Land Use Problems in the Brazilian Amazon

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Background Information

The name of this region comes from the Amazon Basin and its main river system, the Amazonas – Solimoes – Ucayali axis, which originates on Mt. Huagra in Peru at 5,182 meters above sea level, 195km from the Pacific shore. This river is 6,762km in length, and in the first 965km from its source, it drops 4,876 meters while in the remaining 5,797km the fall to sea level is only 306m. Almost 30,000km are navigable during the rainy season.

This region has the largest continuous tropical moist forest in the world. The main characteristic of the Amazonian forest is its considerable vegetation diversity, although at first sight it is rather uniform. In Amazonia is reported to contain about 30,000 different species of angiosperms, of which one – sixth are tree species growing to commercial size. The distribution of these trees varies tremendously, particularly in relation to soils and topography.

No doubt that the Amazonian forests are very important from timber – oriented point of view, but more important than that is the fact that these forests are the guarantees for the maintenance of the their priceless biodiversity and many of their ecological functions.

Another outstanding feature of the Amazonia region is the existence of a significant amount of mineral and energy resources. The main mineral resources are : Iron, Bauxite, Tin, Kaolin, Niobium, Manganese, Zinc, Gold, Diamond, Gypsum etc. Besides the fantastic hydroenergy reserves, this region has also petroleum and natural gas deposits.

1. Climate

Temperatures do not differ greatly in Amazonia. Belem, some 100km from the Atlantic Ocean, has a mean annual temperature of 25℃. Manaus, nearly 1,500km from the coast, has an equivalent of 27℃, and Taraqua, some 3,000km inland has a mean annual temperature of 25℃. The maximum temperatures are around 37 to 40℃ with a diurnal variation of some 10℃.

Rainfall shows greater variability than temperature across the region. There is approximately 3,000mm annual rainfall on the coast, 3,500mm at Taraqua, 1,500mm in Boa Vista (the Capital of Roraima State), and 1,600mm Conceicao do Araguaia (South of Para State).

Seasonal variations are determined by the amount of rainfall. Basically two seasons are distinct : wet (from November to April) and dry season (May to October). The wettest months are January and February, and the driest months are August and September.

2. Soils

The soils in Amazonia are very old, reaching back as far as the Paleozoic era. Basically the region is composed of a sedimentary basin (Amazonia Valley) located between two shields (Guyana and Brazilian). These shields are composed of igneous Precambrian and metamorphic rocks from Cambrian − Ordovician that contain some spots of sediments from Paleozoic/Mesozoic (60 to 400 million years ago). The Amazonia Valley is formed by fluvial sediments of coarse texture deposited from the Cretaceous to the Tertiary periods, originated from the erosion of the Precambrian shields. In summary, this is the evolutive process of "terrafirme" (non − flooded ground) formation.

Another important formation in Amazonia region is the "varzea,"or annually or periodically flooded ground. The "varzeas"are constituted by the Holocene flood plains of the Solimoes and the Amazon rivers as well as their white water tributaries. When the ground is flooded by black water rivers, the formation is so − called "igapo."

The main soil orders in Amazonia are : yellow latosols (46%) and red yellow podzolics (30%). In general, the soils are extremely poor in nutrients and very acid (pH 4.5 to 5.5). In fact, almost the entire nutrient amounts required by the forest are contained in the aboveground biomass. Almost 95% of Amazonian soils are not suitable for agriculture and grazing.

3. Vegetation

The forested area of the Amazonia Basin is 3,648,000 km^2 or 364.8 million hectares. Dense and "varzea"forests represent more than 90% of this total. Dominant botanical families for timber species are : Leguminosae, Lecythidaceae and Sapotaceae, and Myristicaceae in "varzea." From the economical point of view "Mahogany"or "Mogno" (*Swietenia macrophylla*) is the most important tree species."Brazil nut"or "Castanheira" (*Bertholletia excelsa*) and "rubber tree" (*Hevea surinamensis*) are also very important, but not for timber. The total volume for dense forests is approximately 50 billion cubic meters, from which 10% is actually merchantable.

