SOCIAL AND ENVIRONMENTAL IMPACTS OF HYDROELECTRIC DAMS IN BRAZILIAN AMAZONIA

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ABSTRACT

Hydroelectric dams have severe social impacts, including flooding the lands of indigenous peoples, displacing non-indigenous residents, and destroying fisheries resources on which downstream residents depend. Subsidized power for aluminum manufacture for export creates economic distortion in Brazil and creates minimal employment and other benefits in the country. Hydroelectric reservoirs increase health risks to local populations, including malaria and, in the case of the Tucuruí Dam, exposure to a plague of <u>Mansonia</u> mosquitos. Mercury contamination of fish is likely to produce grave effects in the future, after people who consume fish from the still recent dams in Amazonia have had time to accumulate higher levels of this poisonous metal. The bottoms of Amazonian reservoirs are devoid of oxygen, creating the conditions for formation of poisonous methylmercury from the metallic mercury that has accumulated over millions of years in the ancient soils of Amazonia. Environmental impacts of dams include radical changes in river hydrology, loss of tropical rainforest, and contribution of greenhouse gas emissions from decomposition of dead trees and other organic matter.

I.) INTRODUCTION

Construction of hydroelectric dams in Brazilian Amazonia causes substantial social and environmental impacts, as is also the case in other parts of the world. The decision-making process for initiating new projects has tended to grossly underestimate these impacts, as well as to systematically overestimate the benefits of the dams. Financial costs of dam construction have also been systematically underestimated. In addition to disparities in the magnitude of the costs and benefits, there are also great inequalities in terms of who pays the costs and who enjoys the benefits. Local populations have often sustained major impacts, while the rewards have largely accrued to beneficiaries in urban centers and, in the case of the largest dam (Tucuruí) to other countries.

The scale of hydroelectric development contemplated for Amazonia is tremendous (Figure 1). ELETROBRÁS (the Brazilian government's power authority) has published a "2010 plan" outlining the possible construction of 68 dams by the year 2010, with the total rising to as many as 80 dams within a few decades. Brazil's financial difficulties have repeatedly forced ELETROBRÁS and ELETRONORTE (the power monopoly in northern Brazil) to postpone dam building plans. However, the overall scale of the plans, as distinguished from the expected date of completion of each dam, remains unchanged and consequently an important consideration for the future.

[Figure 1 here]

The 80 dams would flood roughly 2% of Brazil's Legal Amazonia, and would flood about 3% of Brazil's portion of the Amazon forest. Flooding this area would provoke forest disturbance in much wider areas. Aquatic habitats would, of course, be drastically altered. Most of the sites that are favorable for hydroelectric development are located along the middle and upper reaches of the tributaries that begin in Brazil's central plateau and flow north to meet the Amazon River--the Xingu, Tocantins, Araguaia, Tapajós and others. This region has one of the highest concentrations of indigenous peoples in Amazonia.

Brazilian Amazonia currently has four dams classified as "large" dams: Curuá-Una (Dam No. 27 in Fig. 1, closed in 1977), Tucuruí (Dam No. 62 in Fig. 1, closed in 1984), Balbina (Dam No. 34 in Fig. 1, closed in 1987), Samuel (Dam No. 10 in Fig. 1, closed in 1988). Of the planned dams, most controversial are the dams planned for the Xingu River, beginning with the Belo Monte Dam, formerly known as Kararaô (Dam No. 28 in Fig. 1).

