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STRATEGIC CHALLENGES FOR SCIENCE AND TECHNOLOGY IN THE AMAZON

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ABSTRACT

The strategic challenges for science and technology in the Amazon include the definition of priorities for research and ways to support it. Research whose aim is the sustainability of the population of the Amazon should be a priority. The types of research mentioned in the book "Livro Verde" ["*Green Book*"] by the Ministry of Science and Technology, prioritize large networks which work with high-tech equipment. This approach, which can be called "the genome approach", is inappropriate for many high priority issues in the Amazon. The genome approach also does not stimulate the creation of new ideas, which are essential for the progress of science in this region.

Strategies to support the Amazonian population include the production of commodities, normally with the destruction of the forest. However, the most promising, long-term strategy is based on the maintenance of the forest as a source of environmental services, which can be classified in three categories: biodiversity, water cycling and reduction of the greenhouse effect. The reduction of the greenhouse effect has a great possibility to become a significant source of exchange value in the short term. It is necessary to understand the dynamics of deforestation in order to develop efficient means of controlling this process and to take advantage of the strategy of giving greater importance to environmental services.

KEYWORDS: science and technology, environmental services, deforestation, biodiversity, water cycling, greenhouse effect.

I) STRATEGIES FOR S&T

Supporting the Amazonian population should be the first priority for science and technology (S&T) in the Amazon. This requires a wide range of kinds of scientific research, which necessarily require different approaches according to the nature of each issue. This diversity of research approaches suggests the need for diversified research support.

The choice of priorities for research and the design of research support programs are both strategic challenges, since these choices should be part of a **strategy**. A strategy is not a recipe with a detailed methodology, but rather a consistent approach that allows the identification of intermediate aims and proper methods for specific tasks and goals. In other words, a strategy refers to a far-reaching plan on how to reach desired aims, in this case the maintenance of the Amazon population. One strategy to reach this aim is based on generating monetary flows originating from the maintenance of the forest's environmental services. For this, it is essential: a) to quantify the environmental services in the Amazon Forest; b) to understand the current processes of land-use change and the likely effects of different policies on these processes.

In 2001, Brazil's Ministry of Science and Technology undertook an extensive effort to rethink its priorities for research support. The result was a book known as the "Livro Verde", or "Green Book" (Silva & Melo, 2001). However, the Livro Verde presents only one kind of science and offers advice on how to apply its model to some of the scientific challenges in Brazil. The kind of science presented can be called "the genome approach", where, like the successful Genome Project, large teams from different institutions work in vast inter-institutional networks using expensive equipment to solve a specific challenge. Browsing through "Livro Verde", we can see clearly from the pictures, as well as from the text itself, that the science presented in it focuses on the use of high-tech equipment by large teams of scientists.

The genome approach represents an important kind of research, but it is necessary to acknowledge that it is not the only kind of important research. However, research funding in Brazil is rapidly becoming exclusively destined to this kind of research. For instance, the programs Milênio 1 and 2, PRONEX and CT-Petro are focused on large "networks", and even other forms of research funding, such as Directed Research Projects (PPDs) of the Pilot Program to Conserve the Brazilian Rain Forest (PPG7), are smaller versions of the same design.

The genome approach has produced surprising results in various emblematic projects all over the world, such as the genome sequence projects, and the Manhattan and the Apollo projects. Nevertheless, a number of problems in the Amazon that need to be studied are quite different from these. The genome approach applies to projects that require large laboratories with high-tech equipment. This approach is not suitable for studies that require researchers to live with caboclos, or traditional Amazonian inhabitants, in rough conditions deep in the forest, or to observe different species in their natural habitats.

In business administration there is a basic principle that says that, for any kind of business, there is an optimal scale. If a company is too small, the scale savings needed to make it work efficiently are lost, and many times the result is bankruptcy or fusion with other companies in order to form a bigger enterprise. On the other hand, if the company grows beyond the inherent limits in its sector, there will also be scale limits. For instance, a company that wants to plant eucalyptus and produce cellulose may become as big as the Jari Project, but if it wants to establish a project twenty times bigger than the Jari Project, it will encounter inherent inefficiency and will probably be divided into small companies.

In research, there are similar limits. Unfortunately, the present system of supporting science and technology undermines small projects and rewards big ones, without recognizing the different inherent limits of each kind of research. Therefore, large networks are favored. In theory, a project that brings together all the institutions, specialties and researchers to the Amazon would obtain the highest score in any competition, even though, in practice, it will produce almost nothing.

