipment in order to use technologies which allow more efficiency and better use of all possible by-products of wood pyrolysis.

Another perspective of metallurgy production in Amazonia is present in studies made by SUDAM and by the United Nations Development Program – UNDP –, which try to identify the main dynamics resulting from industrial extraction and transformation of minerals in the region, pointing evaluation criteria for development policies, financing and concession of tax incentives. Such studies greatly emphasize pig iron production, reporting it as "reasonably well succeeded activity" (SUDAM/PNUD, 1997: 89).

With respect to formulation of development policies, the studies state that the timber sector deserves the attention of regional financing agencies and support the allocation of public funds for primary metallurgy due to the potential for generation of productive links from pig iron industries already operating in the region. They are convinced that in the medium term such activities could form the base of a metallurgic activity complex for semi-finished products. They base this argument on the fact that the rather recently installed pig iron park in the region is the "first expression of a transformation process and a favorable condition to induce, in the production process, activities resulting from the second generation of metallurgy production in Amazonia" (SUDAM/PNUD, 1997: 58).

The studies recommend the maintenance of primary iron production using the current patterns, i.e. with smelters using charcoal as reductant, indicating that electrical smelters could be attached to the existent industrial plants in order to produce steel. Therefore, the metallurgy companies already installed could use the high furnace structures to manufacture primary iron (pig iron), which would - in its liquid state - be carried to the electrical smelters for steel production. Such companies would then become small producers of steel. They would produce at a significantly lower scale than the integrated companies, but would enjoy a guaranteed competitiveness for their product because, according to the study, production in such patterns would demand investments compatible with the company's dimension and the energy consumption of the electrical smelters would not be very high: less than 300 kWh for each ton of steel (SUDAM/PNUD, 1997: 58).

The study recommends that agencies supporting regional development programs, responsible for the allocation of public funds, take into consideration the necessity of actions aiming at the implementation of small steel factories in the region, in the medium term, when analyzing projects applying for tax and credit concessions (SUDAM/PNUD, 1997: 141).

The construction of small steel factories is an idea that will probably be pursued by the metallurgy industry in the region. And as already indicated, it seems evident that in order to bear the costs of charcoal produced under ecologically prudent bases and sustained by social relations which respect the labor protection laws, pig iron companies will have to advance in the direction of producing goods with higher aggregate value. This may be done through the operation of small steel factories, operating with electrical smelter. However, it is not a good idea to add to this alternative the indication that an environmentally prudent solution for charcoal production would be biomass from babacu cocoa, as suggested by the SUDAM/UNDP studies (SUDAM/PNUD, 1999: 71).

The suggestion of installation of small steel factories does not solve the main socio-environmental problem in the region: the iron ore processing in the region, linked, as already mentioned, to the harmful effects caused by charcoal production. On the contrary, they can be even worsened. Such indication does not take into consideration the social dynamics, which enhances the fact that if there are no efficient measures to prevent illegal deforestation for farming as well as for timber extraction to supply sawmills, the Amazon forest and the savannah in the State of Maranhao will be largely explored as sources of biomass for regional charcoal production, even when this charcoal is used to support an activity which will produce merchandises with more aggregate value than pig iron.

The lack of attention to this fact is also one of the greatest limitations of the proposal submitted by Pro-Natura Institute to establish a sustainable supply of charcoal for regional metallurgy industries. The proposal suggests charcoal production in a large scale from babacu cocoa. This would be financed by public funds and the possible credit for carbon sequestration (Instituto Pró-Natura, 2000: 7). However, with the public administration lack of power to control illegal deforestation, this alternative will have to compete with charcoal produced from other biomass sources, spatially concentrated and produced without any environmental prudence, using sawmill leftovers as well as deforestations for farming. Therefore, the economic feasibility is based on the over exploitation of labor force, disseminating undesirable labor relationships, which are so common in charcoal production from native forests. Besides that, within this context, charcoal production from babacu cocoa may represent a risk for environmentally prudent and well-succeeded extractive activities, related to babacu use for other purposes, such as oil and soap.

Therefore, the pressure over the vegetal cap would be reinforced by the metallurgy industries, without any ecological prudence and with undesirable labor relationships. The main factor that would break such practices would be the non-acceptance of the division between charcoal production and metallurgy production. These businesses must not be treated nor controlled as independent businesses. Metallurgy industries must be held responsible for the origin of the charcoal consumed by them and be fined for not abiding by the environmental rules regarding access to native forests biomass.

It is not enough that metallurgy industries indicate that the charcoal comes from sawmill leftovers or from deforestation for farming purposes, assuming - very conveniently - that these are environmentally legal activities. They do not take responsibility for verifying the origin of the biomass

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which is supplying charcoal production and constantly postpone the terms to make their charcoal supply a sustainable one.

Only a very severe public control of the origin of the biomass and labor relationships supporting charcoal production may help to revert the social dynamics reinforcing the predatory exploitation of the natural resources of the eastern Brazilian Amazon, the chaos in the several urban spaces, the conflicts in the hinterland and land conflicts, intensifying low wages and unhealthy working conditions. Such dynamics allows a cheap charcoal production, which is of fundamental importance for independent pig iron producers, and represents a cruel transfer of private costs to the society.

However, public capacity to control socio-economic conditions which form the base of charcoal production is something that was not historically possible in the southeast of Brazil and there are no indications that it will be possible in the eastern Brazilian Amazon.

The historical public incapacity to control charcoal production in Brazil; the increasing demand for charcoal by pig iron industries producing undesirable labor relationships and environmental impacts which may compromise the functional integrity of several ecosystems in eastern Brazilian Amazon; plus the metallurgy industries trend in the southeast of Brazil to replace charcoal by new energy sources makes us think that there are medium term feasible alternatives for regional production of primary iron. Such alternatives may be effective with the construction of production routes not linked to charcoal as the only energy source, which would benefit the Amazon region as an alternative for primary iron production and processing.

Such alternatives for primary iron production without charcoal become even more attractive when Petrobras announces that the largest natural gas reserve of the country is located in Amazonia, in the basins of the Jurua and Urucu rivers, in the State of Amazonas, where the gas piping system between Urucu and Coari is already operational and the gas piping system between Coari and the capital of the State of Amazonas is being projected, with a possible extension to Maraba, in the State of Para. Such reality justifies the introduction of possible alternative paths for primary metallurgy production in the eastern Brazilian Amazon with the replacement of charcoal by natural gas in the primary iron production. The result of primary iron production with natural gas is a product called foam iron. This type of primary iron is used, just like pig iron, by the small electrical steel factories.

Obviously, the mere substitution of charcoal by natural gas could important, but not sufficient to achieve sustainability.To induce sustainable economic processes need to establish a new vision of the relationship between material and energy flows, their conversion into values of use and the intervention of social institutions in a framework of indicator systems which include at least four main dimensions: social, ecological, economic and institutional. If we disregard only one of these dimensions, we run high risks to fail in our intentions to project future sustainable societies.

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