Brazil Beyond Kyoto
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Prospects and Problems in Handling Tropical Deforestation in a Second Commitment Period

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Executive summary

The major share of Brazilian greenhouse gas emissions come from land use and land use change (i.e. deforestation) in the Brazilian Amazon. Most studies estimate this source of carbon dioxide (CO_2) to comprise about two thirds of the country's total CO_2 emissions, or between 140 and 250 MtC annually. This is equivalent to a few per cent of global CO_2 emissions from fossil fuel use. Reducing these emissions, by reducing deforestation rates, could therefore play a not insignificant role in the mitigation of global warming.

However, the Kyoto protocol does not create any incentives for reduced deforestation in non-Annex I countries, since "avoided deforestation" was not accepted as an eligible activity under the Clean Development Mechanism (CDM). This decision has been the source of much debate and disappointment among scientists and environmental organizations in Brazil and elsewhere. The Brazilian government, however, has strongly argued that the inclusion of "avoided deforestation" runs the risk of jeopardizing the environmental integrity of the protocol.

The aim of this study is to investigate how one should treat emissions from deforestation in the Brazilian Amazon in a future commitment period where Brazil has binding commitments. More specifically we analyze (*i*) how deforestation rates may be affected if Brazil takes on emission targets that include emissions from deforestation, (*ii*) how the environmental integrity of an international climate agreement might be affected by the large uncertainties in baseline emissions from deforestation in the Brazilian Amazon, and (*iii*) what constraints the participation of Brazil in a climate agreement with binding emission targets put on the treatment of land use, land use and forestry emissions in the agreement.

Our main conclusions are as follows:

(i) The judgment of most scientists in the area, as well as Brazilian officials and environmental organizations, is that it is very difficult to reduce deforestation rates. This is due to the many interacting forces behind current land use patterns, lack of resources for effective enforcement of current legislation, corruption and conflicting views on this issue between the federal government and individual Amazonian states with large sovereignty. Thus, though even a low price on carbon would make most land clearings in the Amazon unprofitable, the complexity of the issue makes it very hard to assess what consequences a carbon price would have on deforestation rates, counter to emissions from the energy sector.

(ii) The risk that one introduces "tropical hot air" in the global carbon market, as a result of overestimating future emissions from Amazonian deforestation, is imminent if Brazil gets binding commitments that includes this emission source. We estimate that the quantity of "tropical hot air" in 2020 may amount to more than the annual EU target under the Kyoto protocol. Conversely, a similar underestimation of deforestation rates will put Brazil in a position were the country has to acquire the same amount of carbon credits on the global market. We also show that the amount of hot air from uncertainties in deforestation rates is even larger if the overall emissions target is set in intensity terms, i.e. total emissions per GDP, but only if deforestation rates are independent of the economic growth rate.

(iii) From our assessment of different schemes for the treatment of emissions from land use change in future commitment periods, we conclude that so called full carbon accounting is unreasonable, since Brazil cannot be held responsible for the large variations in the carbon balance in the Amazon, both due to indirect human perturbations and to natural variations. A Kyoto-like compromise (article 3.3) seems to be a viable option, but it is likely that Brazil under such a regime would demand a generous allocation of emission rights to cover emissions from deforestation, over which they perceive they have little control. Thus, such an approach runs the risk of creating "tropical hot air" as concluded above. The most promising option seems to be the adoption of non-binding commitments for emission from deforestation. This would reduce the risk of creating hot air while at the same time creating an incentive for the Brazilian government to reduce deforestation rates.

The argumentation behind these conclusions can be found in section 4 in the report. Sections 2 and 3 offer a background to role of Brazil in international climate negotiations and to the issue of deforestation. Section 5 presents the results from interviews of important Brazilian actors in this field.

Contents:

Executive summary ... iii
1 Introduction ... 1
2 Brazil & Climate Change ... 2
2.1 Brazil on the Climate Change Arena ... 2
2.2 Carbon Dioxide Emissions from Deforestation in the Brazilian Amazon ... 5
2.3 Natural Carbon Emissions from the Amazon Basin ... 7
2.4 The Brazilian Energy Sector & Carbon Dioxide Emissions ... 8
3 Brazil, the Amazon & Deforestation ... 11
3.1 A Brief History of the Amazon on the Global Political Agenda ... 11
3.2 Deforestation in the Brazilian Amazon ... 13
3.2.1 Cattle Ranching ... 14
3.2.2 Small- & Large-scale Agriculture ... 15
3.2.3 Logging ... 16
3.2.4 Forest fire regime feedbacks ... 17
3.2.5 Mining, Hydro-dams and Roads ... 18
4 Analysis – Brazil, LULUCF-emissions and Future Commitments ... 21
4.1 How Will Deforestation Rates be Affected by a Global Carbon Market? ... 21
4.2 Emission Baseline Uncertainties and the Integrity of an International Climate Agreement ... 24
4.3 Treatment of Land Use Change & Forestry (LUCF) Emissions ... 25
4.3.1 Full Carbon Accounting ... 26
4.3.2 A Kyoto Styled Compromise… ... 27
4.3.3 …with Non-Binding LULUCF Emission Targets ... 28
4.3.4 A Separate Sinks Protocol ... 28
4.3.5 Synthesis ... 29
5 Results from Interviews with Brazilian Representatives ... 29
5.1 Brazil and Climate Change ... 29
5.1.1 The Domestic Debate - Stakeholders and Processes ... 29
5.1.2 The Brazilian Position on Climate Change Issues ... 32
5.1.3 Commitments in a Second Commitment Period? ... 32
5.2 Deforestation in the Brazilian Amazon ... 32
6 Conclusions and Policy Implications ... 33
Interviewees ... 35
References ... 35
Appendix A: Spatial & Temporal Distribution of Deforestation in the Brazilian Amazon ... 40
Appendix B: Estimating Future CO_2 Emissions in Brazil ... 40

1 Introduction

With a population of 170 million people and a gross domestic product (GDP) per capita of about US$$_{PPP}$7200 per year Brazil ranks as the fifth largest country and the ninth largest economy in the world. Brazilian energy use is growing rapidly, making Brazil the largest energy user in the region and, following China and India, the largest energy user among developing countries. Per capita energy use is double that of India, slightly more than the average Chinese but only about a third of the Swedish level. Still, carbon dioxide (CO_2) emissions from the energy sector are relatively low since almost half of the country's energy comes from renewable sources, hydropower and biomass. Per capita emissions of CO_2 from fossil fuel use were about 0.5 tC per year in 2000, half the world average.

But the largest share of CO_2 emissions in Brazil comes not from fossil fuel burning but land use and land use change activities (LULUCF), primarily from deforestation in the Brazilian Amazon. According to official estimates two thirds of Brazil's CO_2 emissions came from land use change on average in the period 1990-94 (MCT, 2002), amounting to a few per cent of global annual emissions from fossil fuel use. Other studies reports even higher emissions (Schroeder & Winjum, 1995; Fearnside, 1997; Houghton et al., 2000; Andersen et al., 2002; DeFries et al., 2002). Curbing emissions by decreasing deforestation in this area could therefore have a not insignificant part in dealing with global warming.

Given the international focus that has been given to the large scale destruction of tropic rainforests, this is a prospect that certainly has not gone unnoticed. However, the Kyoto protocol does not create any incentives for reduced deforestation in non-Annex I countries, since "avoided deforestation" was not accepted as an eligible activity under the Clean Development Mechanism (CDM). This decision has been the source of much debate and disappointment among scientists and environmental organizations in Brazil and elsewhere (see e.g. Bonnie et al., 2002; Bonnie & Schwartzman, 2003; Carvalho et al., 2004; Fearnside 2001a; IGBP Terrestrial Carbon Working Group, 1998; Niesten et al., 2002; Stier & Siebert, 2002; UCS, 2000).

In the light of this discussion, the aim of this study is threefold:

i. To explore to what extent deforestation rates might be affected by Brazil participating in an international climate agreement with binding targets that includes emissions from deforestation.

ii. To investigate how the integrity of an international climate agreement will be affected by the large uncertainties regarding emissions from deforestation in Brazil. That is, the risk that using the wrong baseline for future emissions leads to the creation of 'tropical hot air' undermining efforts to reduce emissions in other countries.

iii. Discuss the implications of the current knowledge on emissions and uptake of CO_2 in the Brazilian Amazon put on a carbon accounting system in an international climate agreement in which countries with large areas of tropical forests participate.

By trying to answer these questions we hope to identify prospects and problems in handling emissions from land use change in the Brazilian Amazon in a second commitment period to the Kyoto Protocol.

This report is structured as follows: the first half of the report, sections 2 and 3, offers a background to the issues at hand, covering the Brazilian stance on climate change issues and giving an in-depth description of the processes behind deforestation in the Brazilian Amazon. In the second half of the report we use the knowledge presented in the first half in order to analyze what requirements the participation of Brazil in an international climate regime puts on the design of that regime. This done from three main perspectives, corresponding to the main questions of this report as posed above; discussing how deforestation rates may be affected by the participation of Brazil in a global carbon market, analysis of how the uncertainty in baseline emissions affect the integrity of a climate agreement and an analysis of what constraints the participation of Brazil in a climate regime puts on a carbon accounting system. Also, section 5 presents the views of Brazilian representatives from government, academia and non-governmental organizations (NGOs) on these issues, as expressed in personal interviews in Brazil. Conclusions and policy implications from this analysis are presented in section 6.

2 Brazil & Climate Change

2.1 Brazil on the Climate Change Arena

Brazil is a country that throughout modern times actively has participated in international cooperation. It was part of the foundation of the League of Nations in 1920. It was the only Latin American country participating with troops in the Second World War and as such it was seen as an important ally by USA and the UK, rendering them a position in the Bretton Woods negotiations. As a result, Brazil has also been a part of the UN, the World Bank, the International Monetary Fund and the General Agreement of Tariffs and Trade from the start. It has also played an important role in the creation of regional institutions such as the Organization of American States and the Inter-American Development Bank. (Viola & Leis, 2001)

During the 1990s Brazils foreign affairs policy shifted radically from nationalistic, emphasizing absolute national sovereignty (especially regarding natural resources such as the Amazon, see below) and aspiring the position as an important power on the global arena (based on a strong military force), to a more liberal view, supporting human rights, democracy, social equity and environmental issues. Brazil now accepts limits to national sovereignty and has a strong commitment to regional integration through e.g. the Mercosur. (Viola & Leis, 2001)

Brazil's position in the discussions on the global environment has, ever since the emergence of these issues on the international political agenda in the early 1970s, been shaped by the fact that it has been and is a developing country. As such it has time and again emphasized the need for development, the issue of international equity and poverty as the main source of pollution. This position is nowhere more evident than in the country's participation and contributions to the international negotiations on climate change.

In all the official statements Brazil has made at the Conferences of the Parties (COPs)[1] to the United Nations Framework Convention on Climate Change (UNFCCC) four points, central to Brazilian position in the negotiations, are recurring: (*i*) the importance of the climate change issue and that there is an urgent need for action, (*ii*) the responsibility of the developed countries to act first in line with the "common but differentiated responsibilities" stated in the UNFCCC, (*iii*) the need for technology transfer and financial aid to developing countries, and (*iv*) pride over what the country has achieved domestically when it comes to climate change policies, opposing the view that developing countries are doing nothing.

The first three of these issues were all embodied in the proposal for a protocol that Brazil submitted at the 7th meeting of the Ad-Hoc working group on the Berlin Mandate, in May 1997 (UNFCCC, 1997) (hereafter referred to as the Brazilian proposal). The model underlying the proposal has since then been refined (Meira Filho & Miguez, 2000) and work is still carried out both in Brazil and elsewhere (Rosa et al., 2004).

The key element of the Brazilian proposal was the notion that historical contribution to climate change, i.e. temperature increase, should form the basis for burden sharing in an international climate regime. This can be seen as an attempt to give the "common but differentiated responsibilities" of the UNFCCC a scientific interpretation.

The original proposal notes that while the developed nations were responsible for 75 per cent of emissions of CO_2 in 1990, their share of accumulated missions up to 1990 were 79 per cent and their contribution to the warming up to 1990 was 88 per cent (UNFCCC, 1997). Also, although annual emissions of CO_2 from developing countries will equal those of developed countries within a few decades, the contribution to temperature increase will not catch up until about 2160 (UNFCCC, 1997).

[1] These can be found at http://www.mct.gov.br/clima/ingles/negoc/Default.htm, the Brazilian government's official climate change site.

Thus the proposal emphasized the responsibility of the developed countries and made a strong case against commitments for the developing countries.

Box 2.1: Main Brazilian stakeholders on the Climate Change Arena

The Brazilian position on climate change issue during the 1990s was shaped by two main actors, the Ministry of Foreign Affairss (*Ministério das Relações Exteriores*, Itamaraty) and the Ministry of Science and Technology (*Ministério da Ciência e Tecnologia*, MCT). Scientific and technical support to these institutions is provided by a Climate Change Advisory Unit within the MCT, established during the UNFCCC negotiations, and the National Institute for Space Research (*Instituto Nacional de Pesquisas Espaciais*, INPE), the latter especially regarding LULUCF issues.

In 1999 an Inter-Ministerial Commission on Climate Change was established, co-chaired by the MCT and the Ministry of Environment (*Ministério do Meio Ambiente*, MMA). Until then the MMA had no formal power over the Brazilian position in climate change negotiations. One responsibility of this commission is to handle issues pertaining to the Clean Development Mechanism (CDM). The Brazilian congress does not participate actively in shaping the Brazilian position in international environmental negotiations, although it is the authority responsible for ratifying international agreements.

In 2000 the domestic climate change arena was further enlarged when the federal government established the Brazilian Climate Change Forum, encompassing government officials at the federal, state and municipal level and representatives from academia, NGOs and corporations. Although having no formal power, the Forum offers a possibility for NGOs and other actors to convey their position in climate change issues directly to Brazilian officials working with the issue.

The academic institutions most active in both domestic and international climate work, supporting MCT in negotiations and preparing the national communication of Brazil, has been the Federal University of Rio de Janeiro and University of São Paulo. In 2000 the Centre for Integrated studies on Climate Change and the Environment was started at the former university, sponsored by the MMA. (La Rovere, 2002)

The Brazilian environmental movement formed in the 1970s, earlier than in most other Latin American countries, although public support was initially weak (Viola, 1997). Public awareness of environmental issues has since then increased dramtically, partly due to an intensive information campaign by the government prior to hosting the 1992 Rio Conference (Viola, 1997). The public support for deforestation in the Amazon has also diminished and shifted to a strong support for preservation (Viola & Leis, 2001).

Since Brazilian environmental organization has also almost exclusively been engaged in the preservation of the Amazon in relation to climate change issues, the most influential NGOs have been organizations like e.g. IPAM (Instituto de Pesquisa Ambiental da Amazônia), a research based institute working with patterns of land and resource use in the Amazon, and ISA (Instituto Socioambiental), working with similar issues.

In the corporate sector the knowledge and awareness on these issues have been alomsot non-existent. However, interest is growing due to the possibility of gaining benefits on a growing global carbon market. Maybe the most active actor on the climate change arena has been the Brazilian branch of World Business Council for Sustainable Development, Conselho Empresarial Brasileiro para o Desenvolvimento Sustentável (CEBDS) (La Rovere, 2002).

Another important group of actors has been the Amazonian states that repeatedly in international negotiations have been advocating the inclusion of avoided deforestation in the Kyoto protocol, at opposition to the official Brazilian delegation.

Although the Brazilian proposal for a protocol was not accepted, an element of the proposal was picked up in the negotiations. The proposal suggested the establishment of a Clean Development Fund for mitigation projects in the developing world, financed by fines from developed countries that failed to meet their emission targets, in line with the polluters pay principle. It was this proposal that laid the foundation to what later became the Clean Development Mechanism (CDM) of the Kyoto protocol.

Regarding Brazilian position on the issue of land use, land use change and forestry, both the domestic and international attention has focused mainly on the opposition to including these activities (and especially avoided deforestation) under the CDM. This issue, were Brazil has been in opposition to most of the other developing countries as well as domestic NGOs and scientists, is accounted for in detail in box 2.1. But this position has been in line with a more general skepticism against a generous use of LULUCF activities to meet emission reduction targets.

The main arguments put forward for this position is the uncertainties in measuring changes in carbon stocks, the difficulties in factoring out human anthropogenic effects and the temporary nature

Box 2.2: The issue of avoided deforestation under the CDM

Clearly the most contentious and debated climate change issue in Brazil has been the issue of avoided deforestation under the CDM, i.e. if Annex I countries should be able to acquire emission rights through projects that reduced deforestation rates in the developing countries.

Internationally this was advocated mainly by the Umbrella Group (USA, Canada, Japan, Australia and New Zealand), seeing the possibility of buying carbon credits at a low price to reach their targets, and many developing countries, among them many Latin American countries, seeing the prospect of receiving large funds for this kind of projects. On the other side of the spectra was the EU, pressing hard for limits on inclusion of sink-activities in the Kyoto-protocol in general and under CDM in particular.

The Brazilian delegation also clearly stated that they would not accept the inclusion of avoided deforestation under the CDM. They did this, not only in opposition to many other developing countries, but also in opposition to all Brazilian NGOs, most of the Brazilian scientific community and the governors of the Amazonian states.

In line with the Brazilian delegation's general effort to trying to limit the use of LULUCF activities in the protocol, the main arguments used by the Brazilian government for the position on avoided deforestation was that:

(i) conserving an existing forest do not contribute to mitigating climate change,

(ii) given the magnitude of carbon storage in standing forests would mean that the inclusion of avoided deforestation could practically nullify the emission reductions under the Kyoto protocol, and

(iii) given the problems of additionality and leakage it would never be possible to verify that an avoided deforestation-project did actually lead to reduced emissions (MCT, 1999).

However, the Brazilian NGOs have questioned these official arguments, claiming that the government's fear of internationalization of the Amazon is the core in the Brazilian unwillingness to include avoided deforestation in a climate agreement. Although official representatives admit that this is an issue, they see it is exaggerated (Marco Túlio S. Cabral and José Domingos Gonzalez Miguez, interviews). (For more on this, see section 5.)

The outcome of the negotiation process was that avoided deforestation was not accepted as an eligible activity under the CDM, something that has been the source of much debate and disappointment, both within Brazil and internationally. The issue is still on the agendas of Brazilian NGOs and scientists and has gained new interest with the change of government (see section 5).

of carbon storage. Because of this sinks could be a way of buying time, but the inclusion of sinks also diverts focus from the real solution to the problem, i.e. mitigation of emissions from fossil fuel, and because of the uncertainties runs the risk compromising the environmental integrity of a climate regime. (Thelma Krug and José Domingos Gonzalez Miguez, interviews)

Some authors and most Brazilian NGOs, on the other hand argue that the Brazilian position on sinks is the contingent on the government's fear of internationalization of the Amazon (Fearnside, 2001b; Johnson, 2001; Marcio Santilli, interview). Although official representatives admit that this is an issue, they think that it is overstated (Marco Túlio S. Cabral and José Domingos Gonzalez Miguez, interviews).