Besides the relationship between efficiency and scale, there is another characteristic of research: the necessity for creativity to come up with new ideas as an essential part of the so-called "production chain", which leads to scientific progress. Nearly all the great scientific discoveries were obtained in a way different from the genome approach (see Loehl, 1990). Einstein, Darwin, Fisher and many others did not have any project of the genome scale when they made their famous discoveries and inventions. Even James Watson, who until recently was in charge of the Human Genome Project, did not have this kind of support when he identified the DNA structure in 1953, with Francis Crick. Instead of large networks, conceptual discoveries are almost always made by individuals or very small teams, with few material resources. The same happens today.

In the case of the Amazon, the diversity of problems and the incipient research in many areas indicate a need to stimulate the creation of new ideas. The choice of problems to be studied is always the most important step in science, even more important than technology. After ideas are created and initially evaluated, large networks may be established, depending on the issue. A good system to support science and technology in the Amazon should not only stop excluding small projects, but also set aside a reasonable part of the budget for them. It should also have specific mechanisms to support the creative process, not requiring the elaboration of a detailed "project" in advance. An international example of this in biomedicine is the Howard Hughes Foundation, which supports, for a period of 3 to 5 years, a number of researchers with a good track record of creative productivity.

II) STRATEGIES TO SUPPORT THE AMAZONIAN POPULATION

There are two main ways of supporting science and technology towards the maintenance of the population in the Amazon. One of them is to improve the present production systems, which are mostly based on cutting down trees and selling commodities such as wood, grain and meat. Improvements can be made to these systems so that they can yield more from a smaller area, for a longer time, with less input and risks. However, the majority of these activities are based on destroying the forest in order to make a profit, although some of them aim at selling non-wood products, such as rubber latex, chestnuts and medicinal products, which do not lead to the destruction of the forest.

The non-sustainability of land-use in the most deforested part of the Amazon is absolutely clear. Also, well-known is the degradation of the pastures, which occupy most of the deforested areas (Fearnside, 2002). Unfortunately, the area that could be used for pastures, as in agriculture, is limited by the quantity of phosphate in the Amazon and in Brazil, although phosphate imports could, in theory, increase this use for some time, this is also limited (Fearnside, 1997a). Weather conditions also restrict pasture productivity (Schneider *et al.*, 2000). Before choosing development policies, it is necessary to estimate these limitations, the perspectives to reduce them, and their implications. This includes the maximum number of people that can be permanently supported by a given area, with a given kind of agricultural technology, consumption patterns, and environmental quality (Fearnside, 1997b).

There is another way to support the population which is based on a completely different logic: the maintenance of the forest and the importance of its environmental services. The environmental services in the Amazon Forest can be classified into three groups: biodiversity, water and carbon (Fearnside, 1997c). The carbon issue has been in greater evidence since the Kyoto Protocol was ratified, in December 1997 (UN-FCCC, 1997). In the Amazon, the high speed of construction of huge infrastructure projects, the migration of people to this region, and the increase in deforestation, logging and forest fire indicates the need for better principles in order to evaluate the impacts and benefits of theses changes.

III) ENVIRONMENTAL SERVICES

A) BIODIVERSITY

Biodiversity offers us a strong argument for the maintenance of significant areas of the Amazon Forest, since it has one of the biggest concentrations of species on the planet. The Convention on Biodiversity, ratified in 1992 at ECO-92, is the beginning of international efforts towards maintaining and increasing the value of biodiversity. Nevertheless, if we compare the United Nations Framework Convention on Climate Change (UN-FCCC) with the Convention on Biodiversity, the latter has been making little progress towards increasing support for biodiversity maintenance, although there is some progress in the regulation of the exploitation of genetic resources and other areas. In the long term, reasonable amounts of money may also come from biodiversity *maintenance*. This money should not be mistaken for money originated from biodiversity *exploitation*, such as bio-prospecting (Fearnside, 1999a). Although the challenges for taking advantage of biodiversity are huge, both because of maintenance and exploitation, the potential value should exceed the costs and be a priority for S&T in the Amazon.

B) WATER CYCLING

The Amazon Forest has an essential role in water cycling in the region, since almost half of the rainfall comes from water that is recycled by the trees. The transformation of wide areas of rain forest into pastures can induce important effects on water cycling and rainfall. Considering that evapotranspiration is proportional to leaf area, the quantity of water recycled per hectare of forest is much greater than the quantity recycled by pasture, especially in the dry season when the pastures dry up and the forest remains green. This tends to become more serious because of the water runoff under the pasture. An increase in the surface water runoff has been measured in sets of small blocks near Manaus (Amazonas), Altamira (Pará), Ouro Preto do Oeste (Rondônia) e Apiaú (Roraima) (Barbosa & Fearnside, 2000; Fearnside, 1989). As the soil under the pasture becomes highly compacted rain water is prevented from seeping in. The rain water that falls on compacted soil flows quickly over the surface, not being released later into the atmosphere through evaporation. Pastures and secondary forests have shallower root systems than primary forests, which prevents them from obtaining water during droughts (Cochrane *et al*., 1999; Nepstad *et al*., 1994, 1999).