II.) SOCIAL IMPACTS

A.) Indigenous peoples

Existing and planned hydroelectric development includes some of the portions of Amazonia most heavily populated by indigenous peoples. The Tucuruí Dam on the Tocantins River flooded part of three indigenous reserves (Parakanã, Pucuruí and Montanha) and its transmission lines cut through four others (Mãe Maria, Trocará, Krikati and Cana Brava). In addition, the rerouting of the Transamazon Highway to skirt the western edge of the reservoir cut through the Parakanã Reserve, which was truncated to occupy only one side of the highway. The land between the highway and the reservoir was used as a resettlement area (the Gleba Parakanã), thereby denying the tribe access to the reservoir. Invasion of the reserve by non-indigenous poachers was facilitated by the arrangement. The Trocará Indigenous Area, inhabited by the Asuriní do Tocantins Indians, is located 24 km downstream from the dam, thereby suffering the effects of water pollution and loss of fish resources affecting all downstream residents. In the case of the Balbina Dam, part of the Waimiri-Atroari reserve was flooded. Most dramatic is the potential for impacts on indigenous peoples of dams are built on the Xingu river. The first dam planned (Belo Monte) is likely to set in motion a chain of events that would inexorably lead to building the other planned dams or, under ELETRONORTE's current plans for "redistribution of the fall" of the Xingu River, possibly resulting in dams in slightly different locations than those originally announced in the 2010 plan. The physical location of the proposed Belo Monte is a dam-builder's dream, with a 94-m drop and an average flow of 8600 m^3/s. The problem with tapping it is institutional: Brazil's electrical authorities may declaim as they might that only the first dam is at stake, but such claims are not likely to have any effect on building the other dams when their time arrives in the construction schedule. The history of broken promises (to use a euphemism) in the case of filling Balbina provides a directly parallel example. In the case of the largest Xingu dam (Babaquara: Dam No. 29 in Fig. 1), ELETRONORTE has not even promised not to build the dam, but only to remove it from the "2010 Plan"; moreover, the "redistribution of the fall" leaves open the option of flooding the same areas with other dams with different names.

2.) Resettlement

Displacement of population from the reservoir area can be a severe impact in some locations. In the case of Tucuruí 23,871 people were moved. Resettlement problems led the International Water Tribunal to condemn the Brazilian government for the impacts of Tucuruí at its 1991 session in Amsterdam. Although the Tribunal has only moral authority, the condemnation brought world attention to existence of an underlying pattern of social and environmental problems caused by this would-be model undertaking. The population that would be displaced by planned Santa Isabel Dam (Dam No. 74 in Fig. 1) is undoubtedly well over 100,000.

3.) Downstream residents

When a dam is built the residents along the river downstream of the dam suffer tremendous impacts. While the reservoir fills, the stretch below the dam often dries up completely, denying riverside residents water and fish. In the case of Balbina Dam the first 45 km downstream was dry during the filling stage. After the dam is filled, the water released through the turbines is virtually devoid of oxygen, killing fish in the river downstream and for a substantial distance below the dams preventing re-establishment of the fish populations. The virtual total loss of fish from lack of oxygen applies to 145 km at Balbina, while at Tucuruí it applies to to 60 km in the dry season on the western side of the river. Blocked migration reduces the river fish stocks over the full distance between these dams and the confluences of the rivers with the Amazon: 200 km in the case of Balbina and 500 km in the case of Tucuruí.

Below the Tucuruí Dam, the fish catches were three times smaller than pre-dam levels beginning in the second year after closing the dam. The fish catch per unit effort, as measured either in kg per trip or kg per fisherman, dropped by about 60%, while the number of fishermen also fell dramatically. In addition to declines in fish catches, freshwater shrimp harvests also decreased: local production in the lower Tocantins fell by 66% beginning in the second year after closure.

4.) Economic distortion

The power generated by Amazonian dams often does little to better the lives of people living near the projects. In the case of Tucurui this is dramatized by the high-tension lines passing over hut after hut lit only by the flickering of kerosene lamparinhas. As of 1996 of the power from Tucurui supplied subsidized energy for multinational aluminum plants in Barcarena, Pará (ALBRÁS-ALUNORTE, of Nippon Amazon Aluminum Co. Ltd. or NAAC, a consortium of 33 Japanese firms) and in São Luis, Maranhão (ALUMAR, of Alcoa). Brazil's Companhia Vale do Rio Doce (CVRD) maintains 51 and 61% interests in ALBRÁS and ALUNORTE respectively. The power is sold at roughly one-third of the rate charged to residential consumers throughout the country, and so is heavily subsidized by the Brazilian populace through their taxes and home power bills.

Brazil’s commitment to supply subsidized power aluminum firms distorts the entire Brazilian energy economy, inflicting wide-ranging social costs. The root of the problem is administrative ruling (Portaria) No. 1654 of the Ministry of Mines and Energy, dated 13 August 1979, which concedes electricity for a period of 20 years at a rate linked to the international price of aluminum, the energy used in the smelting not being allowed to exceed 20% of the international price of the product. When aluminum is cheap, as it is now, the companies pay almost nothing.