The restrictive position regarding sinks is in line with the Brazilian position in other issues, for example contrary to the other developing countries Brazil has not laid any emphasize on the issue of adaptation, again arguing that the focus should be on solving the root causes of the problem, i.e. the use of fossil fuels. This focus on energy related emissions may partly be explained by the fact that the Ministry of Science and Technology (MCT), together with the Ministry of Foreign Affairs (Itamaraty) has been the most influential actors in shaping the Brazilian position in climate change issues. Of course this could be seen as a strategic decision. Early attempts by the minister of environment José Lutzenberger, during the preparations for the Rio conference, to link the climate convention with a forestry convention meet fierce resistance from Itamaraty and led to the dismissal of Lutzenberger (Jakobsen, 1997).

As evident from the above, Brazilian has been an active and important actor in the international climate negotiations from the outset. Although Brazil has largely followed, or led, the G77/China position in the negotiations, the country has maintained its independence. This is especially true for the issues regarding the LUCF provisions of the Kyoto protocol, where Brazil has held a much more rigid position than its G77/China allies (Johnson, 2001).

Some argue that the Brazilian relations with the G77/China coalition are plagued by ambivalence, torn between the solidarity with the G77/China and a wish for alignment with the western countries, both positions derived from the underlying ambition of becoming a key player on the global arena (Jakobsen, 1997; Viola & Leis, 2001). The Brazilian ambition to uphold a position as a leader of developing countries in international negotiations partly has a historical explanation and there still is a strong ideological support for solidarity with the rest of the developing world among Brazilian foreign policy decision makers. But Viola & Leis also argue that another important reason for the continued affiliation with the G77/China groups is the ambition to become a permanent member of the UN Security Council. In order to achieve this goal, the support of the other developing countries will be crucial.

On the other hand, the shift away from the nationalistic position that shaped Brazilian foreign policy prior to the 1990s has opened up for forces within Brazil that want to see an end to the tight association with G77/China and the adoption of a foreign policy more convergent with the western countries, in line with the path followed by the neighboring country Argentina. For example Jakobsen (1997) cites a high level official from the Brazilian foreign affairs ministry, MRA, that explained Brazil's late signatory of a G77/China statement at COP-2, expressing dissatisfaction with the slow progress towards an agreement on targets and timetables for the Annex-I countries, stemmed from a fear that this would damage relations with important North partners, i.e. the US, while at the same time Brazil wanted to show support for the G77/China.

2.2 Carbon Dioxide Emissions from Deforestation in the Brazilian Amazon

The carbon emission resulting from land clearing in the tropics is one of the largest contributors to the uncertainty in today's understanding of the global carbon budget (Potter et al., 2001; DeFries et al., 2002). The most widely cited estimate of missions from land use change is the IPCC range of 1.7±0.8 GtC annually during the 1980s and 1.6±0.8 GtC annually during the period 1989-1998 (Watson et al., 2000). However, more recent estimates, based on better data on deforestation rates in the world's tropical forests from satellite observation, indicates that annual emissions from LULUCF in the tropics may not exceed 0.96 GtC (Achard et al., 2002).

A large part of the uncertainty in carbon emissions from tropical deforestation stems from differences in estimates of the extent and spatial distribution of forest biomass (Houghton et al., 2001; Houghton et al., 2000). Other uncertainties regard e.g. the rate of deforestation, the amount of biomass on cleared areas that is directly converted to CO_2 through combustion (the combustion fraction, CF), the rate of decay of the remaining biomass, the uptake of carbon from secondary regrowth on deforested areas. Still, quite a few estimates of carbon emissions from Brazilian land use change have been preformed (e.g. Schroeder & Winjum, 1995; Fearnside, 1997; Houghton et al., 2000; Andersen et al., 2002; DeFries et al., 2002).

The net fluxes of carbon from land to atmosphere reported in these studied are displayed in table 1. Apart from Fearnside (1997) most studies report the annual balance of emissions or accumulated balance of emissions over a certain time period, i.e. taking into account the direct emissions from clearing by biomass burning, decay of uncombusted biomass left from the initial clearing of land in earlier years, uptake of carbon from secondary regrowth on abandoned lands and changes in soil carbon. Fearnside's (1997) approach differs in that it accounts all emissions occurring under a 100 year period on the following the clearing of land a certain year, an approach generally referred to as *net committed emissions*.

All of these studies estimate emissions from land clearing for pasture and cropping, i.e. the land counted as deforested in the INPE data. They do not try to estimate carbon emission from forest degradation, e.g. by selective logging, or forests partially affected by surface fires. Nepstad et al. (1999) estimate that these emissions may be in the same order of magnitude as those from deforestation during severe droughts such as the one following the El Niño episode of 1997-98, although these estimations are contended, the estimations carried out by INPE reaching much lower levels of emissions (Thelma Krug, interview). Thus this further adds to the uncertainties regarding carbon emissions from land use change in the Brazilian Amazon.

Table 1: Estimations of the annual carbon flux from deforestation in the Brazilian Amazon.

Study	Time period	Average annual emissions (MtC/yr)	Average emissions per hectare (tC/ha/yr)	Assumed average forest biomass (tC/ha)
Schroeder & Winjum, 1995	1990	174-233		96-134
Fearnside, 1997	1990	261[a]	139[a] (182 / 20[b])	204
Houghton et al., 2000	1989-1998	180 (102-264)		145-232
Andersen et al., 2002	1970-1985	168	94,6	115
DeFries et al., 2002	1980's	150 (85-290)		140
	1990's	280 (170-490)		140

[a]Calculated net committed emissions for 100 year period following land clearing

[b]Numbers in parenthesis for forests and cerrado respectively

Direct comparison of the calculated fluxes shown in table 1 cannot be made since the studies look at different time periods and since the emission estimates include direct emissions as well as emissions resulting from previous clearing dividing emissions by deforestation rates for the year(s) in question they do not yield comparable results. Also, as mentioned above, different methods are used, i.e. annual balance vs. net committed emissions, and the geographical area covered by the studies varies between the Legal Amazon (Fearnside, 1997; Houghton et al., 2000; Anderssen et al., 2002) and the whole of Brazil (Schroeder & Winjum, 1995; DeFries et al., 2002).

As mentioned above a large part of the differences in the estimates of the carbon flux can be attributed to uncertainties in forest biomass. Houghton et al. (2000) report that of the uncertainty range given for their estimate, see table 1, 60 per cent can be accounted to different assumptions regarding forest biomass. Houghton et al. (2001) reviews 7 studies on forest biomass in the Brazilian Amazon in order to compare the estimates yielded by different methods, i.e. field measurements and remote sensing, both when it comes to the amount of carbon in forest biomass and the spatial distribution of the biomass.

They find that the estimates of total biomass varies by more than a factor of two between the studies, ranging from 39 GtC to 93 GtC, in the tropical moist forests of the Brazilian Amazon, i.e. excluding non-forest areas such as the *cerrados*. The mean forest biomass varied between 100 tC/ha and 232 tC/ha. A comparison of the spatial distribution of high-, medium- and low-biomass forests between four of the studies reviewed revealed large disparities; all four maps agreed over less than 5 per cent of the covered area, three or two maps agreed on 30.6 per cent and 70.4 per cent of the area respectively. None of these rates of agreement much better than what one would have expected by chance.

The spatial distribution of biomass in the Amazon is of course important for the emissions from land use change as the land clearing that is and has been taken place is not evenly distributed across states or vegetation types (see Appendix A and B). Based on the poor agreements on spatial distribution of forest biomass between the studies reviewed Houghton et al. (2001) concludes that "[f]or the forests of the Brazilian Amazon spatial variation in biomass are too uncertain at present for accurate calculations of [carbon] flux".

2.3 Natural Carbon Emissions from the Amazon Basin

Although the magnitude of the land use change flux of carbon from the Amazon region is uncertain, nobody contests the fact that it is a source of carbon. But what about the region as a whole? The Amazon Basin, containing almost half of the worlds remaining tropical moist forest and large areas of tropical savanna and contributing about 10 per cent of the global net primary productivity, could potentially be a large sink for carbon. As such is has received ample attention in the debate on "the missing sink", i.e. the unaccounted discrepancy between anthropogenic emissions of CO_2, from fossil fuel use and land use change, the uptake of oceans and the increase in the atmosphere. Although the missing sink is large compared to the anthropogenic fluxes of carbon, in the order of 2 GtC per annum[2], it is only about 0.1 per cent of the total carbon stored on land, which in practice makes it hard to find (Prentice, 2001; Prentice & Lloyd, 1998).

Measurements preformed to date indicate that the Amazon Basin in fact may be a large sink, on average in the order of 200 MtC per year in the period 1980-1994, though with large inter-annual variability, from a sink of 700 MtC one year to a source of 200 MtC another (Prentice & Lloyd, 1998; Tian et al., 1998). The main explanation for the Basin being such a large sink is increased rate of photosynthesis, and subsequent carbon uptake, due to the elevated levels of CO_2 in the atmosphere, an effect referred to as CO_2-fertilization (Prentice & Lloyd, 1998; Chambers et al., 2001). The large inter-annual variability is largely explained by year-to-year climate fluctuations controlling soil moisture through precipitation and temperature (Grace et al., 1995; Prentice & Lloyd, 1998; Tian et al., 1998).

These remaining, large uncertainties regarding the regional carbon balance for the Amazon, and other large tropical forest areas, and the possible large interannual variability of course have large implications on how sinks can be treated in a future international climate agreement where these countries participate, a topic that will be thoroughly addressed in section 4.

[2] However, a adjustment downwards of emissions from tropical deforestation as put forward in Achard et al. (2002) would however imply a smaller "missing sink".

2.4 The Brazilian Energy Sector & Carbon Dioxide Emissions[3]

With about a third of total Latin American primary energy supply, or about 2300 TWh/yr, Brazil is the largest energy user in the region. Per capita energy use is about 16000 kWh/yr, double that of India, slightly more than the average Chinese but only about a third of the Swedish level. Energy demand grew rapidly during the 1970's, the growth rate then declined during the 1980s, partly due to a turbulent economy experiencing bouts of hyperinflation as well as recession. In the latest decade energy demand rose again, by 34 per cent. The primary supply of the Brazilian energy sector, by fuel, can be seen in figure 1. For a relatively rich country the energy sector of Brazil is unique in that renewables account for nearly 60 per cent of total supply.

Because of the large share of renewable energy, in the electricity, transport and industrial sectors, the carbon intensity of the Brazilian energy system is low. Aggregate emissions were about 84 MtC in the year 2000. The CO_2 characteristics of the Brazilian economy, absolute, per capita and per GDP emissions are shown in table 2. As a comparison the same data for China, India, USA and Sweden is also shown.

The electricity sector is totally dominated by hydropower, today supplying more than 90 per cent of total electricity consumed. The total capacity has increased almost six-fold since the 1970s, reaching 60 GW in 1997. Part of this includes the world's largest hydroelectric plant, the Itaipu dam, jointly owned and operated by Brazil and Paraguay, with an installed capacity of 12,600 MW, almost

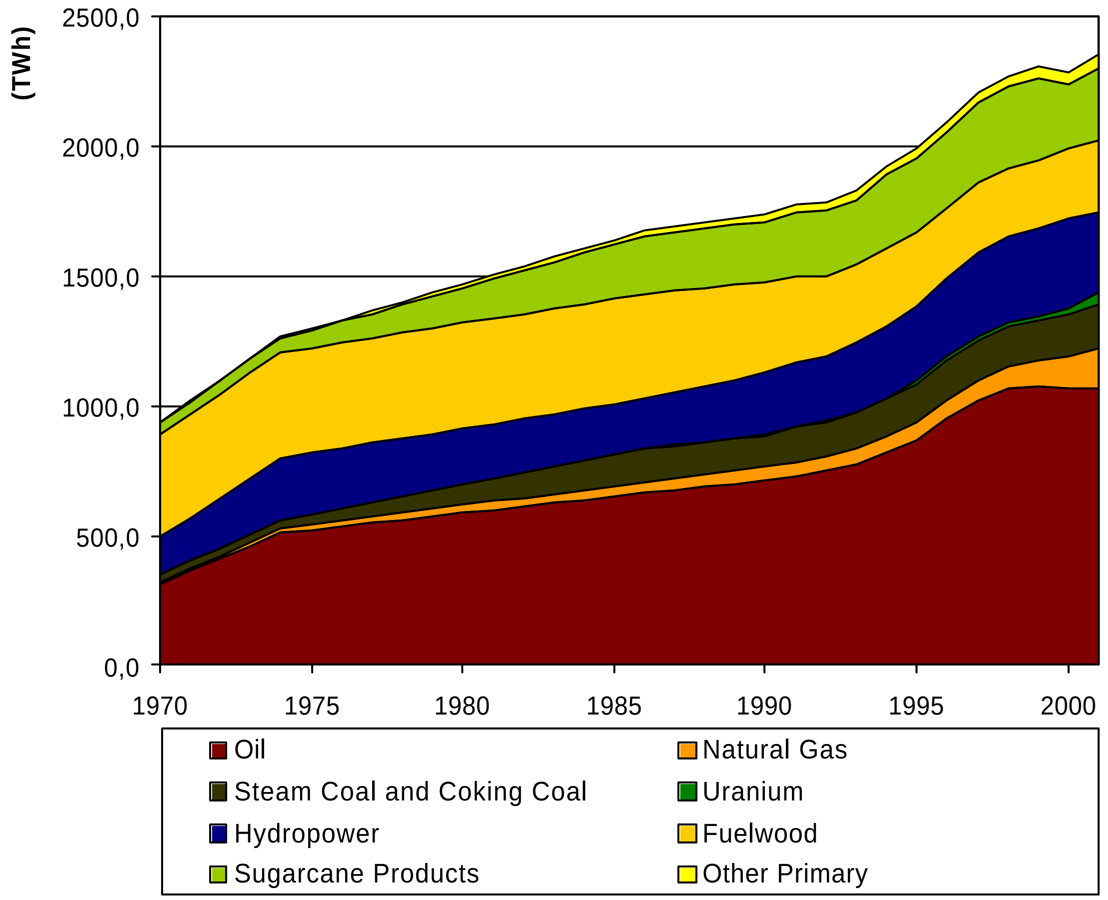


Figure 1: *The gross primary supply of energy in Brazil, by fuel, 1970-2001. Source: BEB - Brazilian Energy Balance, DNPE & CGIE (1996; 2002).*

[3] This section is based on the Pew Climate report "Developing Countries & Global Climate Change: Electric Power Options in Brazil" (Schaeffer et al., 2000), the chapter on Brazil in World Energy Outlook (IEA, 2002) and Poole et al. (1998).

twice that of the world's second largest dam. Support to the grid during the dry season and supply of electricity in remote areas not connected to the grid comes from a mix of fossil fuel, biomass and nuclear power plants. Brazil currently has two nuclear reactors in operation, with one more under construction but public opposition and high costs have prevented nuclear from playing a large role in the energy sector of Brazil as in many other countries.

Table 2: *Carbon dioxide characteristics of the Brazilian economy in the year 2000 as compared with that of China, India, USA and Sweden. Includes only CO_2 emissions from fossil fuel use, cement production and gas flaring, i.e. not emissions from LUCF-activities.*

	Brazil	China	India	USA	Sweden
CO2 emissions (MtC)[a]	84	762	292	1,529	13
CO2 per capita (tC/cap.)[a]	0.49	0.60	0.29	5.40	1.44
CO2 intensity (kgC/'000US$$_{ppp}$)[b]	68.6	161.4	115.9	166.7	62.0

[a]Taken from Marland et al., (2003)

[b]Emission data as above and GDP data in purchase power parity (PPP) from Penn World Tables, Heston et al. (2002)

The transport sector accounts for about a third of the final energy use in Brazil, the manufacturing sector and the residential sectors about 43 per cent and 10 per cent, respectively, although the latter figure does not include use of firewood. The use of biomass in both the transportation and industry sectors in Brazil is relatively high. In the transportation sector, alcohol from biomass (sugarcane) accounts for about 16 per cent of total energy use. Still, the sector is the largest consumer of fossil fuels in the Brazilian energy sector and the fleet of vehicles has grown at a pace much higher than the economy as a whole in the latest decade. Also, the federal alcohol program, *Proálcool*, see box 2.3 that was launched during the oil crises of the 1970's in order to reduce the country's dependence on oil imports has been question and the majority of cars sold nowadays run on gasoline. The large contribution of renewable energy in the industrial sector comes from the use of charcoal in the metallurgical industry.

The electricity sector in Brazil has gone through extensive reforms during the last decade, partly through an intensive privatization process from 1995 onwards focusing primarily on distribution but also generation facilities. The aim of this program has been to attract foreign and domestic capital to the energy sector in order to increase competitiveness and reduce the risk of electricity shortfalls, which has been badly needed since the debt crisis of the country in the 1970's, causing investments in the energy sector to drop rapidly in the 1980's and onwards.

The insufficient investments in generation and transmission capacity was clearly felt in the 2001 electricity crisis, caused by the worst drought in 70 years and forcing the government to introduce a 10-month electricity-rationing program in the industry, service and residential sectors. This strict program on the other hand raised awareness of the large possibilities for energy efficiency measures, both for consumers and in the industrial sector. It has been estimated that while electricity consumption in the industry was 14 per cent lower under the rationing period than under the same months in 2000, production declined by only 1.1 per cent.

The large need for investment in the near future means that the energy sector in Brazil may face a transition. Although expansion of hydropower is possible it is viewed as increasingly costly, controversial and risky. Focus is therefore shifting towards natural gas. A new pipeline from Bolivia was recently completed and several others from Argentina on the drawing board, although many of these projects are also highly controversial.

Box 2.3: The Brazilian ethanol program – *Proálcool*

In 1975 the Brazilian government launched what became the world's largest commercial bioenergy program, Proálcool. Since then a cumulative amount of about 30 billion barrels of ethanol has been produced from sugar cane. The ethanol is used both for fueling purely ethanol powered vehicles as well as in a 24 per cent blend with gasoline (*gasohol*), fueling the remaining car fleet in the country.

The rationale behind the government initiative to promote ethanol production from sugar cane was mainly to reduce the country's dependence on oil imports, that in the wake of the first oil crisis was putting serious strain on the country's trade balance. But the program was also an answer to the problem of fluctuating, and at the time rapidly decreasing, world market price on sugar.

The Proálcool program consisted of three main elements: the guarantee that the state-owned oil company, Petrobrás, would purchase a certain amount of ethanol, economic incentives such as tax-exemptions and low interest loans to agricultural enterprises willing to invest in ethanol production and indexing the price of ethanol facing consumers at 59 per cent of that of gasoline (this was later been increased to 80 per cent). The latter was made possible by a cross subsidy system where gasoline and diesel oil is taxed and using this revenue to subsidize ethanol production.

As a result of these measures ethanol production quadrupled in a decade, reaching 1,800 million barrels in 1985. Around 1990 ethanol took half of the transportation fuel market in Brazil. Production then increased more slowly to peak at nearly 2,500 million barrels in 1997. After that, production declined sharply, reaching 1,700 million barrels in 2000. Sales of ethanol fueled vehicles peaked around 1985, taking about 96 per cent of the light vehicle market. It has since declined rapidly, today representing around a per cent of total sales.

Apart from reducing the countries dependence on imported oil, reducing foreign expenditures by some US$$_{1996}$33 billion up to 1996, the program has also reduced urban air pollution significantly and created about 700,000 jobs, mostly in rural areas. By offsetting fossil fuel consumption the program lead to mitigation of about 9 MtC in 1996, or about 12 per cent of Brazil's fossil fuel CO_2 emissions that year. In total the program has lead to a cumulative emissions reduction of about 150 MtC* up to 2000. This has been achieved at a cost of about US$$_{1996}$200/tC. A relatively high cost, although one has to remember that the program has had several other positive benefits.