If deforestation greatly expands, the reduced evapotranspiration will cause less rainfall in dry periods in the Amazon, and consequently the rain will also decrease in Center-West, Center-

South, and South regions of Brazil (Eagleson, 1986; Salati & Vose, 1984). In absolute terms, the rain would decrease in the Amazon constantly throughout the year, but in percentage terms it would increase most during the dry season (Lean *et al*., 1996). Although the total annual rainfall decreased by only 7% with the conversion of forests into pastures, in August the mean rainfall would decrease from 2.2 mm/day (with forest) to 1.5 mm/day (with pastures), which represents a reduction of 32% (Lean *et al*., 1996: 560-561).

The importance of the rain for agriculture implies a substantial monetary cost for Brazil. Thus, the level of rainfall should be kept suitable and stable in the main agricultural zones of the Center-South region. The energy “crisis” that occurred in 2001 in the non-Amazonian portion of Brazil shows the importance of rain, since most of the country's energy is generated in hydroelectric power stations. Unfortunately, this “crisis” result in result in wide public understanding of the importance of maintaining the Amazon Forest to keep the Brazilian capacity for generating energy in the future.

Water cycling maintenance is of great importance to Brazil as a nation, but it is different from maintaining biodiversity and stopping the greenhouse effect. This water cycling does not have a direct impact in countries of Europe, North America and Asia, thus it does not carry the same power to generate international monetary flows. Nevertheless, the importance of water in the Amazon, for Brazil, should at least help to encourage the government to accept international monetary flows in order to maintain the Amazon Forest, as it should accept help with other environmental problems, particularly those related to the greenhouse effect.

C) THE GREENHOUSE EFFECT

Halting the greenhouse effect is one of the best opportunities to generate significant monetary flows before deforestation goes far beyond the present “arc of deforestation”. However, the Brazilian scientific community has diverse opinions on this issue. The present Minister of Science and Technology and his advisers are against the inclusion of avoided deforestation in the Clean Development Mechanism (CDM), of the Kyoto Protocol, although most of the Brazilian scientific community which deals with this issue has reached the opposite conclusion (see “Manifestation…”, 2000). Inside the government, opinions also diverge. The Ministry of Foreign Affairs is against the concession of credit to avoided deforestation, while the Ministry of Environment is in favor of granting credit. In June 1999, in Cochabamba, Bolivia, the Brazilian Minister of Environment ratified a combined declaration of all the Latin-American environment ministries supporting the inclusion of avoided deforestation in CDM.

The discussions on gas emissions caused by the change in land usage have been following at least four different directions. First: the problem of parameter data, such as rate of deforestation, forest biomass, and the secondary forest’s growth rate. Second: the appraisal of these data in terms of gas emissions. Third: a theoretical debate on how carbon computations should be made, particularly in regard to weather and uncertainties. Fourth: the advantages, for Brazil, of different items in the Kyoto Protocol and the thoughts that guide the present opinions of countries (including Brazil) and of non-governmental organizations (Fearnside, 2001a, b).

The best opportunity for Brazil is the possibility to obtain credits for reducing the rate of deforestation, especially if Brazil joins Appendix B of the Kyoto Protocol, i.e., the list of countries with national limits for gas emission (Articles 3.7 and 17 of the Protocol) (Fearnside, 1999c). The best potential opportunities refer to avoided deforestation (Fearnside, 1999d, 2000), even the simplest ones offered by the Clean Development Mechanism (Article 12 of the Protocol).

The agreement reached in the second round of the Sixth Conference of the Parties (COP-6-bis) of UN-FCCC, that took place in Bonn, Germany, in July 2001, excluded avoided deforestation from the Clean Development Mechanism in the first commitment period (2008-2012). The agreement that enables ratification of the Protocol is a lengthy progress and modifies the scenario for investments in the maintenance of the Amazon Forest, even without credits from CDM up until 2013. European countries and non-governmental organizations opposed the inclusion of avoided deforestation but the statement that explains this opinion depends on circumstances that only apply to the first commitment period. That is, the fact that the “assigned amounts” (national quotas for carbon emissions) were defined in Kyoto in 1997 for the first commitment period, i.e., before reaching an agreement on the “rules of the game”, such as the inclusion of forests. This circumstance forced the United States to raise the price of fossil fuels (Fearnside, 2001a). For the second commitment period the assigned amounts for each country will be renegotiated; therefore, the inclusion of avoided deforestation in CDM would result in the countries accepting quotas bigger than they could do without the forests. The agreement in Bonn ended the paralysis in terms of the Protocol’s future and increased long-term investments favoring carbon, such as forestry management plans, spanning at least 30 years.