International financiers of dams in Brazil are essentially channelling money to Japan instead of to Brazil. The funds build dams to supply electricity to Brazilian cities that could be supplied from existing dams, such as Tucuruí, but are not because the Brazilian government is effectively giving away Tucuruí's power to Japan in the form of subsidized aluminum ingots. For example, Manaus could have been supplied with electricity from Tucuruí without building either Balbina or the planned gas pipeline from Urucú, cut this did not occur because the power from Tucuruí was already committed to making aluminum.

On a global scale, the subsidy of energy for aluminum permits wasteful use of this metal. Aluminum is used, for example, for cans for soft drinks and beer; even if recycled several times these eventually wind up in the trash. An aluminum can without recycling uses 7000 British thermal units (BTU) of energy, a recycled can uses 2500 BTU per use, while a reusable bottle refilled 10 times consumes an average of only 500 BTU per use. If the true cost of aluminum were charged for the product, including the cost of building hydroelectric dams and compensating for their environmental and social impacts, aluminum would be much more expensive and would only be used for purposes that have no substitute. The principal aluminum-consuming countries are not building more large dams, having found that the financial, social and environmental costs of dams are too heavy. They would much prefer to export these impacts to countries like Brazil, while continuing to enjoy the benefits in the form of cheap aluminum.

Financial loss is only a part of the impact of the subsidy to the aluminum industry. The quantity of employment generated by aluminum processing is minimal: there are 1200 jobs in Barcarena and 750 in São Luís. In 1986, ALBRÁS used 49.5% of all of the electricity consumed in the state of Pará. The "workers town" at Barcarena, including dependents, shopkeepers, etc., has a population of only 5000 people; this town consumes more energy than Belém, Santarém, and all of the other cities of Pará together. Virtually any other use of electricity would bring greater benefits to Brazil.

The construction of Tucuruí cost a total of US$ 8 billion when the interest on the debt is included, according to the calculations of Lúcio Flávio Pinto. Considering the percentage of power used for aluminum, Tucuruí alone (which is only a part of the infrastructure supplied by the Brazilian government) cost US$ 2.7 million per job created.

5.) Health

Health impacts of hydroelectric dams are substantial. Malaria is endemic to the areas where dams are being built, leading to increased incidence as human populations swell in these areas. The reservoirs provide breeding grounds to <u>Anopheles</u> mosquitos, maintaining or increasing the population of vectors for this disease in the surrounding areas.

In the case of Tucuruí, a dramatic impact was a "mosquito plague" of the genus <u>Mansonia</u>. This species does not transmit malaria, but it can transmit several arboviruses. It can also be a vector for filaria, the parasitic worm that causes elephantiasis. Although this disease occurs in neighboring countries such as Suriname, it has not yet spread to Brazilian Amazonia. After filling the Tucuruí reservoir, populations of <u>Mansonia</u> exploded along the western shore of the lake. These mosquitoes bite both by night and by day; biting intensity was measured at up to 600 bites/hour on exposed human subjects. The swarms of these insects make life intolerable in the areas where they are concentrated, and caused a significant number of residents to leave for more hospitable locations. The explosion of mosquitos was a predictable consequence of the aquatic weeds in the reservoir, which are believed to provide breeding grounds for these mosquitos throughout Amazonia. The prevailing winds concentrate the weeds along the reservoir's left bank. The initial explosion of aquatic weeds (especially <u>Salvinia auriculata</u>), which covered much of the reservoir's surface in the first year, died back to its present level as the initial flush of nutrients was exhausted. The current level of water weed infestation, and hence the current locally intolerable level of mosquito infestation, appears to be stable.

Mercury methylation represents a major concern for hydroelectric development in Amazonia. Mercury is concentrated biologically, and concentrations increase by an order of magnitude with each step up the food chain. Humans tend to occupy the top position and can be expected to harbor the highest levels of mercury. It is likely that high concentrations in soil and vegetation in Amazonia have built up from background deposition over millions of years, rather than from recent anthropogenic inputs.