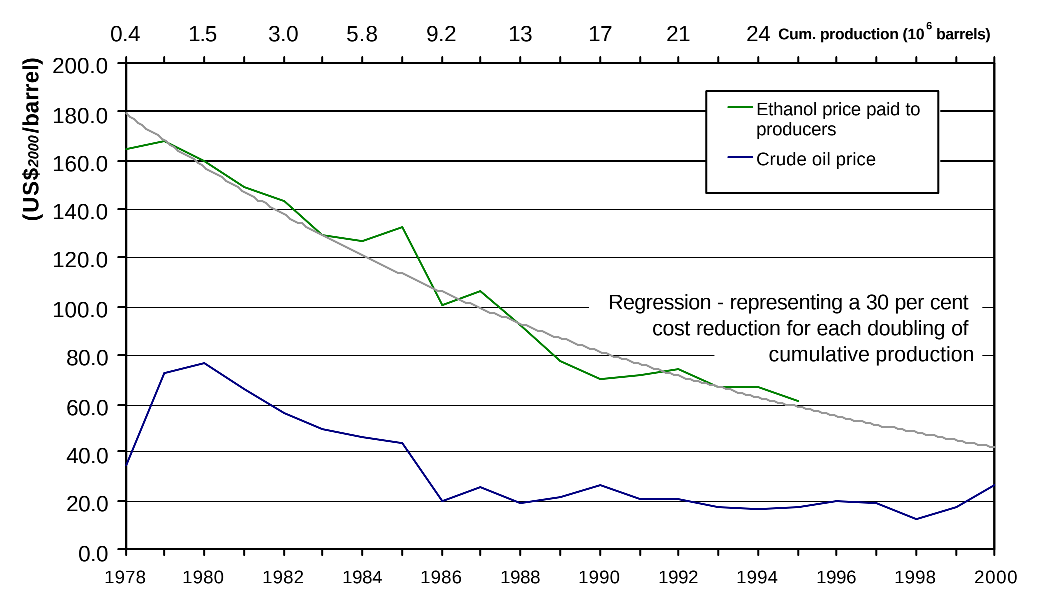
Due to the rapid expansion of ethanol production technology improved and costs have dropped, see figure below. Between 1977 and 1996 yields roughly doubled, from about 2600 l/ha to 5100 l/ha.

The ethanol program originally relied on traditional governmental 'command & control' policies. In the process of deregulation the government has removed all such incentives so that ethanol production today is totally determined by market forces. This means that the supply of ethanol is determined by the international prices on sugar and oil, making it uncertain for the consumers.

The future of the ethanol program is highly uncertain. Although ethanol was 35-50 per cent cheaper than gasoline in 2000-2002, new government policies in support for ethanol production are discussed. But despite the technological progress made in production and the resulting cost reductions both ethanol production and ethanol vehicle sales have declined rapidly in the last years

Source: Goldemberg, 1996 and MCT, 2002

*Extrapolating the relation between emissions reductions and production in 1996 to 1975-2000.



The learning curve for the Brazilian ethanol program. Data from Goldemberg (1996), adopted from Nakicenovic (2001).

3 Brazil, the Amazon & Deforestation

The intention with this section is to offer a background to the process of deforestation in the Brazilian Amazon. It starts off looking at the extension, trends and spatial distribution of the deforestation that has taken place to date. The following subsections then scrutinize the main sources of deforestation in the Brazilian Amazon, cattle ranching, small- and large-scale agriculture, logging and fire. Also, when understanding the process of tropical land use change it is important not to stop at the direct sources but to try and understand the underlying forces driving deforestation. These are dealt with in connection with each of the sources below. Finally this section ends with an attempt to summarize the historical forces driving land use change in the region.

3.1 A Brief History of the Amazon on the Global Political Agenda

With an area 5.3 million km^2 the Amazon constitutes the world's largest freshwater basin. Its rainforest-covered area makes up one third of the world's remaining tropical forests, which is home to 30 per cent of the world's flora and fauna. About 60 per cent of this forest is within Brazilian territory and makes up the states of Acre, Amapá, Amazonas, Roraima, Rondônia, Pará and Tocantins. In the discussion on planning and development in the region focus has been on a larger area, also encompassing the state of Mato Grosso and parts of Maranhão, defined as the Legal Amazon, see figure 2. This area, covering 61 per cent of Brazilian territory and hosting 16.5 million, or 12 per cent, of the country's population, will also be the focus of this report.

Though mainly constituted of tropical moist forests the region is far from being a uniform biome. It comprises also seasonal forests (3.0 per cent), savannas or *cerrados* (15 per cent), heath forests or *campinaranas* (6.4 per cent), wetlands (2.0 per cent) and vegetation of ecological transition (5.1 per cent) (Andersen et al., 2002). Some of these types of lands are believed to host just as much biodiversity and store as much carbon as the dense forests.

It is predominately because of its natural resources and the services it provides, hosting rich biodiversity, storing huge amounts of carbon, and at the threat from loggers, miners, slash-and-burn farmers, cattle ranchers, that the Amazon has appeared on the global agenda during the last decades.

Figure 2: *The area constituting the Brazilian Legal Amazon, encompassing the states of Acre, Amapá, Amazonas, Maranhão, Mato Grosso, Roraima, Rondônia, Pará and Tocantins.*

But the fate of the Amazon has been on the geopolitical arena long before global environmental issues emerged and the region has been seen alternately as “El Dorado, Second Eden, Green Hell, Earth's Lung, or the Last Frontier” (Godfrey & Browder, 1996).

The international interest started with the colonization efforts aimed at natural resources, first rubber and gold and then forest and agricultural products. But as the rubber industry collapsed, following the introduction of plantations in Indonesia, and the soils of the Amazon were found to be poor and ill suited for farming or forestry, the image of the richness of the Amazon faded. Still, ever since international commercial interests started to play a role in the Amazon region there has been clear indications that countries outside the region, primarily the US, has tried to gain influence over the area, an effort that has been constantly reinforced in the last fifty years (Roman, 1998).

This was recognized by the military when it seized power in 1964. As a consequence, it launched an ambitious colonization program to secure access to the border areas. As a result of this occupation policy population in the region grew from four to ten million people between 1970 and 1991. The colonization program is generally is described as a social and environmental disaster. However, the gross internal product of the region has increased from 1 to 25 billion US$ from 1970 to 1996 (Nepstad et al., 2000) and increasing real per capita GDP has lead to higher average life expectancy and decreasing illiteracy rates and infant mortality rates in the region (Andersen et al., 2002).

Though the fear of internationalization of the Amazon still lives in Brazil (Council on Foreign Relations Independent Task Force, 2001; Fearnside, 2001b; Johnson, 2000), the international debate over the region has shifted in the latest decades towards the environmental services that the region provides, both locally and globally. Due to the high complexity of the issue, involving ecological, economical and social factors, it has emerged as “one of the most influential issues in the international environmental debate" (Roman, 1998), providing a striking example in the growing international discussion on environment and development and the possible conflicts between the two[4].

3.2 Deforestation in the Brazilian Amazon

In 1970, 97 per cent of the area of the Legal Amazon was undisturbed and two thirds of the remaining area was fallow land in the process of forest regeneration. Thus merely 1 per cent of the whole area was being actively used for crops or pastures (Andersen et al., 2002). This situation has since then changed. Following the governmental efforts to increase population and production in the region, land clearings soared, averaging about 21,000 km^2/yr in the period from 1978 to 1988. Deforestation has since fluctuated, falling during the economical recession in the late 1980's, and recovering to reach an all time high of nearly 30,000 km^2 in 1995[5]. Still, only about 15 per cent of the original land cover in the Legal Amazon has been completely deforested (although a much larger area may be more or less degraded, see below).

The rate of deforestation in the Brazilian Amazon, as reported by Brazil's National Institute for Space Research (INPE, Instituto Nacional de Pesquisas Espaciais), is displayed in figure 3. As can be seen, the bulk of deforestation has taken place along what is called the arc of deforestation, in the states of Pará, Mato Grosso and Rondônia. (For a detailed account of the temporal and spatial distribution of deforestation in the Legal Amazon, across states, see Appendix B).

These figures are based on the interpretation of imagery provided by the Landsat Thematic Mapper (TM) satellites, giving estimates of forest conversion to agricultural land at a reasonable cost

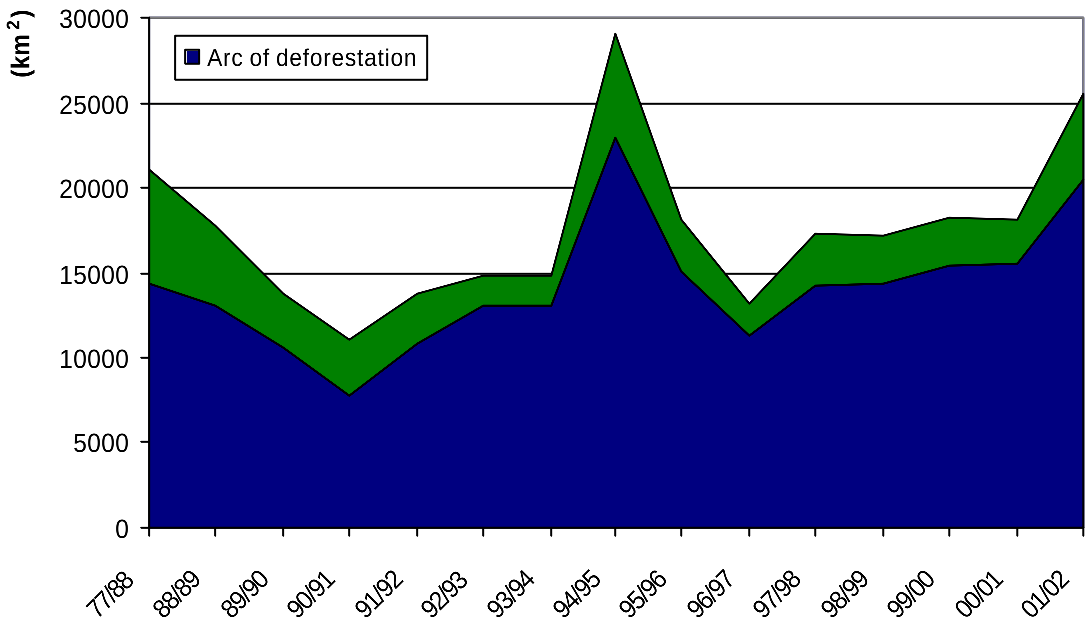


Figure 3: *The rate of deforestation in the Brazilian Amazon in the period 1978-1988 (the rate for the years 1978-1988 constitutes a mean for that period). The share of deforestation that is taking place along the agricultural frontier in what is called the Arc of Deforestation (the states of Pará, Mato Grosso & Rondônia) is also displayed. (INPE, 2002)*

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[4] For an excellent account of the role that the Amazon has played in international environmental negotiations, from the 1972 Stockholm conference and onwards, see Roman (1998).

[5] There is some debate as to whether deforestation rates in 1995 did actually amount to the 29000 km^2 reported. Some argue that the high figure reported includes forest loss from earlier years that was not reported earlier because cloud cover and other complexities hindered interpretation of satellite images (Cattaneo, 2002). Other argue that the figures reported are corrected, leaving the 1994 Real Plan for economic stabilization or an increase in accidental fires as the explanation (Lele et al., 2000).

and speed. Brazil has one of the most advanced satellite monitoring systems in the developing world and the data reported by the INPE are widely accepted. Still, these figures may not tell the whole story of forest degradation in the Amazon.

Firstly, the INPE estimates do not include small clearings (<6,25 ha) (Laurance et al., 2001). Secondly the binary classification used by INPE, where land is interpreted as either forest or non-forest, is well suited for the analysis of the land clearings preformed by ranchers and farmers but does not well capture alterations that reduce the forest tree cover but not totally eliminate it. Two such important processes discussed below are logging and surface fires in standing forests. Thus, the figures reported by INPE may be a reasonable correct estimation of the deforestation in the Amazon may be an underestimation of the full extent of forest degradation in the area (Nepstad et al., 1999).

Figure 3 also shows that deforestation rates rose by more than 40 per cent in 2001/2002, to a level only precedent by the record high rate of 1994/1995. The main reasons cited for this increase is the fact that is was election year, making enforcement of forest protection contentious, and an increase in demand for soy products, augmented by a weak exchange rate making exports even more profitable (Bhattacharya, 2003; Rother, 2003)

3.2.1 Cattle Ranching

Cattle ranching have been pursued in the Brazilian Amazon in the last three centuries, though it has historically been confined to the natural grasslands of the Marojo Island and the floodplains (*varzea*) of the Amazon River. This picture has change dramatically since the 1960s. The amount of land dedicated to pasture has doubled since 1970, from about 238,000 km^2 to 517,000 km^2, while the cattle herd today is nearly six times that in 1970 (Andersen et al., 2002). This development has been one of the main sources to land use change in the area, medium to large cattle ranchers accounting for about 70 per cent of the deforestation taken place (Fearnside, 1993).

Early analyses of the driving forces behind the growth in cattle ranching focused primarily upon government policies and land speculation as the underlying causes of land use change (e.g. Browder, 1988; Hecht et al., 1988). The advocates of the latter cause argued that ranchers claim and clear land in order to sell the land at a later time at a high price and that cattle ranching is an inexpensive way to occupy the land in the meantime. But according to Faminow & Vosti (1998) nearly all the empirical evidence put forward in favor of the land speculation hypothesis originate from one set of data (Mahar, 1979) combined with anecdotal evidence. In fact real farmland and pasture prices has been stable or stagnant in the Amazon since the 1970s (Faminow & Vosti, 1998; Andersen et al., 2002) and returns on land has been significantly lower than elsewhere in Brazil (Andersen et al., 2002). Faminow & Vosti (1998) concludes that although some investors may have experienced large gains from land speculation “this is not the widespread and pervasive phenomena that is commonly believed”.

Government policies in the 1960s and 1970s, as a part of the SUDAM (Superintendency for the Development of the Amazonia) program for development of Amazonia, had a preference for large-scale ranching projects and included investment funds and tax breaks for ranchers. In 1989, 58 per cent of the projects approved under the SUDAM program were cattle ranching projects, concentrated mostly in the states of Mato Grosso and Pará (Faminow & Vosti, 1998). The financial incentives were expanded again in the 1980s and a surge of investment in large-scale projects occurred which finally led to the exhaustion of financial resources. In the late 1980s subsidies for new projects were suspended and all fiscal incentives for cattle ranching were officially removed by a presidential decree in 1991 (Andersen et al., 2002).

Still, in 1995 there were 36 million unsubsidized cattle in the Amazon region. Also, the state experiencing the most rapid growth in the number of cattle during the period of government subsidies, Rondônia, was also the state receiving the least amount of subsidies (Andersen et al., 2002). Of 50,000 medium to large-scale ranchers in the Amazon only 500 ever received a generous incentive package from SUDAM (Faminow, 1998). Thus, even though government policies may have played some role in the early expansion of cattle ranching in the Amazon, the notion that cattle ranching in the region is not profitable *per se* has been heavily contested in later analyses of deforestation (e.g. Arima & Uhl, 1997; Faminow & Vosti, 1998, Andersen et al., 2002).

One can list a series of reasons why cattle ranching is attractive to farmers in the Amazon (Arima & Uhl, 1997; Egler, 2001; Andersen et al., 2002):

i. Cattle is a liquid investment that can be sold in case of a crisis or opportunity but sales can also be delayed without major losses
ii. Ranchers are not dependent on a road infrastructure to reach the markets
iii. The cost of establishing pastures after cropping is low
iv. Cattle ranching is a low risk activity compared to cropping
v. Cattle is perceived as a more secure and familiar investment than banks where the interest rates given may be lower than inflation
vi. Cattle produces valuable by-products as milk, skins, manure and off-spring
vii. Cattle ranching has a higher labor productivity than cropping, an important aspect in a region where rural labor is scarce

Also, the decreasing relative price of land in the Amazon compared to land in the south of Brazil might have been a driver for cattle ranching expansion in the region. The introduction of soybean production in the South and Center-West (see below), giving large increases in land productivity, gave rise to a surge in land prices pushing land extensive activities such as cattle ranching towards the cheaper lands in the Amazon (Andersen et al., 2002). Supporting this notion is the fact that the total area of land dedicated to cattle ranching have stabilized or even decreased in most Brazilian states, apart from the states in the arc of deforestation, Mato Grosso, Rondônia and Pará, where pastures are advancing towards the interior of the Amazon (Egler, 2001).

Another important factor pulling cattle to the Amazon, complementing the relative land price push factor, has been the expansion of local markets (Faminow & Vosti, 1998; Andersen et al., 2002). The population of the Legal Amazon rose from about 2.7 million in 1970 to 10.8 in 1995. The growth in cattle roughly matched the growth in population between 1960 and 1980 but grew more quickly between 1980 and 1991 so that the region was roughly self-sufficient in beef production in 1991 (Faminow & Vosti, 1998).

However, a recent report shows that the expansion of cattle ranching during the later part of the 1990s has also been driven by sharply rising beef exports (Kaimowitz et al., 2004). Between 1997 and 2002 beef exports increased fivefold. The report claims that increase in Brazilian cattle herd during the period (of which 80 per cent was in the Amazon) was largely export driven and spurred by the devaluation of the Brazilian reais.

To sum up, although government policies have played a role in the early growth of cattle ranching in the Amazon, the economic provisions of the activity have been good enough to make it attractive even in absence of subsidies. Thus, the growth of cattle ranching, and subsequent deforestation, is likely to continue in the region in the coming decades, but this process is of course dependent on a wide array of factors (Arima & Uhl, 1997; Faminow & Vosti, 1998).

3.2.2 Small- & Large-scale Agriculture

The second largest direct contribution to land clearing in the Legal Amazon comes from the cultivation of annual crops, i.e. rice, maize, beans, potatoes, sugarcane, soybeans, manioc, corn, wheat, tobacco and others, contributing about 10 per cent of the deforestation to date (Andersen et al., 2002). A subject that has been, and still is, widely debated, is to what extent deforestation is carried out by small-scale, subsistence farmer, and to what extent large-scale agricultural companies are the culprits.

As discussed above, early deforestation, in the 1970s and 1980s, was predominately caused by middle- and large scale cattle ranchers due to the government's preference for these projects and the fact that the ambitious governmental colonization programs for small farmers failed (Browder, 1988). The most convincing evidence that this is still the case is that new clearings are predominately larger than 15 ha, 82-90 per cent of new clearings in 1995-1999 according to INPE (2002). Small-scale farmers however, are only capable of clearing about 3 ha per annum using family labor (Fearnside, 2001a; Homma, 1998, cited in Cattaneo, 2002). With about 0.6 million smallholders in the Amazon clearing new land every 3 years this would amount to about 6,000 km^2 of clearing (Homma et al., 1998, cited in Cattaneo, 2002), or a maximum of 35 per cent of annual clearings in 1995-2000.

Even land clearings carried out by small scale farmers is very much driven by the demand for new land for cattle ranching. The common slash-and-burn agricultural pattern means clearing and burning a plot of land, cultivating annual crops until the nutrients in the ashes are used up and washed away, and then selling the land to a nearby ranch (Andersen et al., 2002). If the land were to be used again for cropping a fallow period of about ten years is usually required (Toniolo & Uhl, 1995).