TIMBER PRODUCTION (1,000 m^3)

STATE	CHARCOAL		FIREWOOD		ROUNDWOOD	
	1988	1989	1988	1989	1988	1989
Rondônia	1.5	0.9	1,009	968	2,190	2,255
Acre	1.6	1.7	1,285	1,265	310	309
Amazonas	0.0	0.0	78	22	552	626
Roraima	0.0	0.2	61	69	56	37
Pará	45.6	75.8	7,503	7,738	28,428	43,139
Amapá	0.5	0.6	369	440	471	549
Tocantins	−	2.2	−	2,183	−	570
Total	49.2	81.4	10,305	12,685	32,007	47,485

4. Amaxonia in South America

There are two Amazonias in South America: the Amazonia Territory and the Amazonia Basin.

The Amazonia Territory extends outside the basin, most particularly in the Orinoco region and into Guyanas. Also political definition is included in the Territory such is the case of the so-called Legal Amazonia in Brazil.

Table 1. Amazonia area by country (in squared kilometer $-km^2$)

COUNTRY	AREA	% NT	% AT	POPULATION
BOLIVIA	824,000	75.0	10.9	344,000
BRAZIL	4,988,939	58.7	65.7	17,000,000
COLOMBIA	406,000	36.0	5.3	450,000
ECUADOR	123,000	45.0	1.6	410,000
GUYANA	5,870	2.7	0.1	798,000
PERU	956,751	74.4	12.6	2,400,000
VENEZUELA	53,000	5.8	0.7	9,000
SURINAME	142,800	100.0	1.9	352,000
FRENCH GUYANA	91,000	100.0	1.2	90,000
TOTAL	7,591,360		100.0	21,853,000

NT = National Territory of each country
AT = Amazonia Territory

5. Amazonia in Brazil

a. Legal Amazonia: Geopolitical division.

Almost 60% of the Brazilian Territory is in the Amazonia region, while its population represents only about 10% of the whole country.

Table 2. Area of each State of the region and its deforestation area through 1989 (in squared kilometer $-km^2$)

STATE	ORIGINAL VEGETATION		DEFORESTED AREA		
	DENSE FOREST	SAVANNA	FOREST	SAVANNA	% D
ACRE	152,589	–	8,836	–	5.8
AMAPA	99,525	42,834	1,016	–	0.7
AMAZONAS	1,562,488	5,465	21,551	–	1.4
MARANHAO	139,215	121,017	88,664	20,664	42.0
MATO GROSSO	572,669	308,332	79,549	25,568	10.0
PARA	1,180,004	66,829	139,605	1,722	7.3
RONDONIA	215,259	27,785	31,476	169	13.0
RORAIMA	173,282	51,735	3,621	–	1.6
TOCANTINS/GOIAS	100,629	169,282	22,327	34,114	20.9
TOTAL	4,195,660	793,279	396,645	82,237	

%D = Deforested area in relation to the original vegetation

TOTAL AREA OF LEGAL AMAZONIA = 4,988,939 km^2
Deforested Area (through 1989) = 478,882 km^2

The most recent figures of deforestation annual rate
in the Brazilian Amazonia are:
from 1978 to 1988 · · · · · · 21,130 km^2/year
in 1989 · · · · · · 17,860 km^2
in 1990 · · · · · · 13,810 km^2
in 1991 · · · · · · 11,130 km^2

PROTECTED AREA = 1,000,000 km^2
National and State parks, National Production forests,
Ecological reserves, Experimental stations and
Indian reserves (70% of the total)

b. Amaznia Basin

TOTAL AREA = 3,940,000 km^2
Forested Area = 3,648,000 km^2
Non - Forested Area = 292,000 km^2

FORESTED AREA (km^2)	
1. "Terra - firme" (non - flooded) Forests:	
- Dense Forests	3,303,000
- Dense Forests with Lianas	100,000
- Open Forests with Bamboo	85,000
- Hillside Forests	10,000
- High "Campina" or "Campinarana"	30,000
- Dry Forests	15,000
2. "Varzea" (flooded) Forests	55,000
3. "Igapo" (flooded) Forests	15,000
4. "Manguezal" (Swamp) Forests	1,000
5. "Campina"	34,000
Total	3,648,000