Opposition to include avoided deforestation in CDM by the Brazilian negotiation team can be explained by the concerns of key decision makers that a commitment to maintain the forest will lead to an increase in foreign pressure and even to the “internationalization” of this region (Council on Foreign Relations Independent Task Force, 2001; Fearnside, 2000). Although discussions always focus on scientific or moral elements, most important are the opinions about hypothetical geopolitical scenarios which are never overtly debated or explained. The potential advantages of Brazil in changing its position and taking economic advantage of the role of the forest in stopping the greenhouse effect is based on a phenomenon known through scientific data: the huge gas emission caused by deforestation in the Amazon (Fearnside, 2001c). In other words, it depends on the situation, and not on individual opinions. The opinions on geopolitical hypothesis vary from individual to individual, and the alternation of people in decision making positions will lead, sooner or later, to a change in the government position. It may be compared to a coin tossed up in the air: sometimes it comes down heads, sometimes tails. Sooner or later there will be people in key positions who will include the forests in CDM. And once this is done, forests will not be excluded anymore.

A number of research projects are still necessary to justify the use of avoided deforestation as a source of benefits in fighting the greenhouse effect. And a better understanding of the causes of deforestation and its process is more urgent than the improvement of data such as biomass measures and carbon stocks.

IV) DYNAMICS AND DEFORESTATION CONTROL

It is necessary to foresee the probable results of different changes in policies that may affect the process of deforestation. Above all, the present Brazilian government needs self-confidence to take serious and effective action to reduce deforestation. Many high-level government officials believe that deforestation is out of control and that they would not be able to greatly and permanently reduce the deforestation rate. Obviously, research targeted at justifying different scenarios could help in changing this situation.

A good understanding of the causes of deforestation should be a priority for research in the Amazon. It is essential to identify who is responsible for deforestation, including the role of big and medium-sized ranchers and small farmers (Fearnside, 1999b). Other reasons, such as land speculation, tax evasion, and the role of different kinds of tax incentives should be quantified. The impact of specific processes, such as logging, land reform, and the construction of infrastructure, especially for the plantation of soy beans, should also be quantified.

The most dangerous feature is fatalism, which leads to paralysis and the use of monetary and human resources to attend to other problems which are considered easier to be solved. Year after year we see the government announcing the deforestation data from the year before, with a series of measures to stop this process. But the data of the year after show ups and downs that do not reflect the measures applied. And the rate of deforestation is quite high: 18.3 thousand square kilometers/year in 2000 (Brazil, INPE, 2002).

Sometimes, a supposition of inability to reduce deforestation is mentioned as a reason for Brazil not having projects to prevent more deforestation since there could be punishments if Brazil committed itself to reducing deforestation and did not keep its promise. However, Brazil is not incapable of controlling deforestation. Strong proof of this was the drastic fall in the number of fires from July 1st 2000, when a ban took effect. The fall was over 80% in Mato Grosso, a state which normally has the greatest problems with fires. The critical factor is the self-confidence that Brazil must have to make the changes it decides to make. And I believe that in Brazil there is enough patriotism for this.

V) CONCLUSIONS

Research that aims at the maintenance of the Amazon population should be a priority. The "Livro Verde", which prioritizes large teams working with high-tech equipment, is inappropriate for many high-priority issues in the Amazon. This approach does not stimulate creation of new ideas either. Stimulating the creative process is essential for the progress of science in this region.

In the long term, the most promising strategy to support the population in the Amazonian region is based on maintaining the forest as the source of three categories of environmental services: biodiversity, water cycling and reduction of the greenhouse effect. In the short term, avoiding the greenhouse effect is more likely to become a more significant source of exchange value than biodiversity and water. It is necessary to understand the dynamics of deforestation in order to take advantage of the strategy of assigning greater importance to environmental services and to take efficient action in controlling this process. The worst obstacle to taking actions to stop deforestation is the tendency towards fatalism over the destiny of the Amazon Forest. Fortunately, the destiny of the forest depends basically on human decisions. Also, if the government actions are based on reliable information about the deforestation process, they may have a real effect on the forest loss rate.

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