But as pasture land is typically 2-3 times more valuable than uncleared forest (Andersen et al., 2002) the small-scale farmer can make a reasonable profit from the initial cropping when fertility on the land is high as well as a capital gain from the sale of the land. This means that subsidizing fertilizers, as suggested as a means to slow down deforestation, does not necessarily have the desired effect since land clearing is driven primarily by the demand for new land rather than the demand for nutrient rich soils (Vosti et al., 2002).

The cultivation of perennial crops, e.g. cacao, coffee, black pepper, bananas, could offer an alternative to the extensive slash-and-burn practices, decreasing pressures on the remaining forests and having many supplementary benefits: they are better adapted to the region and therefore less susceptible to pests, they are less perishable which gives smaller losses due to the lack of transport and storage facilities and the returns to land from these crops are much higher and sustainable over a longer period (Andersen et al., 2002).

For the small-scale farmer though, the cultivation of these crops presents some serious disadvantages. First of all the initial investment required is about ten times that for annual crops and often it takes more than one season to get a positive return (Andersen et al., 2002). Also the investment stands at risk of being burnt down by fires escaping from neighboring farmers practicing slash-and-burn agriculture (see discussion below). Finally these crops, contrary to annual staples like rice, beans and corn, cannot feed you if the need arises.

In contrast to the small-scale slash-and-burn practices of the forested, sparsely populated areas of the Legal Amazon, land clearing and cultivation on the *cerrados* are increasingly being dominated by highly mechanized and profitable large-scale soybean production. Brazil's soybean production has more than doubled in the latest decade, making it the world's second largest producer after the US. Almost all of the expansion in soybean cultivation has taken place on the *cerrados*, primarily in the state of Mato Grosso (Flaskerud, 2003). While both production and yields in the traditional soybean regions in the south have stagnated since the 1970s, they have increased rapidly in the Legal Amazon (Flaskerud, 2003). To a large part this is due to an ambitious governmental research program targeted at making soybean varieties better adapted to the poor and acid *cerrado* soils. Also a large part of the three latest federal pluriannual investments plans, *Brasil em Ação* (Brazil in Action), *Avança Brasil* (Brazil Forward) and *Brasil para Todos* (Brazil for the People), has been targeted at soybean infrastructure (Fearnside, 2001c).

This source of land clearing is different from small-scale agriculture, cattle ranching and logging (see below) in that it is primarily driven by the demand of a global market. The global soybean market has been increasing rapidly during the last decade. Primarily this is due to the emerging middle class in China demanding a more varied diet and thereby increasing the demand for soy meal to feed poultry and hogs (Rother, 2003). In the last decade China has gone from being a net exporter of soy products to become the world's largest importer (Rother, 2003; Fearnside, 2001c). This factor will also be crucial in the future expansion of soybean cultivation in the Brazilian Amazon.

3.2.3 Logging

As mentioned above the direct contribution of logging to deforestation in the Amazon has been limited. Especially before the 1980s logging activity was low owing to difficult access and very high species diversity, making commercial extraction of a certain variety of wood unprofitable (Andersen et al., 2002). Thus, up till the 1980s, the domestic demand for timber was met by logging in the more accessible settled areas of the Atlantic Forest (Lele et al., 2000). But as timber production in that area declined sharply in the 1970s and 1980s due to high levels of deforestation (less than 10 per cent of the original forest cover is left standing today) the pressure on Amazon forests rose (Lele et al., 2000).

Between 1975 and 1995 annual timber production in the Amazon increased from 7 million m^3 to 52 million m^3 (Andersen et al., 2002) and it is expected to continue to increase at a rate of 5 to 7 per cent annually (Lele et al., 2000). The bulk of this, 86 per cent, is consumed domestically and only 14 per cent is exported, constituting 4 per cent of the global market for tropical wood (Lele et al., 2000).

While the high-value timber destined for export is harvested from deep inside the forest, the timber feeding domestic demand generally comes from the agricultural frontier (Lele et al., 2000). 93 per cent of the production comes from the states in the arc of deforestation, Pará, Mato Grosso and Rondônia (Lele et al., 2000) where logging often follows a boom-bust cycle, quickly exhausting the resources in a region (Andersen et al., 2002). Although timber companies could log for free in most of the Amazon they are willing to pay farmers in the state of Pará about US$150/ha for the right to harvest timber on their lands (Andersen et al., 2002). This highlights the importance of market access for the timber producers as well as the synergies between logging and land clearings for cropping and cattle ranching.

The forest sector of Brazil is actually highly regulated, the law demanding environmental impact assessments, clearing permits, forest management and defining cutting restrictions (Lele et al., 2000), see box 4.1. Though, these regulations are often at odds with the regulations and policies promoting development in the Amazon and enforcement is weak. Thus, about 87 per cent of logging in the Amazon is carried out illegally (IBAMA, 2002). For a deeper discussion on this problem, see section 4.1.

Every year logging affects 10,000-15,000 km^2 of forest, an area in the same order as annual deforestation, albeit part of this area is subsequently cleared for pasture or cropping (Nepstad et al., 2001). As mentioned above, logging on forest lands prior to land clearing and burning increases the economic viability of the agricultural activity and in this way favors extensive agricultural practices and the expansion of the agricultural frontier. This process is also facilitated by logging roads giving access to new areas.

But logging also affect forest cover in undisturbed areas by reducing tree cover and making the forest more susceptible to surface fires. Current logging practices in pristine forests kills or damages 10 to 40 per cent of the living biomass and reduces leaf canopy cover with 14 to 50 per cent (Nepstad et al., 1999). This in turn allows sunlight to penetrate the forest floor, drying out the organic debris left from the logging. The reduced leaf cover also increases the risk of severe seasonal drought. Thus fires escaping from agricultural lands can easily penetrate the forests fragmented by logging, killing 10 to 80 per cent of the biomass left standing and increasing the risk for second and third burnings killing even more of the forest, see below. (Nepstad et al., 1999)

3.2.4 Forest fire regime feedbacks[6]

Historically, fire has been a rare event in most tropical forests (Cochrane & Laurance, 2002). The undisturbed, dense, high-canopy forests of the Amazon normally acts as effective fire brakes because of its remarkable capacity to absorb soil water at depths down to more than 10 m, thereby avoiding drought induced leaf-shedding. This situation has changed in recent decades though, as a result of forest fragmentation from agriculture, cattle ranching and logging, making forest fires a large threat to the future of the forests. The magnitude of this threat is amplified by social and biophysical feedbacks further increasing the forest's susceptibility to surface fires.

The first feedback is a social one. The same economic rationale that makes large-scale cattle ranching and small-scale agriculture in the Amazon rely on fire as the primary land management tool, i.e. shortage of labor and capital, also makes fire control scarce. Landowner seldom has the incentive or resources to pay labor for the preparation of firebreaks or organize fire brigades to hinder the spread of fire from their lands when they are (re)burnt. Subsequently a large part of accidental fires on agricultural and pasture lands originates from escaping fires from neighboring lands. Thus, a prisoners dilemma situation occurs where a single landowners investment in fire protection is at risk of being lost if his neighbors do not take the same precautions. Also this enforces the dependence on extensive activities such as cattle ranching, annual cropping or high-impact logging since investments in more intensive land-uses such as perennial crops or forest management stands at the chronic threat of destruction from fire escaping from neighboring lands.

[6] This section builds upon work by researchers at the Instituto de Pesquisa Ambiental da Amazônia (IPAM), Brazil, presented in Nepstad et al. (1999; 2000; 2001)

The second feedback regards the effect surface fires have on a logged or fragmented forest cover. Logging and fragmentation increases the forests susceptibility to surface fires by opening up the canopy, permitting sunlight to penetrate to the forest floor drying it out, especially then dead biomass left as a result of the logging activities. Fire escaping from neighboring agricultural lands can then spread into the forest. Although the initial surface fire seldom is impressive, spreading as a thin, slowly creeping ribbon of flames, maybe not more than a few tens of centimeters in height, consuming little more than leaf litter (Cochrane & Laurance., 2002). But the trees in the Amazon, having very thin bark, are relatively sensitive to fire and even if the first surface fire in an area only kills part of the trees this further opens up the forest for sunlight and increases the amount of combustible material on the forest floor. Thus the likelihood of a second fire, having more severe consequences, increases; fire begets fire.

This situation has been worsened in the last 15 years as a consequence of the more frequent El Niño episodes, giving rise to severe droughts in the Amazon, which in itself provoke leaf shedding, opening up of forest canopy and increasing forest flammability. Nepstad et al. (1999; 2000) estimate that in half of the Amazon forests soil water was exhausted to a depth of 10 m during the severe drought following the 1997-98 El Niño episode. As a consequence maybe as much as 15000 km^2 of forest burned in the Amazon state of Roraima alone. The extent of droughts can also be exacerbated by a third feedback factor, concerning local climate impacts of forest degradation.

The climate of the Amazon is closely tied to the forest cover. The forest heats up the air above it by absorbing solar irradiation and releases water vapor through evapotranspiration, forming cumulus clouds which in turn release the water as rainfall. This way seven trillion tons of water is recycled by the forest annually. By substituting forest cover for pasture, crop fields and secondary regrowth, cattle ranching, slash-and-burn agriculture and surface fires decreases evatranspiration and absorption of sunlight, thereby inhibiting the formation of cumulus clouds and subsequent rainfall. Again this serves to increase the probabilities of droughts and subsequent fires, amplifying the strength of the initial processes. Nepstad et al. (1999) estimate that the amount of forest affected by surface fires are in the same order of magnitude as the amount of forest cleared for pasture and cropping.

3.2.5 Mining, Hydro-dams and Roads

As explained above, road construction is a very important indirect cause of deforestation, since it opens up virgin areas to settlement. Historically two thirds of deforestation has taken place within 50 km of major paved highways (Nepstad et al., 2001). It is thus understandable that the latest governmental investment plans in the Amazon, that has emphasized infrastructure development, has caused an intense debate, see box 3.1. Apart from logging, mining activities and construction of hydro dams are activities that have minor direct effect on deforestation but that have an indirect effect by providing access to virgin areas.

The Amazon holds deposits of gold, bauxite, tin, copper, uranium, among many other minerals, with a accumulated value estimated at US$3 trillion (Andersen et al., 2002). Still, mining is probably one of the most intensive land uses possible in the Amazon and is therefore responsible for little direct deforestation. Hoppe (1992) estimates that no more than 4,500 km^2 of forest has been cleared in connection with mining activities.

Mining is pursued either by small-scale, placer miners (*garimpeiros*) or by government supported mining corporations, performing large-scale, highly mechanized mining. The main environmental effect of the latter probably is disruption of soils and the siltation and pollution of rivers. However, even if mining activities result in only little direct deforestation it may have been the source of much deforestation around the mineral growth poles of the Legal Amazon, mainly in the state of Pará. (Andersen et al., 2002) Also, the extraction of bauxite for aluminum production has caused deforestation due to the hydroelectric dams constructed to supply electricity to the smelters.

Because of the relatively flat contour and wide flood plains of the Amazon rivers, the area flooded and subsequently the environmental impact, is hard to limit. The four largest dams in the Amazon, with a total installed capacity of 7,200 MW, has flooded a total area of 5,537 km^2 (Andersen et al., 2002). These dams were all completed in the 1970s and 1980s and due to the increasing reliance on natural gas and public opposition against dams, there have been little prospects for further large-scale dam projects. Still, the latest pluriannual investment plan proposed by the Lula administration, Brasil para Todos (Brazil for the People) (see box 3.1), includes a US$8 billion investment in the 11,800 MW Bela Monte Hydroelectric plant at the Xingu river, originally planned in the 1970s.

Box 3.1: *Avança Brasil* and *Brasil para Todos*

Following the economical recovery in the late 1990's government interest in large scale development plans for the Amazon region surfaced again. As a result of this the federal government presented the *Avança Brasil* (Brazil Forward) program, an investment plan targeted at development in the Amazon region, enhancing equality and creating a more united and homogenous country (Andersen et al., 2002). The ambitious plan calls for investments in the order of US$45 billion in the region over an eight year period, 2000-2007, about a third aimed at the northern parts of the region (Acre, Amapá, Amazonas, Roraima and most of Pará) and two thirds at the states in the arc of deforestation (Rondônia, Mato Grosso, Maranhão, Tocantins, the eastern parts of Pará). Though a third of the funds are supposed to aid social development projects in the areas of health, education, housing, water and sanitation, and 5-8 per cent environmental projects, the nexus of the debate over *Avança Brasil* has been the bulk of the budget targeted at large-scale infrastructure projects (Andersen et al., 2002).

The infrastructure plans emphasizes road improvements (paving), river channeling, port improvements and expansion of energy production, see figure below (Carvalho et al., 2001; Andersen et al., 2002; Cattaneo, 2002). If implemented the plan will increase the total length of paved roads in the region by about 6,200 km (equivalent to about a 50 per cent increase), though almost all of this increase will be from paving of existing, unpaved roads, rather than the construction of new roads (Nepstad et al., 2001; Andersen et al., 2002; Cattaneo, 2002). Still, this would for the first time give all-weather access to the core region of the Amazon, for example through the BR-163 Santarém-Cuiabá and BR-319 Humaitá-Manaus highways cutting through 1,800 km of sparsely populated forest, see figure below (Nepstad et al., 2001; Cattaneo, 2002). The prime reason for these investments is to provide access to markets for producers of agricultural products, i.e. soybeans, corn and grains (Nepstad et al., 2001; Cattaneo, 2002). They are also intended to facilitate the process of integration with neighboring countries as envisaged in the Mercosul trade agreement (Nepstad et al., 2000; Cattaneo, 2002).

The *Avança Brasil* plan, put forward by the Cardoso administration, was superseded by the new Lula administrations Brazil para Todos (Brazil for the People) plan. This investment plan contains more or less the same infrastructure projects as the *Avança Brasil* plan, although more focus has been laid on environmental assessment plans and environmental zoning along the roads to be paved, especially along the BR-163 Santarém-Cuiabá road. In particular this has been emphasized in response to latest years high deforestation rates.

What one should also keep in mind in the discussion around these plans is that they have been on the drawing board for a long time and that they more reflect a will of the government than concrete plans that will be realized. Still this situation might be changing as private enterprises, primarily soy-producers, are saying that they are willing to contribute with funding for the construction of some of the roads.

To what extent these investments, would they become reality, will affect future deforestation rates is an issue that has been widely debated. In a much cited article in *Science* Laurance et al. (2001)[1] asserted that the planned infrastructure investments could lead to deforestation rates accelerating with 2,700-5,000 km^2/yr in the next 20 years, following a non-optimistic and an optimistic scenario.

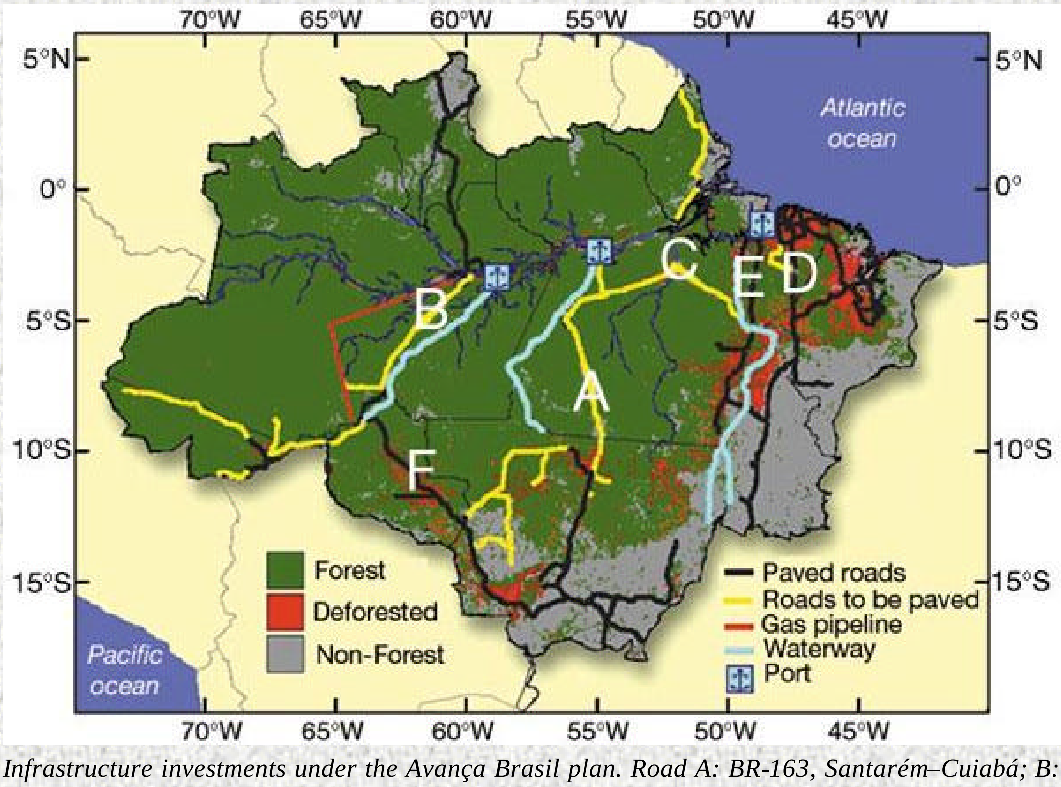
In addition the moderate or heavy degradation of forest areas could increase by as much as 23,700 km^2/yr. As a consequence about 28 to 42 per cent the area would be deforested or heavily degraded by the year 2020 in the optimistic and non-optimistic scenario respectively (Laurance et al., 2001: supplementary material).

Based on a similar approach, estimating future deforestation rates from the historical relation between highway paving and deforestation, Nepstad et al. (2000, 2001) calculated an increase in deforestation rates of 4000-9000 km^2/yr or a consequent additional land clearing of 120000-27000 km^2 over the next 25-35 years. Cattaneo (2002) reached similar conclusions, cumulative deforestation increasing by 160000-240000 km^2 or rates by 8000 km^2/yr, when decreasing transportation costs in an econometric model of land clearing in the Amazon by 20 per cent.

In stark contrast to these predicted increases in deforestation rates following the implementation of the *Avança Brasil* plan Andersen et al. (2002), also building upon an extensive econometrical analysis of historical deforestation rates, infer a decrease of accumulated clearing in ten years by 15600 km^2. The reason for these contrasting conclusions is the assumption regarding the relation between road paving and deforestation. As mentioned above the Laurance et al. (2001) and Nepstad et al. (2000; 2001) calculations both rely on the historical relation between road construction and deforestation, not reflecting chances in factors such government subsidies and settlement programs or the enforcement of environmental regulations that have changed over time (Andersen et al., 2002).

The logic behind the lowered deforestation rates in the Andersen et al. simulations is that the improvement of existing roads, contrary to new roads through pristine areas, will tend to drive up land prices, thereby encouraging intensive land uses and discouraging extensive uses such as cattle ranching (Andersen et al., 2002). On the other hand the relationship between road construction and land clearing observed in the Andersen et al. model, where unpaved roads have larger impacts than paved, may not hold for the projects under *Avança Brasil* since these road improvements take place in large municipalities with relatively little cleared land, as opposed to the historical paving (Andersen et al., 2002).