"Campina" = forest on white sand
"Campinarana" = transition between "Campina"and dense forest

NON – FORESTED AREA (km^2)	
1. "Varzea" Fields	15,000
2. "Terra – firme" Fields	150,000
3. "Serrana" (Mountain) Vegetation	26,000
4. "Restinga" (Beach and Dunes) Vegetation	1,000
5. Water	100,000
Total	292,000

The Process of Transforming Amazonian Forest to Other Uses

(i) Cattle Ranching and Agriculture

Since the late 1960s, cattle ranching has dominated the landscape in deforested areas as a result of improved access through highway construction. The main source of income from ranching is often land speculation rather than the sale of beef. Disease prevents beef export in frozen form to Europe, North America and Japan. In Brazil's Legal Amazon region, 62% of the private land was in properties over 1000 ha in area at the time of Brazil's last agricultural census in 1985.

Land speculation has been a key factor in making unproductive cattle pastures attractive to their owners. Profits from logging have also been a critical income source to ranching operations as well as to small colonists. For small farmers, the traditional system of gaining access to land through squatting leads to deforestation as a means of obtaining land titles : clearing for cattle pasture is still considered an "improvement" on the land by state and federal government land agencies.

(ii) Hydroelectric Dams

Hydroelectric development is a potentially – large source of forest loss. Brazil's 2010 plan for a series of dams (whose expected time of construction has been temporarily postponed due to the country's financial difficulties) calls for a total of 100,000 km^2 in Amazonia, or 3 % of the forest.

The hydroelectric dam at Balbina, for instance, located 146 km north of Manaus, was closed in 1987 and filled to its normal full level of 50 m above sea level, flooding 2360 km^2. The reservoir contains approximately 1500 islands, making the area of land affected much larger than that actually submerged.

(iii) Mining

Mining is another activity that is rapidly increasing as an agent of environmental destruction in Amazonia. Some of the impacts are direct, while others are indirect. Open pit mines obviously completely transform the environment in the specific localities affected, such as the iron mine at Carajás (Pará), manganese at Serra do Navio (Amapá), kaolin at Jari (Amapá), bauxite (aluminum) at Trombetas (Pará) and cassiterite (tin) at various locations in Amazonas and Rondônia. The areas destroyed are small, although the destruction is total.

Mining, while destroying relatively little forest directly, is a significant influence in other ways. These include the building of highways to mineral-rich areas, and the processing of ores in the region in ways that consume forest. Carajás, with the world's largest highgrade iron ore deposit, is coupled to a regional development plan that produces pig-iron from some of the ore. Charcoal, used both as a reducing agent and as an energy source, comes largely from native forest wood-contrary to the claims of the mill owners. If fully implemented, supplying charcoal to the scheme would require deforesting as much as 1500 km^2/year.

(iv) Logging

Logging is rapidly increasing in importance as a factor in Amazonian deforestation. Timber harvesting has, in the past, been much less prominent in Amazonia than in the tropical forests of Africa and southeast Asia. The tropical forests of southeast Asia are dominated by a single family of trees: the Dipterocarpaceae. Despite a high diversity on the level of Amazonian tree species, the wood of many of these is similar enough to be grouped into only six classes for the purpose of sawing and marketing. Another disadvantage is the dark color of the wood of most Amazonian trees, in contrast to the light colors that dominate in southeast Asian hardwoods. The light colored woods are more easily substitutable for such temperate species as oak and maple in European and North American furniture manufacturing.

Decimation of the tropical forests of Africa is almost complete from a commercial standpoint, while of southeast Asia are rapidly nearing a similar end. Exports from Amazonia are therefore increasing. Logging in the uplands (*terra firme*) is rapidly destroying stocks of some of the most valuable species, including "cerejeira" (*Amburana acreana*) and "mogno" (*Swietenia macrophylla*). In the flooded *várzea* forests-the first to be affected because of the ease of transporting logs by water; commercial species such as "ucuúba" (*Virola* spp.) are rapidly declining.