Methylation is occurring in reservoirs, as indicated by high mercury levels in fish and human hair at Tucuruí. In a sample of 230 fish taken from the reservoir by Finnish researchers Tuija Leino and Martin Lodeius, 92% of the 101 predatory fish had Hg levels higher than the 0.5 mg Hg per kg fresh weight safety limit in Brazil. The tucunaré (Cichla ocellaris and C. temensis)--a predatory fish that makes up over half of the commercial catch at Tucuruí, is contaminated with high levels, averaging 1.1 mg Hg per kg, or over twice the 0.5 mg Hg per kg fresh weight safety limit. Canadian researcher Marc Lucotte has calculated that one could eat a maximum of one meal of tucunaré per week without exceeding the recommended limits to mercury consumption. Many residents around Tucuruí eat fish every day, as do many people in Belém where much of Tucuruí's fish harvest is marketed.

Mean Hg in hair of people fishing in the reservoir was 65 mg per kg of hair studied by Leino and Lodenius, a value many times higher than that in goldmining areas. For example, in gold mines near Carajás, Hg concentrations in hair ranged from 0.25 to 15.7 mg per kg of hair studied by R. Fernandes and colleagues. Data from the Tapajós River have indicated measurable symptoms, such as visual field reduction, among riverside residents with hair Hg levels substantially lower than both the levels found at Tucuruí and the 50 mg per kg threshold that is currently recognized as the standard. The Hg concentrations in human hair at Tucuruí are already more than double those that have been found to cause fetal damage, resulting in psychomotor retardation.

The human health consequences of mercury poisoning can be devastating, and are not understood by most people in Amazonia. Mercury concentrates in the body throughout a person's life--it is not removed by natural cleansing processes. Cooking fish does not alter the levels or toxicity of methylmercury. The appearance of severe symptoms--even death in severe cases--can occur with great rapidity after years of apparent health. In Minamata, Japan, healthy fishermen could be stricken and die within less than a week of the onset of symptoms. Mercury is concentrated in the fetus--a healthy mother can often give birth to a deformed child. The time before symptoms occur is very long. In Minamata, the Chisso Chemical Company began dumping mercury waste into Minamata

Bay in 1932, yet it was not until 1956--24 years later--that the first case of contamination was recognized. Many people in Amazonia today are eating fish and feeling no ill effects, leading them to the mistaken conclusion that they are escaping the consequences of mercury poisoning.

B.) ENVIRONMENTAL IMPACTS

A.) River hydrology

Damming a river breaks the natural cycle of seasonal changes in streamflow. Below a dam the peak flood stage is usually lower than in the unregulated river, and releases of water during the low water stage prevent river flow from reaching the low point that it normally would. Under some circumstances, however, the reverse effects can occur: precipitous release of water can cause unprecedented downstream flooding, and the river's flow can be completely blocked when the reservoir is being filled or re-filled, thereby causing a section of the river downstream to dry up completely.

B.) Forest loss

Loss of highly diverse tropical rainforests flooded by reservoirs is obviously a major impact. The area of forest lost due to hydroelectric projects is much more than that directly flooded by the reservoirs. Roads must be built to each dam, with consequent deforestation by farmers, ranchers and land speculators along these access routes. Population displaced by the reservoirs move to new areas, where they clear additional forest. In addition to loss of biodiversity, the forest loss contributes to greenhouse gas emissions.

C.) Global warming

Dams also contribute to global warming through emissions of methane formed when organic matter decomposes at the bottom of the reservoirs, which are devoid of oxygen. In the case of the Balbina Dam, which was built in an area of flat topography, giving it a large shallow reservoirs and little capacity to produce electricity, the impact on global warming is worse than generating the same power from fossil fuels. In the case of dams such as Tucuruí, where power generation is much higher than at Balbina, the balance is positive from the point of view of global warming despite substantial emissions. However, the relative impact of hydroelectric versus fossil fuel generation depends heavily on what value is given to the timing of the impacts (still an open question in discussions over global warming); if a weight is given to time as high as some that are currently under discussion, the current configuration of Tucuruí would be counterproductive from the point of view of greenhouse gas emissions.

IV.) CONCLUSIONS

Hydroelectric dams in Amazonia cause severe social and environmental impacts. If fully implemented, planned developments would provoke massive social impacts, including flooding large areas of indigenous homeland, displacing populations of non-indigenous residents in the submerged areas, and loss of fish and other resources for downstream residents. Environmental impacts include loss of highly diverse tropical forest, release of greenhouse gases through decay of forest biomass, disruption of aquatic ecosystems and formation of poisonous methylmercury from mercury present in the soil in the areas to be flooded.