This discussion gives an insight to the difficulties in providing a credible baseline for future deforestation rates, an issue elaborated in section 4.2.



Infrastructure investments under the Avança Brasil plan. Road A: BR-163, Santarém–Cuiabá; B: BR-319, Humaitá–Manaus; C: BR-230, Marabá–Rurópolis; E: BR-010, Belém–Brasilia; F: BR-364, Cuiabá–Porto Velho. Taken from Carvalho et al. (2001).

4 Analysis – Brazil, LULUCF-emissions and Future Commitments

The aim of section is to synthesize the knowledge of the previous chapter in order to assess what requirements the participation of Brazil in an international climate regime puts on the design of that regime. This is done from three main perspectives. First we discuss what the prospects of the inclusion of deforestation in the Brazilian Amazon in an international carbon market would have in decreasing deforestation rates. Secondly we analyze how the uncertainty in emissions baseline may affect the integrity of the climate regime, i.e. how will choosing the wrong baseline affect the amount of carbon credits available on the global carbon market. And thirdly we explore what demands the inclusion of emissions from LULUCF activities in the Brazilian Amazon put on the carbon accounting system.

4.1 How Will Deforestation Rates be Affected by a Global Carbon Market?

Given the attention that the contribution of avoided deforestation in the Brazilian Amazon could have in curbing global warming, relatively few systematic analyses on how deforestation rates would be affected by a price on carbon emissions has been presented. Most articles stops at calculating the total revenue that Brazil would earn if the country would be paid for stopping deforestation or comparing the possible benefits from carbon credits with the observed prices of land, which is generally low (e.g. Fearnside, 2001a; Schneider, 1993).

However, this may not be an adequate comparison in a region where land is abundant but where labor and capital is scarce. Rather, a more illuminating approach is to look at net present value (NPV) of the stream of revenues to the farmer from land clearing and subsequent cultivation. Table 3 shows some estimations of this value of land depending on the use. As can be seen the NPV of traditional, extensive, cropping is in the order of US$800/ha. The potential economic gains from a transition to more intensive cultivation of perennial crops are also obvious.

These values can be compared with the cost of clearing in the presence of a tax on emissions on CO_2 emissions from land clearing. Using the methodology presented in Appendix B, we have calculated the NPV of the tax paid by the land owner in the case of the clearing of one hectare, for different land types and at different taxes and discount rates. The cost of clearing dense and non-dense forests is in the same order of magnitude as the NPV of extensive cropping for the US$5/tC tax rate but many times larger in the high tax rate case. This clearly indicates that even a low carbon tax, at least theoretically, could act to protect the forests of the Amazon from this source of deforestation[7].

However, the question is what effect the introduction of a carbon tax alone would have in practice? This will be determined by at least two other factors: the design of the carbon pricing scheme and to what extent the government will be able to halt deforestation with policies and enforcement.

An alternative to the carbon tax system, providing a disincentive to clear land, is to do the opposite, create an incentive to preserve land by compensating land owners for the carbon they store on their lands. This way of paying for avoided deforestation has some major drawbacks. The first is how to create a credible baseline. Given the number of forces driving deforestation and their complex interactions this is close to impossible. This clearly increases the risk of moral hazard (Schneider, 1993), i.e. landowners claiming and threatening to clear land that would otherwise not have been cleared in order to get revenues. Secondly there is no way of assuring that a land owner that is paid to preserve the forest for a period of time does not cut it down later, i.e. the issue of permanence.

The third important issue is how to deal with leakage, i.e. the risk that protection of an area of forest simply has the effect of locally displacing the deforestation. Given the abundance of land in the Amazon this most certainly will be the result in most preservation projects. This is also most likely the

[7] Although, soybean cultivation that has primarily expanded on the cerrados, lands that may be harboring as much biodiversity as the forests, will probably be affected by a carbon tax to lesser extent because of the lower biomass content of the land and the much higher returns to land from the intensive cultivation.

Table 3: *Different estimations of net present value (NPV) of land uses in the Brazilian Amazon compared to the cost of land clearing in the presence of a carbon tax.*

	Net present value of land use (US$/ha)		
Study / Discount rate:	6%	9%	12%
Almeida & Uhl (1995)			
Ranching – extensive	-290		-280
– intensive (improved pastures)	520		-8
Agriculture – extensive (slash-and burn)	650		380
– intensive (perennial cropping)	13,500		6,000
Andersen et al. (2002)			
Rural benefits from clearings 1985-1995	800	-	400
Carpentier et al. (2000)			
Agriculture – extensive (slash-and burn)	-	850	-
	Carbon tax cost of land clearing (US$/ha)		
Carbon tax US$5 – 20 per tC [a]:			
Dense forest	1,100 - 4,300	990 - 4,000	920 - 3,700
Non-dense forest	900 - 3,400	830 - 3,300	780 - 3,100
Non-forest	410 - 1,600	370 - 1,500	350 - 1,400

[a]Calculated using the methodology described in Appendix B, adopting the high forest biomass estimation from Fearnside (1997) displayed in table 8 and excluding secondary regrowth, the latter making this an overestimation of the total tax payment.

case with the different conservation units existing today, national forests, extractivist reserves and indigenous lands, reserves that to a large extent are respected (Thelma Krug, interview).

Finally, another major drawback is the enormous sums of money needed to finance the system if it is to have an effect on aggregate deforestation rates. Still, this approach can of course be successful in preserving areas of special interest and value. But to reduce total deforestation rates a carbon compensation scheme is not an attractive option.

But what would be the effect of a carbon tax? If enforced it would seriously affect the possibility for small-scale farmers in the region to earn a living. This would probably lead to an upsurge in illegal land clearing from this group of farmers since it does not come to terms with the underlying forces driving deforestation, providing an alternative to today's land use pattern. As mention in section 3, land use activities in the Brazilian Amazon are highly regulated. The Brazilian forest code, dating back as far as 1965, is considered one of the world's best. For an introduction to this legislation see box 4.1. However, there is a clear mismatch between the legislation on the book and its implementation in the Amazon region, for a number of reasons.

Although the public policy has shifted from being supportive of deforestation to a strong support for the curbing of deforestation, the major obstacles against realizing reduced deforestation by public policies are lack of resources for enforcement and corruption. Another important problem is the large sovereignty of the Amazonian states. These states have the possibility adopting its own legislation, complementary or even concurrent to the federal legislation (IBAMA, 2002).

As powerful state politicians, governors, senators and congressmen, often represent the local economic powers, i.e. logging companies, cattle ranchers, soybean producers etc, local policies often run opposite to any will of the federal government to reduce deforestation rates. Also, because of the way the 1988 Brazilian constitution was written, all states has a minimum of eight representatives in congress and three senators. This means that the interests of the Amazon states, with small populations, are overrepresented in the Brazilian federal legislative forum (Fabio Feldmann, interview; Viola & Leis, 2001).

An illustration of this conflict between the federal governments will to reduce deforestation rates and the economic interests of the ruling elites of the Amazonian states are the conflict over the provisional measure issued by the presidency in response to the high deforestation rates of 1995, raising the share of legal reserves on private lands (see box 4.1). In order for this provision to become law the congress instituted a joint parliamentary commission, composed of eight senators and eight congressmen. The result of this commission was a proposal, not endorsing the strengthening of the forest code in line with the provisional measure, but clearly weakening the legislation by drastically reducing the area of the legal reserve, giving amnesty to landowner that had not complied with the law in earlier years, enabling silviculture using exotic species (e.g. eucalyptus and pine) in primary forest lands, making it easier to clear land under permanent protection etc (IBAMA, 2002). In the words of IBAMA this proposal, if adopted, would "transform an environmental protection law into a law of incentives to the expansion of the agro-pastoral sector" (IBAMA, 2002). Although this proposal was not passed as a law, neither has the provisional measure of 1996.

Although the traditional forest conservation policies have relied on traditional command and control legislation, market based instruments are playing an increasing role, see box 4.1. One such future instrument could of course be a tax on carbon emissions, either on a national scale or as a part of an international carbon market. As mention earlier this is an issue that has received ample attention, to date most intensely in connection with the issue of including avoided deforestation under the CDM.

What one has to bear in mind when contemplating the prospect that a price on carbon could help reducing deforestation rates is that this type of policy instruments demands even more stabile and well-functioning institutions than the traditional 'command & control' instruments. As should be evident from the discussion in section 3 and above this is far from being the case in the frontier areas of the Brazilian Amazon. This is probably one of the main issues that Brazil has to tackle if the country is to come to grips with the deforestation problem.

If a carbon tax is to have an effect on the practice of slash-and-burn agriculture it must be complemented with policies targeted at reducing risk and providing credits to farmers, enabling them to shift to more intensive and profitable land uses such as perennial cropping. Apart from the environmental benefits in focus here this would also facilitate economic development in the region.. Thus, from this perspective it is unlikely that a carbon tax alone would have any significant effect on deforestation rates.

To sum up, the picture that emerges is that the current trend of land use and land clearing in the Amazon is very stable and hard to affect in the short term by policies, even though the political will exist both in the society as a whole and in the federal government. The main reasons behind this is lack resources for the enforcement of existing legislation, corruption, strong economic interests in the states favoring continued deforestation, leading to conflicts between federal and state institutions, and a constitution that makes these interests strong representation in the Brazilian senate and congress. This view of deforestation in the Amazon as more or less 'out of control' is endorsed by the people in academia, government and NGOs interviewed in Brazil and whose views are presented in section 5.

The conclusion that can be drawn from this is that it is very hard to estimate the effect that the introduction a tax on carbon emissions from land clearing could have. These findings of course have large implications for the willingness of the Brazilian government to accept emission targets for CO_2 that include emissions from land use change in the Amazon, or at least making them accept emission targets based on a low baseline of deforestation, an issue discussed more in depth in the following sections.

Box 4.1: Current legislation regarding land use in the Brazilian Amazon

In article 225 of the 1988 Brazilian constitution it is stated that the Amazon is considered a national property of which any utilization must guarantee the conservation of environmental services and natural resources (Porru, 1996). The main legislative instrument in place to meet this overarching objective is the country's federal forest code, initially adopted in 1965. This law originally required that 50 per cent of original forest cover on private lands in the Amazon should be kept as a *legal reserve*.

In response to the record high deforestation rates of 1995 this law was amended by a provisional measure the following year, differentiating the size of the legal reserve by region, setting it to 80 per cent in the Amazon forest region and 35 per cent in the cerrados (Brazilian savanna). In addition to the legal reserves, all vegetation on riverbanks, around lakes, on steep sloops or on hilltops, is protected by law as *areas of permanent protection* (APPs) (Lele, 2000). Also, any logging is legally dependant on the authorization of IBAMA, following the submission of a *forest management plan*.

Apart from these regulations of land use on private lands, around 1 million km^2 in the Amazon, or about a fifth of the total area, is protected through national forests (35 areas covering 166,000 km^2), extractivist reserves (36 areas covering 80,000 km^2) and indigenous lands (189 areas covering 832,000 km^2) (IBAMA, 2002).

As evident, the legislation regarding land use in the Amazon has historically relied primarily on 'command & control' measures. New instruments are evolving though, more based on creating market incentives for conservation, e.g. a Tradable Development Rights scheme and Private Natural Heritage Reserves (RPPN).

The Tradable Development Rights scheme allows landowners to exceed the area of legal reserve for agriculture on one property if an equal area is protected in another property. The RPPN tries to create incentives for private land-owners to create protection areas by offering them economic incentives such as tax exemptions for this land, having priority in obtaining resources from the National Environmental Fund and easier access to credits for agricultural activities outside the RPPN. About 150 RPPNs had been established as of 1998, covering an area of about 3,400 km^2 (MMA, 1998).

Other initiatives to increase the amount of forest protected by law include the ICMS Ecológico. In this system six states (Paraná, Sao Paulo, Minas Gerais RO, RS, MS) allocate the part of funds from the Brazilian VAT to municipalities that create conservation areas.

4.2 Emission Baseline Uncertainties and the Integrity of an International Climate Agreement

In Appendix B we present high and low estimates of emissions deforestation in the Brazilian Amazon and from the Brazilian energy sector up to year 2020. These estimates are of course highly uncertain and should not be seen as scenarios or predictions of future emissions. Rather, we will use these estimates to analyze how the uncertainties in baseline emissions, especially regarding emissions from future land use change, play out under different allocation principles.

The emission estimates from deforestation are based on the minimum and maximum of a five year moving average of deforestation rates in the Brazilian Amazon during the period 1988 to 2002. The reason for looking at the five year average is that this is the time period equal to the first commitment period of the Kyoto protocol. This gives a low deforestation rate of 13,700 km^2/yr and a high deforestation rate of 19,300 km^2/yr, which is extended up to 2020. The underlying uncertainty in forest biomass is also included by calculating the emission using both a low (Andersen et al., 2002) and a high (Fearnside, 1997) estimate of biomass.

It should be noted that even the high deforestation rate is relatively conservative, leaving almost 75 per cent of the Amazon's forests standing in 2020, which is what Brazil's Ministry for Science and Technology has publicly admitted they expect (Laurance et al., 2001, dEbate).

For the energy sector we use the high and low growth EIA (2003) scenarios to illustrate the uncertainty in the baseline CO_2 emissions. We then combine these estimates to yield a high and a low estimate of future Brazilian CO_2 emissions in absolute, per capita and per BNP terms respectively. These are shown in table 4, together with the value of these indicators in year 2000.

Table 4: *Estimates of CO_2 emissions from deforestation in the Brazilian Amazon (based on the high biomass estimation, see text) and from the Brazilian energy sector in 2020, reflecting the uncertainties future emissions. The absolute and per capita emission estimates are a result of a combination of the low(high) deforestation rate and low(high) economic growth scenario. The CO_2 intensity on the other hand reflects a combination of high deforestation rates and low economic growth in the high estimate and vice versa for the low estimate.*

	Deforestation (MtC)		Energy sector (MtC)		Total (MtC)		Per capita (tC/cap.)		Intensity (tC/'000US$)	
	Low	High	Low	High	Low	High	Low	High	Low	High
2000	254		84		338		2.0		0.28	
2020	161	259	150	203	311	462	1.5	2.2	0.11	0.19

Now, assume that Brazil would participate in an international climate agreement with a binding, fixed, target. Choosing the high estimate as the basis for Brazil's commitment could seriously undermine the integrity of the agreement if real emissions turn out to follow the low estimated path. If Brazil would be given emissions rights equal to the high estimate minus some decrease in emissions they would end up with up to 150 MtC per year in hot air to put on the international carbon market.

This situation is aggravated if an intensity target is set based on a high baseline for the intensity, i.e. low economic growth and high deforestation rates, and the opposite occurs. In such a situation Brazil could gain up to 230 MtC in windfall credits to put on the global carbon market. For the energy related emissions on the other hand, an intensity target reduces the risk of setting the wrong target, decreasing the uncertainty to about 20 MtC.

On the other hand, if a low estimate of absolute emissions or intensity is chosen as baseline for the Brazilian target, the country could end up in a situation where they would have to buy carbon credits in the same magnitude to cover their emissions. This uncertainty in baseline is of course exactly why developing countries have been so reluctant to discuss binding target since choosing the wrong baseline could turn out to put a serious strain on economic development.

Figure 4 displays how this uncertainty in a future emissions reduction target is divided between underlying uncertainties in deforestation rates and energy related emissions. As can be seen the greatest share of the uncertainty stems from uncertainty in deforestation rates and this uncertainty is augmented by the uncertainty in forest biomass, especially in the intensity target case.

This uncertainty in a future target for Brazil can be compared with the mitigation needed to comply with the Kyoto target for the EU in 2010, i.e. the difference between estimated baseline emissions and the Kyoto target, amounting to about 135 MtC (Persson & Azar, 2003). The corresponding figure for the US is about 410 MtC (Persson & Azar, 2003). Thus an overestimation of Brazil's baseline emissions in line with the uncertainty range estimated here runs the risk of undo a large part of emission reductions that would otherwise occur in other regions.

4.3 Treatment of Land Use Change & Forestry (LUCF) Emissions

In this section, we review three proposals to handle changes in terrestrial carbon stocks in a future international climate agreement. The focus will be on what implications different carbon accounting

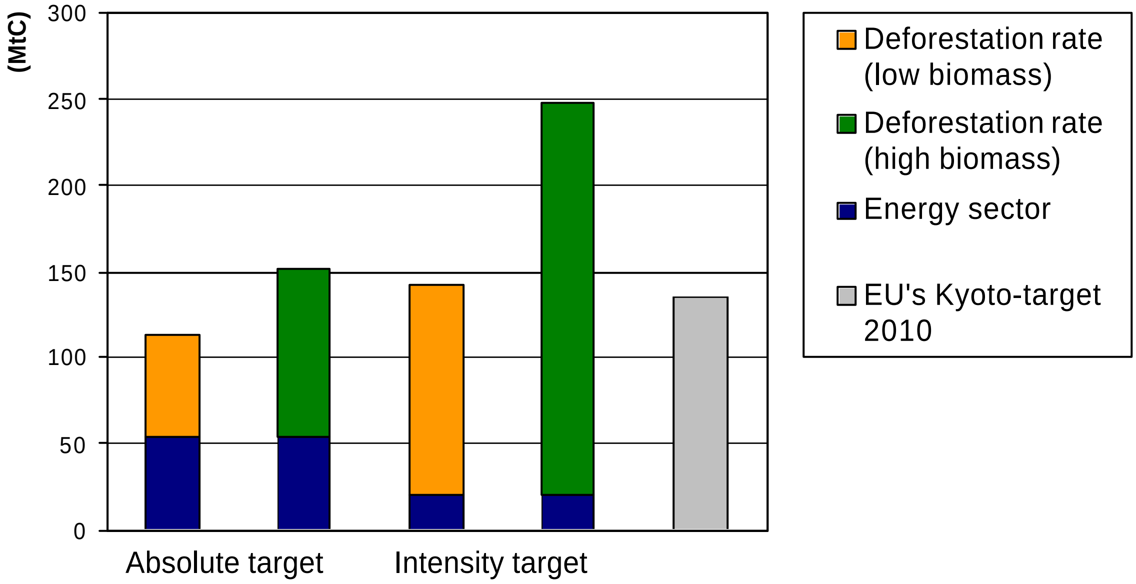


Figure 4: *Uncertainty in Brazil's emission reduction target in 2020 under two allocation principles, fixed target and intensity target, see text for explanation. The uncertainty is divided into uncertainty attributed to energy sector emissions and deforestation baseline. Also two estimations based on different assumptions of forest biomass is shown to reflect this underlying uncertainty. An estimate of the emissions reduction needed in the EU to reach the Kyoto target is also shown for comparison (taken from Persson & Azar, 2003).*

systems will have if Brazil participates with binding commitments and on how to handle emissions from deforestation, i.e. we will not in detail discuss question regarding afforestation, reforestation and the management of forests and other lands. Although the focus here is on Brazil many of the points raised will be the same for other countries with a large share of its emissions from LULUCF activities.

The proposals discussed range from the inclusion of all changes in terrestrial carbon stocks, an approach generally referred to as full carbon accounting, to the proposal of a separate 'sinks protocol', completely separating LULUCF emissions from energy related emissions. In-between these two proposals at different ends of the spectra, we discuss a Kyoto-styled compromise, with and without binding commitments for LULUCF emissions for Brazil.