Impacts of Deforestation

(i) Environmental Impacts

1) Greenhouse gas emissions

The biomass present in Amazonian forests is the subject of intense interest because of its importance for the impact than deforestation has on global warming. Carbon, which makes up half of the dry weight of the biomass, is released to the atmosphere as carbon dioxide (CO_2) and other gases. Based on 2,892 ha of forest volume surveys distributed throughout the region, the average total biomass (dry weight, including belowground and dead components) for all unlogged mature forests present in the Legal

Amazon is 397 metric tons per hectare.

The net committed emissions from deforestation in 1990 are estimated to be 234 million ton of carbon in terms of carbon dioxide (CO_2) only. The annual flux represents approximately 4 % of the global total CO_2 flux from fossil fuel combustion and tropical deforestation. Halting global warming cannot be achieved without significantly reducing global fossil fuel use. The emissions from deforestation in Brazil are nevertheless substantial.

2) Hydrological cycle

One of the consequences of widespread Amazonian deforestation that has the greatest likely impacts on Brazil itself is potential alteration of the water cycle. Precipitation in Amazonia is characterized by tremendous variability from one year to the next, even in the absence of massive deforestation. The example of tropical forest burned in Indonesia during the El Niño/Southern Oscillation drought of 1982-1983 serves as a warning of the potential for much more widespread impact from this source in Amazonia in the future. The reductions in rainfall potentially affect not only Amazonia but also Brazil's major agricultural regions in the central－south part of the country.

3) Genetic erosion

The potential for obtaining valuable genetic material from the forest is another opportunity that is sacrificed by deforestation. Like medicinal plants, genetic resources are irreplaceable－they cannot be bought back with the money earned through deforestation. Germplasm can be valuable both in supplying new crops to agriculture and in providing a store of varieties of already－cultivated species.

The ability of Amazonian plants to make efficient use of scarce nutrients is a feature markedly lacking in the crops favored by present－day agriculture. The dwindling of nutrient and fossil fuel stocks in the world will make this ability more and more valuable as time passes. Great potential value exists in incorporating new capabilities into the repertoire of crop plants, either by adopting new species, breeding wild relatives with present crops, or by genetic engineering techniques.

Geographical isolation provides the principal protection against diseases and pests for many crop plants. Rubber, for example, was taken thereby leaving behind such devastating diseases as the South American Leaf Blight caused by the fungus ***Microcyclus ulei***. Cacao, native to Central and South America, was taken to Africa and Asia where it grows free of "witches"broom disease (***Crinipellis perniscios***a). Coffee was brought from Arabia and the horn of Africa to the new world, freeing it of coffee rust (***Hemileia vastatrix***). In 1964 the last remnants of forest in Ethiopia had provided invaluable genetic material for developing resistant strains ; the opportunity might well have disappeared had the germplasm collection expedition been delayed by only a few years.

Maintaining disease resistance in cultivated plants requires continual changes in the plant population's genetic material in order to keep pace with the evolution of pathogens. Because the life cycle of disease causing organisms is much shorter than that of the plants – especially perennials – the disease causing micro – organisms have an inherent advantage in the race. Genetic material conferring resistance to crop diseases is best obtained from wild populations that have been coexisting with the diseases for millennia.

4) Loss of biodiversity

The biodiversity of Amazonia is legendary, while little reliable information exists on the numbers of species present. Trees dominate the physical structure of the forest, but make up a relatively small share of the total number of species of organisms present. Plants other than trees make up a significant part of the plant diversity in non – Brazilian parts of the region. Brazil as a whole has an estimated 55,000 angiosperm plant species.

Mammals are significantly less numerous in the Brazilian portion of the Amazon than in Peru and Ecuador. Brazil as a whole has 428 species of mammals, placing it third in the world. Brazil has 1622 bird species, a number only exceeded by Colombia and Peru, while Brazil's 516 species of amphibians is the world's greatest number in a single country. Similarly, Brazil's reptiles and butterflies place the country in 4th place with 467 and 74 species respectively.