One basic dilemma that runs through this discussion is that the inclusion of LULUCF emissions in a climate agreement runs the risk of compromising the environmental integrity of the regime, reducing the pressure to decrease emissions from the energy sector, while exclusion of LULUCF emissions eliminates a not insignificant, low cost, possibility to mitigate climate change and leaves the protection of the worlds forests to other international regimes that are less powerful.

Thus, people may draw different conclusion from this discussion based on the underlying views one has of what an international climate agreement should ultimately achieve. Proponents of full carbon accounting may see a climate agreement, not only as a response to global warming, but in a wider context, as a tool in the work for sustainable development. They thereby may put more emphasis on the prospect of a climate regime protecting virgin forests than the fact that decreased LULUCF emissions are offset by increased energy related emissions. On the other hand, people that see a climate agreement solely as a tool for mitigating climate change, where the transition to a carbon neutral energy system is decisive, may put more emphasis on the potential risk of compromising the reduction of emissions in the energy sector the inclusion of these options has.

4.3.1 Full Carbon Accounting

The main arguments for full carbon accounting are two: completeness and simplicity (e.g. separability issues are avoided). The fact that the atmosphere does not distinguish human-induced emissions of GHGs from natural emissions is used as an argument for the inclusion of all terrestrial sources and sinks (Graßl et al., 2003). Thus, the aim of FCA is to create an incentive to utilize all possible options of mitigating climate change by the active manipulation of terrestrial sources and sinks, e.g. conserving existing carbon stocks, increasing sink capacity by afforestation and reforestation and reducing agricultural emissions of GHGs (e.g. Bonnie et al., 2002; IGBP, 1998)[8]. Still, as there is no point in including sources and sinks that cannot be affected by human activities the completeness argument actually works against the FCA approach.

The second argument in favor of FCA is that it avoids the complicated issue of separating the direct and indirect effects of human activities from the effect of natural factors on the terrestrial carbon balance (Graßl et al., 2003; Jonas et al., 1999). Although this may be the strongest argument in favor of FCA, it may also be its greatest weakness. The reason for this is that the countries participating in an international climate agreement with FCA are held accountable for all emissions that occur within their boundaries, irrespective of their cause.

For Brazil this would have a couple of important implications. First of all one has to deal with the large interannual variations in the carbon balance of the Amazon. These may be in the order of 900 MtC, or some 10 times the country's annual emissions from fossil fuel use. The difficulty of constructing baseline for these emissions would seriously undermine Brazil's will to accept legally binding emission targets since it will be held accountable for emissions that are largely beyond the country's possibility to influence.

Secondly, in a FCA system countries will also be held responsible for emissions that occur as an indirect consequence of the actions of other countries. For Brazil this could mean that more frequent El Niño episodes, a possible effect of climate change, could lead to large increases emissions due to droughts and fires[9]. Other studies show that there is a risk that the whole Amazon is converted to savannah due to increase in temperatures and decreases in precipitation, which of course would lead to huge emissions of CO_2 (Cox et al., 2000). Making Brazil accountable for these emissions would again make little sense and would seriously undermine the country's will to take on binding emission targets[10].

Thus, to secure the stability of an international climate agreement with FCA, one would have to deal with the issues of which emissions the parties should be held responsible for. For example, countries could have the right to seek permission from an international board of experts to exclude the emission debits resulting from large natural emissions, or emissions resulting from climatic effects. Still, this would imply that even in a FCA one cannot avoid the complicated issue of separability. Thus, one has lost the main argument in favor of FCA and the issue of accountability will still create a disincentive to participate in the climate regime, or will at least make parties less willing to accept strict targets.

4.3.2 A Kyoto Styled Compromise…

The results of the Kyoto protocol negotiation process has been a focus on human induced changes in terrestrial carbon stocks, through afforestation, reforestation and deforestation (article 3.3), and management of terrestrial carbon stocks (article 3.4). During the process was explicitly stated that countries should not be able to gain carbon credits from the mere presence of forests[11], a response

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[8] The economic equivalent of this argument is that the complete coverage of GHG sources and sinks has the potential of lowering the total cost of meeting a certain climate target since measures can be implemented where costs per tC-equivalent in abated emissions are cheapest. However, one also has to include the monitoring and verification costs associated with LULUCF activities, which are likely to reduce the economic gains.

[9] This sensitivity of the terrestrial carbon sink, varying between 0.2 and 1.4 ± 0.7 GtC per annum in the 1990s (Schimel et al., 2001), to climatic factors could create large problems for more countries than Brazil, would a FCA system be adopted. As an illustration see the historical relation between El Niño events and increase in atmospheric CO_2 in (Graßl et al., 2003, pp. 47).

[10] The mirror image of the argument is that countries should not be able to acquire windfall credits from an increased terrestrial sink due to e.g. CO_2-fertilization, longer growth season or other climatic factors.

[11] Although the inclusion of forest management under article 3.4 could be seen as a violation of this principle.

specifically aimed at disqualifying the attempts of the Amazonian states to gain carbon credits from preservation of the rainforest (i.e. avoided deforestation) (Thelma Krug, interview).

Thus, for Brazil a Kyoto-styled compromise would avoid the problems of accountability under a FCA approach as discussed above, since the variability in natural emissions would not affect the reported emissions. However, a Kyoto-styled system puts high demands on the ability to factor out the human influences on carbon stocks. One would thus have to deal with the indirect human impacts, such as the effect of climatic change on the carbon stocks in the Amazon, as discussed above. Also, interactions between e.g. selective logging and climate induced droughts makes it very difficult to factor out the share of emissions resulting from human intervention.

The largest drawback with a Kyoto-styled compromise, would Brazil get binding commitments, is the probable reluctance of the country to accept binding commitments for emissions over which they perceive they have little control. If they are to accept commitments for the emissions from deforestation, they will probably have to be based on a high baseline, and thereby one runs the risk of flooding the international carbon market with “tropical hot air”, as discussed above.

Another uncertainty with a Kyoto based accounting system is how LULUCF activities that fall under article 3.4., especially forest management, will be handled if Brazil get commitments. On the one hand Brazil has an extensive forest fire surveillance program that it could be argued that they should be given credits for. On the other hand you have the synergies between selective logging and climate induced droughts that some argue give rise to huge emissions annually (e.g. Nepstad et al., 1999), while other estimate these emissions to be minor (Thelma Krug, interview).

4.3.3 …with Non-Binding LULUCF Emission Targets

One way to avoid the problem of a generous allocation of carbon credits to Brazil to cover emissions from deforestation, as discussed in relation to the Kyoto-styled compromise above, would be to separate these emissions from the energy related emissions. One could then set binding targets for the latter emissions, where it is possible to create a credible baseline and over which the federal government have more control. For the LULUCF emissions one could set a non-binding emission target. This would make it easier for Brazil to accept a low target, since they will not be held responsible if they are not able to reduce deforestation enough to meet the target. Thus, one would minimize the risk of creating “tropical hot air” while maintaining an incentive to reduce deforestation rates.

4.3.4 A Separate Sinks Protocol

To avoid the problems associated with offsetting changes in terrestrial carbon stocks against fossil carbon emissions, it has been proposed that one should adopt a separate protocol for the protection of terrestrial carbon stocks (Graßl et al., 2003). This way of treating two separate sources of greenhouse gas emissions, with very different characteristics when it comes to e.g. variability and verifiability, could simplify the negotiations of the climate regime and make the resulting protocols more adapted to the specific circumstances regarding the different emission sources.

A separate sinks protocol would also mean that ecosystem services other than carbon storage could be given a value, e.g. biodiversity, watershed protection, erosion control and local climate protection. For example, the Brazilian *cerrados*, harboring as much biodiversity as the tropical forest and at current threat of soybean expansion, that would be less protected by a carbon tax alone because of the lower biomass content and the high returns to land from the intensive cultivation, could be protected by such a regime.

The weakness with this proposal is that a separate sinks protocol runs the risk of becoming a much weaker instrument, as has been the case with the Convention on Biological Diversity. The reason for the widespread hope that an emerging global carbon market could save the Brazilian Amazon, would avoided deforestation be included in some mechanism, of course lies in the money in this market. Thus, for a separate sinks protocol to have an effect on deforestation in the Brazilian Amazon it is crucial that funds are created to give some muscle to the regime.

For Brazil, separating out LULUCF emissions would certainly increase the possibility of the country accepting emission targets for the energy sector. This is because of the perception that deforestation rates are very hard to affect and the conviction that deforestation is a national affair and should remain so. Consequently, Brazil would most likely be reluctant to sign a separate sinks protocol.

4.3.5 Synthesis

The main arguments put forward for and against the different carbon accounting systems above are summarized in table 5. The conclusion that we draw from this discussion is that the most promising option seems to be adopt non-binding commitments for emission from deforestation in the Amazon. Such a solution would protect the stability and environmentally integrity of the climate regime, make it easier for Brazil to accept commitments while at the same time creating an incentive for the Brazilian government to reduce deforestation rates.

5 Results from Interviews with Brazilian Representatives

In this section we present the Brazilian views on some of the above discussed matters, as expressed by 13 representatives of the Brazilian government, academia and NGOs, in interviews carried out in Brazil in March, 2004. The results of these interviews are here grouped around two main issues, Brazil and the climate change issue, and the issue of deforestation in the Brazilian Amazon.

5.1 Brazil and Climate Change

5.1.1 The Domestic Debate - Stakeholders and Processes

The general picture that emerges from the interviews is that the Brazilian capacity when it comes to climate change issues is very centered around a few institutions and some specific individuals within these institutions, something that is also pointed out by some of the interviewees.

Many interviewees pointed out that this situation may partly be changing as the ministry of environment (MMA) in the new government is very interested in having more influence on climate change issues, something that many NGOs and also researchers greet since the MMA is more inclined to put focus on the forestry issues than the ministry of science and technology (MCT) and the ministry of foreign affairs (Itamaraty) (see box 5.1). However, most interviewees are very disappointed in the new government because of its complete lack of interest in the climate change issue. For example, the president has not yet convened the Brazilian Climate Change Forum. And although the new minister of environment Maria Silva is very strong, most people feel that she is very isolated within the new government.

The focus of Brazilian environmental organizations when it comes to climate change has been almost solely on the issue of deforestation and specifically the issue of avoided deforestation under the CDM. Accordingly, the most active NGOs have been organizations like e.g. IPAM (Instituto de Pesquisa Ambiental da Amazônia), a research based institute working with the use of land and resources in the Amazon, and ISA (Instituto Socioambiental), working with similar issues. When it comes to the broader issue of climate change, Brazilian NGOs have played a very marginal role, not even the big international NGOs like Greenpeace and WWF has worked with these issues in Brazil.

Table 5: Summary of the main arguments for and against different proposals on how to treat LULUCF emissions if Brazil would get commitments in a future commitment period, as put forward in the text.

	Pros	Cons
Full carbon accounting	- Simplicity - Completeness, which means avoiding the separability issue and increasing the cost-effectiveness of the system - Creates an incentive for Brazil to reduce deforestation rates	- High demands on verifiability - Countries are held responsible for emissions that they cannot control (e.g. large natural variations and indirect human effects) - Risk for "leakage" of carbon credits into the energy system
A Kyoto styled compromise….	- Creates an incentive for Brazil to reduce deforestation rates	- Risk for "leakage" into the energy sector - High demands on separability - Uncertainty in how emissions falling under article 3.4 will be treated
…with non-binding LULUCF emission targets	- Easier to negotiate a baseline (since the risks for Brazil would be much lower) - Much lower risk for "leakage" into the energy sector (since a lower baseline for LUCF emission becomes possible) - Creates an incentive for Brazil to reduce deforestation rates	- High demands on separability - Uncertainty in how emissions falling under article 3.4 will be treated
Separate sinks protocol	- No risk for 'leakage' into the energy sector - Other ecosystem services than carbon contents can be included - Negotiating energy sector targets and LULUCF targets separately simplifies the process and solutions can be better adopted two the different sources	- The protocol runs the risk of becoming a weaker instrument than a integrated climate regime - LUCF-negotiations have to start from scratch - High risk that Brazil will not participate in such a protocol and thereby no incentive is created to reduce deforestation rates

The focus on the forest issue on the part of Brazilian NGOs has also been in stark contrast to the official Brazilian position, seeking to diminish the role of LULUCF activities in the international climate framework. The NGO representatives perceive this as stemming from the government trying to divert focus from the situation in the Amazon in order to retain sovereignty over the region. The official representatives, although admitting that this is an issue, argue that their position stems from an ambition to defend the environmental integrity of the climate regime and that the NGOs do not see the whole picture.

This conflict is probably one reason why NGOs feel that the decision process regarding the Brazilian position has been very closed, since in the one issue where they have shown any interest, the government (i.e. MCT and Itamaraty) has been very reluctant to change its position. This conflict is also still very much ongoing, see box 5.1.

The awareness of the Brazilian industry when it comes to climate change issues has been almost non-existent. They have therefore not participated to any great extent in the shaping of the Brazilian international position nor regarding domestic policies. However, interest is growing in the prospect of receiving benefits from a global carbon market through the CDM.

Box 5.1: A new proposal for the treatment of tropical deforestation under the Kyoto protocol

At COP 9 in Milan a group of six Brazilian and American researchers and NGO representatives put forward a proposal for the inclusion of tropical deforestation under the Kyoto protocol, in the first and/or subsequent commitment periods (Santilli et al., 2003). This proposal is interesting because it received considerable attention, both within Brazil and internationally, and because it highlights the domestic Brazilian conflict regarding how to treat emissions from deforestation in the Amazon in the international climate regime.

The main idea of the proposal is to circumvent the problems of additionality and leakage that has plagued the issue of avoided deforestation under the CDM by moving from a project based system to one based on national targets for deforestation. According to the proposed system non-Annex I countries participating could earn carbon credits by reducing deforestation rates under a baseline, i.e. the rate during the 1980s, and commit themselves not to increase, or further reduce, deforestation after the first commitment period.

This solution adequately treats the problem of leakage. Although international leakage is still possible, through the relocation of deforestation in one country, it is unlikely to occur at a large scale. However, the way the proposal is currently formulated it does not offer a solution to the issue of additionality because the arbitrarily chosen baseline.

Although the Brazilian government so far has been unable to reduce deforestation, there is a political will to do so, manifested e.g. in a recent plan, for the first time involving 12 federal agencies and not only the environmental agencies as before and with an annual budget of $136 million. Thus simply choosing the 1980s as a baseline do not address the issue of additionality, i.e. it does not take into account what would have happened in the absence of the proposed mechanism. On the other hand, as discussed, creating a credible baseline for deforestation in the Amazon is extremely difficult.

In Brazil the reactions to the proposal has been mixed. The people from the ministry of science and technology and the ministry of foreign affairs, that have been negotiating these issues under the Climate convention, sees nothing new in the proposal and dismisses it. On the other hand, the people from the ministry of environment that are tied to the new administration and are seeking to gain influence over the climate change issue, are putting more emphasize on the issue of deforestation and has therefore been very positive to the proposal.

5.1.2 The Brazilian Position on Climate Change Issues

A point generally stressed in the interviews is the fact that Brazil has been an important and active player in the international climate negotiations and a leader for the G77/China group. The unity within that group is also emphasized by some as crucial for the developed countries to get influence in the negotiations. Quite a few feel that the international negotiations are not fair process and that it is difficult for developed countries to get their voices heard, especially when it comes to scientific and technical issues.

Still, many underline that it is important to keep working within the UNFCCC framework and that the focus should be on the Kyoto process. This is partly due to the fact that the central issue for Brazil, the historical responsibility of the developed countries, is embodied in the principle of "common but differentiated responsibilities" stated in the UNFCCC and reflected in fact that only Annex I countries have emission targets under the Kyoto protocol.

The main issue where the Brazilian position has differed from that of G77/China has been the treatment of sinks, and especially the issue of avoided deforestation, as discussed before. But the focus of the Brazilian delegation has also differed from the rest of G77/China in that they have considered adaptation as a secondary issue. The reason given for this, just as in the case of reducing the role of sinks, is that the focus when it comes to mitigating climate change should be on the central point, reduction of energy related greenhouse gas emissions (in the developed world).

5.1.3 Commitments in a Second Commitment Period?

The persons interviewed that have been part of the official Brazilian delegation in the negotiations were of course very clear on the point that Brazil should not accept any binding commitments or emission reduction targets in the near future. This view was based on the arguments used in the negotiations, i.e. that the developed countries have the responsibility to act first because of their historical responsibility for the problem. But a second argument that was emphasized by some persons was the fact that opening up for a discussion on commitments for developing countries would break the unity of the G77/China.

The representatives for the scientific community and NGOs are more open to the prospect of Brazil taking on commitments, though they all concede that this is at odds with the general opinion in Brazil. Also, they stress that it is vital that the developed countries show that they are taking the issue seriously by starting to reduce emissions, along with their historical responsibility. Also, quite a few remarked that if Brazil is to take on emission targets in a (distant) future, they have to be based on "objective" criteria and not in the arbitrary and subjective way they were set in Kyoto.

5.2 Deforestation in the Brazilian Amazon

The view of deforestation in the Brazilian Amazon expressed in the interviews endorsed the findings of our literature study. One of the main messages conveyed was that deforestation is more or less out of control. Many of the interviewees liken the Amazon to the Wild West and none is optimistic about the government's chances to reduce deforestation rates in the short run. They mention corruption, a chaotic property rights system and lack of funds for enforcement among other things, as the obstacles to reduce deforestation and conclude that it will take time to achieve the cultural changes that are needed if deforestation is to be curbed. As a consequence of this some of the interviewees mean that it if Brazil would accept some kind of commitments, it should not include emissions from deforestation since they cannot accept targets for emissions over which they have no control.

The second main point conveyed is that there is no strong conflict between reducing deforestation rates in the Brazilian Amazon and promoting development in the region, noting that only a few per cent of the Brazilian GDP comes from the Amazon despite of the high deforestation rates. Rather on the contrary, some argue that it is the current extensive land use patterns that keep small-scale farmers in poverty. Finally, the official representatives clearly stated that the issue of deforestation in the Amazon is a domestic affair that will not be solved any faster through international intervention.

6 Conclusions and Policy Implications

The aim of this study was to investigate how one should treat emissions from deforestation in the Brazilian Amazon in a future commitment period of the Kyoto protocol, would Brazil get binding commitments. More specifically we intended to analyze (*i*) how deforestation rates may be affected if Brazil takes on emission targets that include emissions from deforestation, (*ii*) how the environmental integrity of an international climate agreement might be affected by the large uncertainties in baseline emissions from deforestation in the Brazilian Amazon, and (*iii*) what constraints the participation of Brazil in a climate agreement with binding emission targets put on the treatment of land use, land use change and forestry emissions in the agreement.

When it comes to the issue of deforestation in the Amazon, it was in the early days driven by ambitious and aggressive governmental colonization programs, initiated in the 1960s. These programs were a response to a legitimate fear of the internationalization of the Amazon forests, an issue still affecting Brazilian foreign policy regarding the Amazon. Although both the public opinion and the federal government's view regarding deforestation has changed, the government has not been able to control deforestation, partly due to the fact that the process of land conversion in the Amazon today very much is a complex, endogenously driven process.

The expansion of cattle ranching and farming, the two major sources of deforestation, is increasingly being driven by local urban demand and, regarding beef production, also rapidly increasing exports, rather than governmental incentives. For small-scale farmers with high risk aversion and lack of resources more intensive agricultural practices, such as the cultivation of perennial crops, are not a viable option. Even the expansion of the road network has become an increasingly endogenous process, driven by the growth of urban centers. The upsurge of soybean cultivation on the Brazilian savannas, *cerrados*, has primarily been driven by an increasing global demand for soy products in the meat and milk industry in Europe and China. Finally, these proximate causes of deforestation are highly intertwined and not easily distinguishable from each other.

Lack of resources for effective enforcement of current legislation, corruption and conflicting views on this issue between the federal government and individual Amazonian states with large sovereignty, are other factors making it very difficult to contain deforestation rates. Based on this we conclude that:

(i) Although even a low price on carbon would make most land clearings in the Amazon unprofitable and increase the pressure on the federal government to reduce deforestation rates, the complexity of the issue and the difficulties in trying to reduce deforestation through public policies to date makes it very hard to assess what consequences a carbon price would have on deforestation rates. Future carbon dioxide emissions from deforestation in the Brazilian Amazon are therefore highly uncertain and much harder to predict than emissions from the energy sector.

As a consequence of the expansion of the agricultural frontier about 570,000 km^2 of natural vegetation has been converted to agricultural land, mainly pasture, since 1960s. Still this represents less than 15 per cent of the total area of the Amazon forest. The annual rate of deforestation has varied between 11,000 km^2 and 29,000 km^2. Estimates of the subsequent carbon emissions varies between 150 MtC and 250 MtC annually, or between about two to three times annual emissions from the energy sector. The uncertainties are large though, primarily because of the uncertainty in amount and distribution of carbon in biomass.

Future emission rates are even more uncertain since on top of the uncertainties afflicting current estimation there is an uncertainty in future deforestation rates, something that is close to impossible to predict. One way of trying to assess the uncertainty of future emissions is to look at the variability in historic deforestation rates and calculating emissions using different estimates for biomass content. Doing this, we estimate that the uncertainty range in future emissions amount to at least 150 MtC annually. As a consequence of this we conclude that:

(ii) The risk that one introduces "tropical hot air" in the global carbon market, as a result of overestimating future emissions from Amazonian deforestation, is imminent if Brazil gets binding commitments that includes this emission source. We estimate that the quantity of

"tropical hot air" in 2020 may amount to more than the annual EU target under the Kyoto protocol. Conversely, a similar underestimation of deforestation rates will put Brazil in a position were they have to acquire the same amount of carbon credits on the global market. The amount of hot air from uncertainties in deforestation rates is even larger if the target is set in intensity terms, i.e. total emissions per GDP, but only if deforestation rates turns out to be independent of economic growth

Both the conclusions presented above have implication for how LULUCF can be treated in a climate regime where Brazil has binding commitments. So has the uncertainties in natural emissions from the Amazon basin. They are even larger than the human induced emissions, interannual variations probably in the order of 900 MtC or more than 10 times the annual emissions from the energy sector. This makes us conclude that:

(iii) Basing a future climate regime on so called full carbon accounting would be completely unreasonable if Brazil has binding commitments, since the country cannot be held responsible for the large variations in the carbon balance in the Amazon, both due to indirect human perturbations and to natural variations. Looking at other schemes for the treatment of emissions from land use change in future commitment periods, a Kyoto-styled compromise (article 3.3) seems to be a viable option. However, it is likely that Brazil under such a regime would demand a generous allocation of emission rights to cover emissions from deforestation, over which they perceive they have little control. Thus one runs the risk of creating "tropical hot air" as concluded above. We therefore suggest that the possibility of adopting non-binding commitments for this emission source is explored. This would reduce the risk of creating hot air while at the same time maintain an incentive for the Brazilian government to reducing deforestation rates.

Interviewees

Dr. Antonio Nobre, Senior Scientist at the Brazilian Institute of Space Research (INPE), Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA)

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Dr. Donald Sawyer, director of the Instituto Sociedade, População e Natureza (ISPN)

Prof. Emilio Lèbre La Rovere, Head of the Environmental Science Laboratory, Federal University of Rio de Janeiro

Fabio Feldmann, Executive Secretary of the Brazilian Climate Change Forum

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Prof. Paulo Yoshio Kageyama, director of the Secretariat of Biodiversity and Forests, Ministry of Envisonment

Dr. Thelma Krug, Inter-American Institute for Global Change Research (IAI) and Co-chair for the contact group for LULUCF - definitions & modalities for including afforestation and reforestation activities under Article 12 of the Kyoto Protocol

All interviews were carried out in Brazil at the interviewees offices (Rio de Janeiro, Cachoeira Paulista, Sao José dos Campos, Sao Paulo and Brasilia), between the 1st and the 12th of March, 2004.

References

Achard F., H. D. Eva, H.-J. Stibig, P. Mayaux, J. Gallego, T. Richards and J.-P. Malingreau, 2002. Determination of deforestation rates of the world`s human tropical forests. *Science*, 297, pp. 999-1002

Almeida, O. and C. Uhl. 1995. Developing a quantitative framework for sustainable resource-use planning in the Brazilian Amazon. World Development, 23, pp. 1745-1764

Andersen, L.E., C.W.J. Granger, E.J. Reis, D. Weinhold, S. Wunder, 2002. The Dynamics of Deforestation and Economic Development in the Brazilian Amazon. Cambridge, UK: Cambridge University Press

Angelsen, A. & Kaimowitz, D. 1999. Rethinking the Causes of Deforestation: lessons from Economic Models. *The World Bank Research Observer*, Vol 14 No. 1. pp 73-98. IBRD / The World Bank

Arima, E.Y., and C. Uhl. 1997. Ranching in the Brazilian Amazon in a national context: Economics, policy, and practice. *Society and Natural Resources* 10(5), pp. 433–451

Bhattacharya, S., 2003. Destruction of Amazon rainforests accelerating. *NewScientist.com news service*, 27 June 2003, http://www.newscientist.com/news/news.jsp?id=ns99993883 (retrieved 2004-01-14)

Bonnie, R., M. Carey & A. Petsonk, 2002. Protecting terrestrial ecosystems and the climate through a global carbon market. *Philosophical Transactions of the Royal Societry: Mathematical, Physical & Engineering Sciences*, 360(1797), pp. 1853-1873

Bonnie, R. & Schwartzman, S., 2003. Tropical Reforestation and Deforestation and the Kyoto Protocol. *Conservation Biology*, 17(1), pp. 4-5

Browder, J. O., 1988. Public policy and deforestation in the Brazilian Amazon. In *Public policies and the misuse of forest resources*, R. Repetto and U. Gillis (eds.), Boston, Cambridge University Press

Carpentier, C. L., S. A. Vosti, and J. Witcover, 2000. Small-scale farms in the Western Brazilian Amazon: Can they benefit from carbon trade?. Environment and Production Technology Division Discussion Paper No. 67. International Food Policy Research Institute, Washington, D.C.

Carvalho, G., A.C. Barros, P. Moutinho and D.P. Nepstad. 2001. Sensitive development could protect Amazonia instead of destroying it. *Nature*, 409, pp. 131

Carvalho G., P. Moutinho, D. Nepstad, L. Mattos & M. Santilli. 2004. An Amazon Perspective on the Forest-Climate Connection: Opportunity for Climate Mitigation, Conservation and Development? *Environment, development and sustainability*, 6, pp. 163-174

Cattaneo, A., 2002. *Balancing agricultural development and deforestation in the Brazilian Amazon*. Research Report 129. International Food Policy Research Institute, Washington, D.C., USA

Chambers J.Q., N. Higuchi, E.S. Tribuzy and S.E. Trumbore, 2001. Carbon sink for a century. *Nature*, 410, pp. 429-429

Cochrane, M.A. and Laurance, W.F., 2002. Fire As A Large-Scale Edge Effect In Amazonian Forests. *Journal of Tropical Ecology*, 18, pp. 311-325.

Council on Foreign Relations Independent Task Force, 2001. A letter to the President and a memorandum on U.S. policy toward Brazil. *Council on Foreign Relations*, New York, USA, (available at http://www.cfr.org)

Cox, P.M., R.A. Betts, C.D. Jones, S.A. Spall & I.J. Totterdell, 2000. Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. *Nature*, vol. 408, pp.184-187

DeFries, R.S., R.A. Houghton, M.C. Hansen, C.B. Field, D. Skole and J. Townshend, 2002. Carbon emissions from tropical deforestation and regrowth based on satellite observations for the 1980s and 1990s. Proceedings of National Academic Sciences, 99: 14256-14261

Departamento Nacional de Políticas Energéticas (DNPE) and Coordenação Geral de Informações Energéticas (CGIE), 1996. Brazilian Energy Balance – BEB 1996

Departamento Nacional de Políticas Energéticas (DNPE) and Coordenação Geral de Informações Energéticas (CGIE), 2002. Brazilian Energy Balance – BEB 2002

Energy Information Administration (EIA), 2003. *International Energy Outlook 2003*. EIA/DOE report nr. 0484, Washington, USA. (Available at http://www.eia.doe.gov/oiaf/ieo/)

Egler, C.A.G., 2001. Recent Changes in Land Use and Land Cover in Brazil in Daniel J. Hogan and Maurício T. Tolmasquim (eds.), *Human Dimensions of Global Environmental Change*. Brazilian Perspectives, Rio de Janeiro, Brazilian Academy of Science

Época, 1999. Amazônia: Um golpe mais forte na floresta. *Época* [São Paulo], 15 February 1999, 39, p. 19

Faminow, M.D., 1998. *Cattle, Deforestation and Development in the Amazon: An Economic, Agronomic and Environmental Perspective*. CAB International, Wallingford, UK

Faminow, M.D. and Vosti S.A. 1998. Livestock-Deforestation Links: Policy Issues in the Western Amazon in Nell, A. (ed) *Livestock and the Environment: International Conference*, IAC, Wageningen

Fearnside, P. M., 1993. Deforestation in the Brazilian Amazon: the effect of population and land tenure. *Ambio*, 8, pp. 537-545.

Fearnside P M, 1997. Greenhouse gases from deforestation in Brazilian Amazonia: net committed emissions. *Climatic Change*, 35, pp 321-360

Fearnside, P.M. 2001a. The potential of Brazil's forest sector for mitigating global warming under the Kyoto Protocol. *Mitigation and Adaptation Strategies for Global Change*, 6(3-4), pp. 355-372

Fearnside, P.M. 2001b. Saving tropical forests as a global warming countermeasure: an issue that divides the environmental movement. *Ecological Economics*, 39, pp. 167-184

Fearnside, P.M., 2001c. Soybean cultivation as a threat to the environment in Brazil. *Environmental Conservation*, 28(1), pp. 23-38

Flaskerud, G., 2003. Brazil's soybean production and impact. North Dakota State University Extension Service, EB-79. Available at http://www.ext.nodak.edu/extpubs/agecon/market/eb79.pdf (retrieved 2004-01-13)

Goldemberg, J., 1996. The Evolution of Ethanol Costs in Brazil. *Energy Policy*, 24(12), pp. 1127-1128

Grace J., Lloyd J., McIntyre J., Miranda A.C., Meir P., Miranda H., Nobre C., Moncrieff J.M., Massheder J., Malhi Y., Wright I.R. and Gash J., 1995. Carbon dioxide uptake by an undisturbed tropical rain forest in South-West Amazonia 1992-1993. *Science*, 270, pp. 778-780

Graßl, H.,J. Kokott, M. Kulessa, J. Luther, F. Nuscheler, R. Sauerborn, H.-J. Schellnhuber, R. Schubert and E.-D. Schulze Climate Protection Strategies for the 21st Century: Kyoto and Beyond. Reportprepared by the German Advisory Council on Global Change (WBGU), Berlin, Germany

Godfrey, B.J. and J.O. Browder, 1996. Disarticulated urbanization in the Brazilian Amazon. *The Geographical Review*, 86(3), pp. 441

Hecht, S.B., R.B. Norgaard and G. Possio, 1988. The Economics of cattle ranching in Eastern Amazonia. *Interciencia*, 13(5), pp. 233-240

Heston, A., R. Summers and B. Aten, 2002. *Penn World Table Version 6.1*. Center for International Comparisons at the University of Pennsylvania (CICUP)

Homma, A. K. O., 1998. *Amazônia: Meio ambiente e desenvolvimento agrícola*. Empresa Brasileira de Pesquis a Agropecuária (Embrapa), Brasília, DF, Brazil

Hoppe, A., 1992. Mining in the Amazonian rainforests. *Nature*, 355, pp. 593-594

Houghton RA, Lawrence KT, Hackler JL, Brown S. (2001) The spatial distribution of forest biomass in the Brazilian Amazon: a comparison of estimates. *Global Change Biology*, 7, 731-746

Houghton RA, Skole DL, Nobre CA, Hackler JL, Lawrence KT, Chomentowski WH., 2000. Annual fluxes or carbon from deforestation and regrowth in the Brazilian Amazon. *Nature*, 403, pp. 301-304

IBAMA, 2002. *Geo Brazil 2002 – Environment Outlook in Brazil*. IBAMA Editions, Brasilia, Brazil

International Energy Agency (IEA), 2002. *World Energy Outlook*. OECD, Paris

IGBP Terrestrial Carbon Working Group, Steffen W, Noble, I, Canadell J, Apps M, Schulze E-D, Jarvis PG, Baldocchi D, Ciais P, Cramer W, Ehleringer J, Farquhar G, Field CB, Ghazi A, Gifford R, Heimann M, Houghton R, Kabat P, Körner C, Lambin E, Linder S, Mooney HA, Murdiyarso D, Post WM, Prentice IC, Raupach MR, Schimel DS, Shvidenko A and Valentini R, 1998. The terrestrial carbon cycle: Implications for the Kyoto protocol. *Science*, 280, pp. 1393-1394

Instituto Nacional de Pesquisas Espaciais (INPE), 2002. *Monitoring of the Brazilian amazon forest by satellite 2001-2002*, available at http://www.obt.inpe.br/prodes.html (retrieved 2004-01-16)

Jakobsen, S.F., 1997. *The Determinants of the National Position of Brazil on Climate Change: Empirical Reflections*. CDR Working Paper 97:1, Centre for Development Research, Copenhagen, Denmark

Johnson, K., 2001. Brazil and the Politics of the Climate Change Negotiations. *Journal of Environment and Development*, 10(2), pp. 178-206

Jonas, M., S. Nilsson, A. Shvidenko, V. Stolbovoi, M. Gluck, M. Obersteiner and A. Oeskog, 1999. *Full Carbon Accounting and the Kyoto Protocol: A Systems-Analytical View*. Interim Report IR-99-025. International Institute for Applied Systems Analysis, Laxenburg, Austria

Kaimowitz, D., B. Mertens, S. Wunder and P. Pacheco, 2004. Hamburger Connection Fuels Amazon Destruction – Cattle ranching and deforestation in the Brazil's Amazon. Report from CIFOR (Center for International Forestry Research), Indonesia

La Rovere, E.L., 2002. *Climate Change and Sustainable Development Strategies: A Brazilian Perspective*. OECD, Paris

Laurance, W.F., M.A. Cochrane, S. Bergen, P.M. Fearnside, P. Delamônica, C. Barber, S. D'Angelo, and T. Fernandes, 2001. The Future of the Brazilian Amazon. Science, vol. 291, pp. 438-439. The subsequent debate can be found at http://www.sciencemag.org/cgi/eletters/291/5503/438 (retrieved 2003-11-24)

Lele, Uma, V. Viana, A. Verissimo, S. Vosti, K. Perkins and S. A. Husain. 2000. *Brazil Forests in the Balance: Challenges of Conservation with Development*. Evaluation Country Case Study Series. World Bank Operations Evaluation Department. The World Bank, Washington, D.C.

Mahar, D. J., 1979. Frontier Development Policy in Brazil: a Study of Amazonia. Praeger, New York

Marland, G., T.A. Boden, and R.J. Andres, 2003. *Global, Regional, and National CO2 Emissions. In Trends: A Compendium of Data on Global Change*. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, USA.

Meira Filho, L.G. & Miguez, J.D.G., 2000. Note on the time-dependant relationship between emissions of greenhouse gases and climate change. Technical note, Ministry of science and technology, Federal Republic of Brazil, available at http://www.mct.gov.br/clima

Minstério de Ciénca e Tecnologia, 2002. First Brazilian Inventory of Anthropogenic Greenhouse Gas Emissions. Available at http://www.mct.gov.br/clima/ingles/comunic_old/invent1.htm

Minstério de Ciénca e Tecnologia, 1999. Brazilian Views on the Clean Development Mechanism. Avaiable at http://www.mct.gov.br/clima/ingles/quioto/dakar.htm (retrieved 2004-01-29)

Minstério do Meio Ambiente, 1998. First national report for the Convention on Biological Diversity. Brasilia, Brazil. Available at http://www.mma.gov.br/port/sbf/chm/report.html (retrieved 2004-04-18)

Nakicenovic N., 2001. GHG Emissions and Reduction Targets GHG Emissions and Reduction Targets From a Historical Perspective From a Historical Perspective, UNFCCC SBSTA Meeting, Bonn, Germany, 28-30 May 2001 (available at http://unfccc.int/program/mis/brazil/documents/nakicenovic.pdf)

Nepstad D. C., A. Veríssimo, A. Alencar, C. Nobre, E. Lima, P. Lefebvre, P. Schlesinger, C. Potter, P. Moutinho, E. Mendoza, M. A. Cochrane and V. Brooks. 1999. Large-scale Impoverishment of Amazonian forests by logging and fire. *Nature*, 398, pp. 505-508

Nepstad, D., J.P. Capobianco, A.C. Barros, G. Carvalho, P. Moutinho, U. Lopes, P. Lefebvre, and M. Ernst, 2000. *Avança Brasil: Os Custos Ambientais para a Amazônia. (Avança Brasil: The Environmental Costs for Amazonia.)* Belém: Gráfica e Editora Alves

Nepstad, D., G. Carvalho, A.C. Barros, A. Alencar, J.P. Capobianco, J. Bishop, P. Moutinho, P. Lefebvre, and U. Lopes da Silva, Jr. 2001. Road paving, fire regime feedbacks, and the future of Amazon forests. *Forest Ecology and Management*, 154, pp. 395-407

Niesten, E., P.C. Frumhoff, M. Manion & J.J. Hardner, 2002. Designing a carbon market that protects forests in developing countries. *Philosophical Transactions of the Royal Societry: Mathematical, Physical & Engineering Sciences,* 360(1797), pp. 1875-1888

Persson, T. and C. Azar, 2003. The Cost of Meeting the Kyoto Protocol: Dealing with the Carbon Surplus in Russia and the Ukraine. *Management of Environmental Quality*, 14(4), pp. 488-507

Poole, A.D., de Hollanda, J.B. and Tolmasquim, M.T., 1998. Energy conservation and greenhouse gas emissions in Brazil. Report prepared for *INEE (Instituto Nacional de Eficiéncia Energética)*, Brazil. Available at http://www.inee.org.br

Porru, P.M., 1996. Legal Aspects Concerning the Conservation and Sustainable Use of Amazonian Forest. *Interdisciplinary research on the conservation and sustainable use of the Amazonian rain forest and its information requirement: report on the workshop held in Brasília, Brazil, November 20-22, 1995*. R. Lieberei, C. Reisdorff and A.D. Machado (eds), Brasilia, Brazil