Fish species described in 1967 totaled 1300; actually the total number estimated vary from 2000 to 3000. In contrast, Europe has an estimate 300 species.

Invertebrates make up by far the largest share of the total biodiversity. Studies of forest canopy insects carried out in Manaus (Brazil), in Peru and in Panama have more than tripled the total number of species estimated to exist on earth. Although one can debate the confidence that can be attached to extrapolations of species numbers from small samples to the globe, the fact that arthropod fauna is tremendously diverse is incontestable.

Amazonia has a number of "centers of endemism," where unique species of a variety of taxa are concentrated in certain locations. One of the theories that has been proposed to explain these is that "refugia" formed in islands of forest surrounded by grassland during the pleistocene glaciations. Speciation occurred in these islands, and when the forest later advanced to coalesce in the formerly non – forested portions of the region, the composition of the more recent areas is less diverse and unique than that in the refuges. Regardless of what the true explanation of the present distribution of species may be, the fact that biodiversity is not evenly spread over the region is widely accepted.

5) Sedimentation and pollution of rivers

Waste from mining can be significant. The fines from the Trombetas bauxite mine form a "red mud" that has completely filled the 200ha Lago da Batata and suffocated trees along its margin and approaches; preparations are being made to transport future production of red mud back to the mine site itself. Devastated as the Lago da Batata is, it represents a tiny area in Amazonian terms. The Balbina reservoir, for example, is over 1000 times larger.

Gold mining contributes greatly to the silt load of rivers. Much of the mining is done in river beds, either by dredging alluvium from the river bottom or by panning it from the banks. The river water is often a milky color from the silt load far below the mining sites themselves. As with other minerals, roadbuilding spurred by gold strikes sets in motion the process of invasion and deforestation of the affected areas. Use of mercury to amalgamate the fine gold particles in the extraction process dumped an estimated 250 metric tons of highly toxic mercury into the rivers between 1984 and 1988. The estimate of mercury discarded is derived from the weight of gold extracted and the 1.2 grams of mercury used per gram of gold ; the amount of mercury could be much greater since much of the gold is smuggled out of the country illegally. Mercury concentrations in fish in the Madeira River (draining Rondônia) are as high as six times the levels permitted in food by the World Health Organization.

Minerals can make possible agriculture and silviculture projects that would otherwise be inviable. Examples include Jari, where the silviculture depends financially on the estate's kaolin mine. The AMCEL silviculture operation in Amapá has also been established in association with the ICOMI manganese mine at Serra do Navio. On a much larger scale, the entire Grande Carajás Program is justified by the extraordinary mining potential of this region – where minerals such as iron, gold, copper and manganese were squeezed up from the earth's mantle at the point where the primordial continents of South America and Africa once joined. This Program includes a agricultural plan, the pig–iron smelting scheme with its associated forest management and/or plantations for charcoal production, a railway and highway network, hydroelectric dams (including Tucurui), power transmission lines and mineral processing facilities such as the Barcarena Aluminum complex.

(ii) Social Impacts

1) Endemic diseases

Human migration in Amazonia has led to endemic diseases. Malaria is widespread in the region, but has caused most casualties in certain locations, such as Rondônia. Many diseases, such as measles, have had devastating effects on indigenous peoples who come in contact with population from the rest of Brazil. Other endemic diseases include leishmaniasis, a debilitating but non – fatal sore transmitted by sand flies. Onchocerciasis, or African river blindness, is spread by black flies that occur throughout the region ; so far the disease has been limited to areas along the border of Brazil and Venezuela.

2) Migration and colonization

Amazonia has served as a safety valve for social problems in the rest of Brazil, with highway construction and settlement projects being the response to such problems as the 1970 drought in northeastern Brazil (the official justification for building the

Transamazon Highway) and the absorption of population outflow from Paraná for paving of the BR -364 highway to Rondônia in 1982 with financing from the World Bank's POLONOROESTE Project.

Forestry and Environmental Policies

(i) Forest Manaogement

Brazil has been an active participant in the International Tropical Timber Organization (ITTO), and, like ITTO, its national policies have emphasized plans for sustainable management of tropical forests. The Brazilian Forest Service (IBAMA) requires "forestry management plans"as a condition for granting logging permits. Effectiveness of the program is hindered by lack of guidelines as to what constitutes sustainable management, and frequent differences between stated plans and field practices.

The underlying logic of increasing profits to loggers as a tool to encourage sustainable management is not supported by observed behavior. Rather than restraining harvest intensity with a view to long-term returns, cutting is increased to capture short-term profits. The lack of interest in commercial application of sustainable management lies mainly in the existence of alternative investment opportunities that pay higher returns on money invested than does waiting for future cycles of a management system. The key comparison is between forest management and other possible uses of *money* - not between forest management and other uses of *land*.

The number of sawmills and level of timber extraction activity has increased in recent years, but is still much less than in forest areas in Southeast Asia. Amazonia's generally dark colored, hard-to-saw, and heterogeneous timber has therefore been spared the pressure of large timber corporations. Asian woods are usually of lower density than Amazonian ones, making them more suitable for peeled veneer. The approaching end to commercially significant stocks of tropical timber in Asia can be expected to change this situation. FAO data indicate that, as of 1985, only 2% of international hardwood comes from all of Latin America, versus 57% from Asia. Before the year 2000, Asian forests are expected to be depleted to the point where they can no longer supply global markets. An alternative view holds that world demand for tropical forest timber may decline due to substitution from plantations.

(ii) Extractivism

What is known in Brazil as "extractivism,"or the harvesting of non-wood forest products without cutting down the trees, has been practiced in the Amazonian interior since the period of the rubber boom (1888-1913). These systems now form the basis for proposals for "extractive reserves"as a means of maintaining forest. The major justification for promoting the system is its potential for safeguarding the environmental services of the forest, as the resident extractivists have a greater stake than hired guards in defending the forest against ranchers, squatters and loggers.

(iii) Environmental Impact Assessment (EIA) and Report (RIMA)

Brazil has had legislation requiring environmental impact reports (RIMAs) since 1981, but this was only "regulamentated"on 23 January 1986 by the National Council of the Environment (CONAMA). Projects already under construction at the time escaped the requirement for a multidisciplinary team of experts that is completely independent of the project proponents.

Making the system work in practice has not always been successful. One reason is the inherent conflict of interest created by the way that the studies are financed. They are done by consulting firms and paid for by the project proponents. The firms realize that their continued financial success depends on pleasing the project proponents, giving them a strong motivation to produce reports that minimize the environmental damage included in the reports. Another problem has been the ability of projects to escape the reporting requirements altogether and begin functioning without the reports.

Despite the many failings that the current environmental reporting system has, it is important that it not be scrapped without having a better system to replace it. Although proponents of major development projects would be delighted to be freed of the RIMA requirements, the current rule is much better than none.

Conclusion

Besides timber and non-timber products, the Amazonian forests also provide important environmental benefits or services, such as regulation of droughts and floods, the control of soil erosion, watershed and catchment protection, groundwater recharges, conservation of genetic resource and biodiversity, protection against weather damage, and generation of recreational benefits and aesthetic values. Despite the significant contribution to humanity and the important role to the ecosystem functioning, the Amazonian forest is often undervalued because the effect of its destruction often is not realized until after the short-term benefits from its destructive use have been enjoyed.

The actual dynamical equilibrium between water and energy in the Amazon depends on the forest cover. Changes in the water cycle will influence the energy cycle and vice-versa. When the forest is clear cut more water will run off and less water will be available for evaporation. This will cause a decreasing of available water for the evapotranspiration and of the relative air humidity that, in turn, will alter the energy equilibrium. The deforestation will also cause the decreasing of water vapor in the atmosphere that will affect the rainfall distribution.