Potter C, Genovese VB, Klooster S, Bobo M, Torregrosa A., 2001. Biomass burning losses of carbon estimated from ecosystem modeling and satellite data analysis for the Brazilian Amazon region. *Atmospheric Environment*, 35, 1773-1781

Prentice, I.C., 2001. The Carbon Cycle and Atmospheric Carbon Dioxide. In *Climate Change 2001: The Scientific Basis*, J.T. Houghton et al., eds., Cambridge University Press, pp. 183-238

Prentice, I.C. and Lloyd, J., 1998. C-quest in Amazonia. *Nature* 396, pp. 619-620

Román, M, 1998. *The Implementation of International Regimes: the Case of the Amazon Cooperation Treaty*. Doctoral Thesis, Department of Government, Uppsala University, Sweden

Rosa, L.P., S.K. Ribeiro, M.S. Muylaert and C.P. de Campos, 2004. Comments on the Brazilian Proposal and contributions to global temperature increase with different climate responses—CO2 emissions due to fossil fuels, CO2 emissions due to land use change. *Energy Policy*, 32, pp. 1499-1510

Rother, L, 2003. Relentless foe of the Amazon jungle: Soybeans. *The New York Times*, September 17

Schaeffer, R., A. Salem Szklo, W. Chandler, J. Logan and J.C. de Sauza, 2000. Developing Countries and Global Climate Change: Electric Power Options in Brazil. Pew Center on Global Climate Change. Available at http://www.pewclimate.org/global-warming-in-depth/all_reports/brazil/index.cfm (retrieved 2003-11-29)

Schneider, R., 1993. The potential for trade with Amazon in greenhouse gas reduction. LATEN Dissemination Note #2, Latin America Technical Department, Environment Division, The World Bank

Schroeder, P. E. & Winjum, J. K., 1995. Assessing Brazil's carbon budget: II. Biotic fluxes and net carbon balance. *Forest Ecology and Management*, 75, pp. 87-99

Stier, S.C. & Siebert, S.F., 2002. The Kyoto Protocol: an Opportunity for Biodiversity Restoration Forestry. *Conservation Biology*, 16(3), pp. 575-576

Tian, H., J. M. Melillo, D. W. Kicklighter, A. D. McGuire, J. Helfrich, B. Moore III and C. J. Vörösmarty, 1998. Effect of interannual climate variability on carbon storage in Amazonian ecosystems. *Nature*, 396, pp. 664-667

Toniolo, A., and C. Uhl. 1995. Economic and ecological perspectives on agriculture in the Eastern Amazon. *World Development*, 23(6), pp. 959-973

UNFCCC. 1997. United Nations Framework on Climate Change: Ad Hoc Group on the Berlin Mandate. Implementation of the Berlin Mandate: Additional proposals from Parties – Addendum – Note by the secretariat. 30 May 1997. FCCC/AGBM/1997/MIS.1/Add.3. available at http://www.unfccc.int

Union of Concerned Scientists (UCS), 2000. Scientists Call for Action on Forest Conservation in the Kyoto Protocol's Clean Development Mechanism. Issued at the Sixth Conference of the Parties, The Hague, Netherlands. Available at http://www.ucsusa.org

Vosti, S. A., J. Witcover and C. L. Carpentier. 2002. *Agricultural Intensification by Smallholders in the Western Brazilian Amazon: From Deforestation to Sustainable Land Use*. Research Report. International Food Policy Research Institute, Washington, DC

Viola, E.J., 1997. The environmental movement in Brazil : institutionalization, sustainable development, and crisis of governance since 1987. In *Latin American environmental policy in international perspective*, Boulder, Westview, p. 88-112

Viola, E. And H. Leis, 2001. Brazil and Global Governence: the case of Climate Change in Daniel J. Hogan and Maurício T. Tolmasquim (eds.), *Human Dimensions of Global Environmental Change*. Brazilian Perspectives, Rio de Janeiro, Brazilian Academy of Science

Watson, R.T., I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo and D. J. Dokken (Eds.), 2000. *Land Use, Land-Use Change, and Forestry*. Special Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, UK. pp 375

Appendix A: Spatial & Temporal Distribution of Deforestation in the Brazilian Amazon

Table 6: Annual deforestation rates in the states of the Legal Amazon for the period 1977-2002 as reported by the Brazilian National Institute for Space Research (INPE), based on analysis of satellite imagery. For the period 1977-1988 an annual mean value is given. For 2001/2002 only aggregate data for the whole region is yet available. (INPE, 2002)

Year	Total	Acre	Amapa	Amazonas	Maranhão	Mato Grosso	Pará	Rondônia	Roraima	Tocantins
77/88	21130	620	60	1510	2450	5140	6990	2340	290	1650
88/89	17,860	540	130	1,180	1,420	5,960	5,750	1,430	630	730
89/90	13,810	550	250	520	1,100	4,020	4,890	1,670	150	580
90/91	11,130	380	410	980	670	2,840	3,780	1,110	420	440
91/92	13,786	400	36	799	1,135	4,674	3,787	2,265	281	409
92/93	14,896	482		370	372	6,220	4,284	2,595	240	333
93/94	14,896	482		370	372	6,220	4,284	2,595	240	333
94/95	29,059	1,208	9	2,114	1,745	10,391	7,845	4,730	220	797
95/96	18,161	433		1,023	1,061	6,543	6,135	2,432	214	320
96/97	13,227	358	18	589	409	5,271	4,139	1,986	184	273
97/98	17,383	536	30	670	1,012	6,466	5,829	2,041	223	576
98/99	17,259	441		720	1,230	6,963	5,111	2,358	220	216
99/00	18,226	547		612	1,065	6,369	6,671	2,465	253	244
00/01	18,166	419	7	634	958	7,703	5,237	2,673	345	189
01/02	25,500									

Appendix B: Estimating Future CO_2 Emissions in Brazil

In this section we present the calculations used as an input to the discussion carried out in section 4.2 on how uncertainties in the future emissions of Brazil play out under different allocation rules, would Brazil have emission targets in second commitment period. High and low range estimates are presented for emissions from deforestation in the Brazilian Amazon, based on our own calculations, and emissions from the energy sector respectively. These are then combined to give an indication of the total uncertainty span of future CO_2 emissions in Brazil. These estimates are of course highly uncertain and should not be seen as scenarios or predictions of future emissions. Rather, the whole point of this exercise is to look at how the uncertainties in baseline emissions, especially regarding emissions from future land use change, play out under different allocation principles.

Future emissions from land use and land use change in the Amazon are highly uncertain, given that even estimations of historical emission rates varies by a factor three or more. The uncertainties in future emissions of course stems from the same caveats plaguing historical estimates, e.g. uncertainties in the amount of carbon below and above ground in standing biomass, the spatial distribution of this biomass, the amount of carbon released from surface fires etc. On top of this, scenarios of future emissions have to deal with the uncertainties regarding future deforestation rates and its spatial distribution. What we are after is a high and a low estimate of emissions from deforestation reflecting these uncertainties.

We construct four emissions scenarios up to 2020, based on high and low assumptions regarding future deforestation rates and forest biomass respectively. The former is done simply by using the historical rate of deforestation for the time for which INPE has presented official estimates, see table 2, and looking at the five year moving average, reflecting how average deforestation rates may vary during a five year commitment period as that of Kyoto, and taking the minimum and maximum values. These values are then taken as annual deforestation rates and extrapolated up to 2020. The low deforestation rate used is 13,700 km^2/yr and the high rate used is 19,300 km^2/yr. Even the high deforestation rate case is relatively conservative, leaving almost 75 per cent of the Amazon's forests standing in 2020, which is what Brazil's Ministry for Science and Technology has publicly admitted they expect (Laurance et al., dEbate, 2001).

To calculate the annual carbon flows resulting from the high and low deforestation rate cases we adopt a simplified bookkeeping model similar to those used in the studies described in section 2.2 and described in e.g. Fearnside (1997) and Andersen et al. (2002). We assume that 30 per cent of the above ground carbon in standing biomass is released as CO_2 in the initial burn. The remaining above ground carbon and the below ground carbon is then released as CO_2 through decay described by an exponential function, assuming that 10 per cent of soil carbon is released. The latter assumption gives a soil carbon release roughly in the same magnitude as that of Fearnside (1997). We then divide land into two types with differing carbon content, dense forest and non-dense forest, and use the decay rate parameters given by Andersen et al. (2002), 0.5 (closed forests) and 0.4 (other lands) for the two types respectively. The same decay rate is used for both above and below ground carbon. With these decay rates the share of carbon released after five years is about 92 per cent in dense forests and 86 per cent in non-dense forests.

The carbon cycle of typical slash-and-burn agriculture can be divided into three phases; (*i*) initial land clearing and burning releasing carbon, (*ii*) agricultural use of land releasing carbon from decay of remaining organic material and subsequent re-burns and finally (*iii*) soil exhaustion, leaving the land abandoned or in fallow where re-growth of secondary vegetation absorbs carbon. Carbon emissions in the two first phases are described by the model above, but not the uptake of carbon through secondary re-growth. This process is much more complex since it involves modeling the choices on when and for how long the land is abandoned, i.e. the age structure of the abandoned and fallow lands since the pace at which carbon accumulates in the secondary vegetation is non-linear, growth in young secondary forests being rapid and then declining as it ages. Also, the carbon content of secondary growth is generally lower than in the original vegetation.

Since carbon uptake from secondary re-growth is relatively small compared to emissions from deforestation, we simplify by extending the re-growth uptake trend as estimated by Houghton et al. (2000) into the future. In this study carbon uptake increases almost linearly from about 10 MtC in 1976 to 50 MtC in 1996, implying an annual increase in the uptake rate of 2 MtC. We assume that this trend continues up to 2011 and then levels off, giving an annual uptake rate of 80 MtC per annum up to 2020 for both the high and low deforestation rate scenarios. Since this assumption is used in all scenarios it does not affect the difference in emissions between the scenarios, i.e. the uncertainty span that we will use in our analysis.

To be able to calculate the annual carbon fluxes we now have to make assumption regarding the forest biomass in the different types of land in the model and how deforestation in the different states are divided between these land types. For the latter we make adopt the method used by Fearnside (1997) and Andersen et al. (2002), assuming that deforestation is randomly distributed between land types so that cleared land of a certain type within state occurs in proportion to the fraction of that land type in that state. The distribution of lands between dense and non-dense forest across states is taken from Fearnside (1997) and displayed in table 7. The assumptions regarding above and below ground carbon in the different forest types are adopted from Fearnside (1997) on the high side and Anderson et al. (2002) on the low side, displayed in table 8.

Table 7: *Distribution of different vegetation types in the states comprising the Legal Amazon. Taken from Fearnside (1997). The types of land used in the future emission estimates are dense and non-dense forests, since clearing of non-forest lands, e.g. cerrados, are not included in the INPE deforestation estimates. Deforestation in each state is assumed to be distributed between dense and non-dense forest proportionally to the area of these two land types.*

	Dense forest		Non-dense forest		Non-forest	
	Area	Fraction	Area	Fraction	Area	Fraction
State	(km^2)	(%)	(km^2)	(%)	(km^2)	(%)
Acre	16,926	11.9	124,971	88.1	0	0.0
Amapa	110,528	78.0	6,049	4.3	25,195	17.8
Amazonas	968,363	61.8	577,441	36.9	19,865	1.3
Maranhão	24,574	17.8	12,709	9.2	101,026	73.0
Mato Grosso	23,154	3.0	486,198	62.0	274,286	35.0
Pará	657,424	60.0	386,893	35.3	51,572	4.7
Rondônia	19,377	9.6	160,363	79.3	22,382	11.1
Roraima	117,927	52.5	69,594	31.0	37,061	16.5
Tocantins	5,665	3.0	23,675	12.5	160,754	84.6
Total	1,943,938	43.4	1,847,893	41.2	692,141	15.4

Table 8: *Two estimations of the carbon content of two types of biome in the Brazilian Amazon.*

	Carbon content in biomass	
	Above ground (tC/ha)	Below ground (tC/ha)
Fearnside, 1997:		
Dense forest	191	61
Non-dense forest	161	51
Andersen et al., 2002[a]:		
Dense forest	150	25
Non-dense forest	78	64

[a]As the definition of different vegetation types differ between Fearnside and Anderson et al. the values for non-dense forests given for the latter is a weighted mean between *seasonal forests* and areas of *ecological transition*.

The emissions of CO_2 from deforestation, as estimated by the above described model, are displayed in figure 4 for the period from 1980 to 2000. As can be seen, the uncertainty range in emissions produced by the high and low assumption regarding forest biomass varies between about 100 to 150 MtC during this period, the higher the deforestation rate the larger the difference between the two assumptions. The two estimates correspond quite well to the range of estimates in the studies reviewed in section 2.2. The temporal pattern also matches that presented by Houghton et al (2000), the only study estimating a time series of annual emissions.

Turning to the scenarios for future emissions produced by the model, the emission estimates for the year 2020 are displayed in table 8. There are four scenarios, featuring the combinations of high and low deforestation rates and forest biomass loadings respectively. The difference in emissions stemming from uncertainty regarding forest biomass decreses to about 100 MtC in the low deforestation rate scenario while it lays fairly constant around 140 MtC in the high deforestation rate case. Similarly, the difference in emissions between the two deforestation paths is exacerbated by a high forest biomass content, being about 125 MtC in the high forest biomass case as opposed to about 85 MtC in the low forest biomass case.

The largest difference in emissions is of course between the BAU scenario with low forest biomass and the Avança Brasil scenario with high forest biomass, reaching 224 MtC, or nearly 3.5 per cent of current annual emissions of CO_2 from fossil fuel burning. Still, in the discussion on how the uncertainty in future emissions may affect the integrity of an international climate agreement where Brazil has binding commitments it is the uncertainty in future deforestation rates that is of most importance. This because if our best estimates of the biomass content of Amazonian forests changes with new knowledge, then this will affect not only are estimates of future emissions but also our estimates of historical emissions. That is, the same estimate of biomass content will of course be used both to calculate the target and the actual emissions during the commitment period. However, it is important to note that the uncertainty regarding forest biomass affects the uncertainty regarding future emissions stemming from different deforestation rates, as a higher biomass estimate gives a larger difference between the high and low deforestation case than a low estimate.

Finally it is important to keep in mind that the scenarios presented here only includes emissions

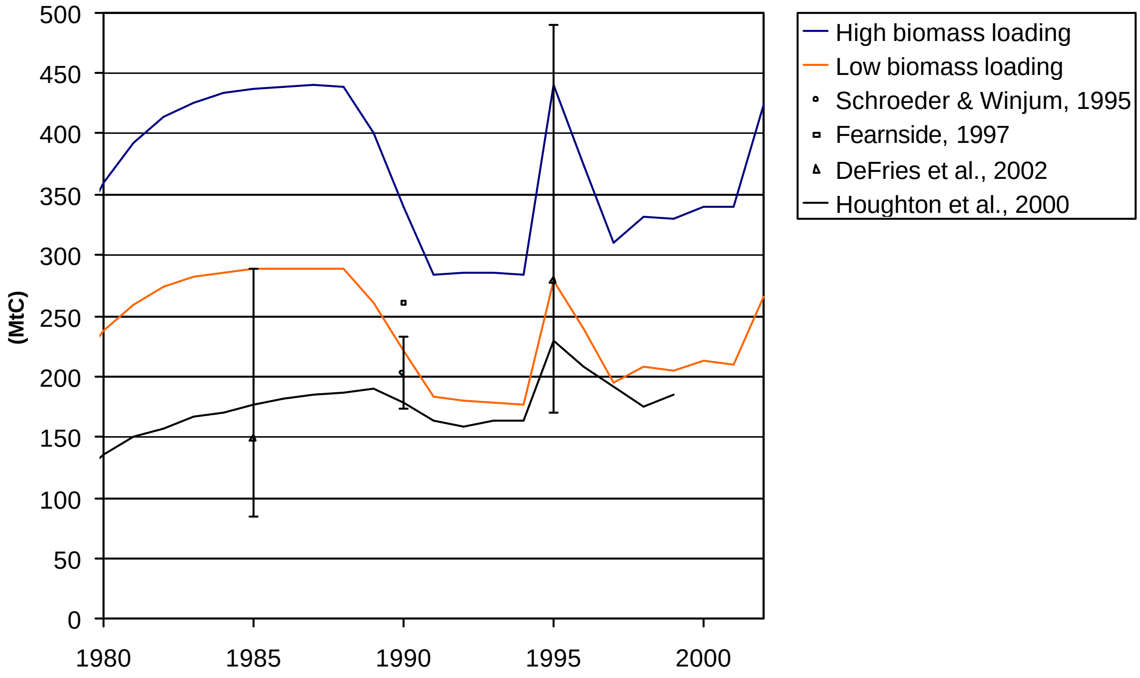

Figure 5: *Estimated historical emission rates of CO_2 from deforestation in the Brazilian Amazon using a simple bookkeeping model described in the text. Some earlier estimates are also shown for comparison (for a discussion on these estimates see section 2.2).*

from deforestation in the Amazon using the definition in the INPE data. Emissions from land clearings in other land types, e.g. the cerrados, or emissions from selective logging, albeit much smaller, are not included. Thus uncertainties in future CO_2 emissions from the Amazon will be even bigger.

Table 9 shows two sets of scenarios of the energy supply and CO_2 emissions from the Brazilian energy sector in the year 2020. We use the high and low growth EIA (2003) scenarios to illustrate the uncertainty in the baseline regarding Brazilian fossil fuel CO_2 emissions.

Table 9: *Scenarios for the total Brazilian energy supply, CO_2 emissions from fossil fuels and CO_2 intensity for the year 2020.*

	Energy supply (TWh)	CO_2 emissions (MtC)	CO_2 intensity (kgC/'000US$)
World Energy Outlook (IEA, 2002)	3200	155	73,2
International Energy Outlook (EIA, 2003)			
Reference	4250	180	62,6
High growth	4810	203	68,5
Low growth	3630	150	69,2

We have now four scenarios for the future emissions from deforestation in the Amazon, based on high and low estimates regarding future deforestation and forest biomass respectively, and two scenarios regarding emission from fossil fuel use in Brazil. The emissions in year 2020 under these different assumptions are shown in table 8. All possible combinations of these scenarios will give us eight scenarios for the total emissions of CO_2 from Brazil in 2020. In order to make the analysis more lucid we want to narrow down the number of possible scenarios.

Table 10: *Emissions of CO2 in the deforestation and energy sector scenarios for the years 2000 and 2020, see text for details.*

	Deforestation				Energy sector	
	High biomass		Low biomass			
Year	Low deforestation rate (MtC)	High deforestation rate (MtC)	Low deforestation rate (MtC)	High deforestation rate (MtC)	Low economic growth (MtC)	High economic growth (MtC)
2000	340	340	212	212	84	84
2020	228	353	129	214	150	203

Remembering that the aim of this exercise to see how uncertainties in emission baselines play out under different allocation principles we chose scenarios that gives us the largest uncertainty span regarding different indicators. The indicators we will focus on are absolute emissions, per capita emissions and emission intensity (per GDP). In the case of absolute and per capita emissions the greatest span is gained by combining low deforestation rates scenario with the low economic growth scenario and the high deforestation rates scenario with the high economic growth scenario. In the case of emission intensity the largest span is obtained by combing the high deforestation rate scenario with the low economic growth scenario and vice versa. Also, as the uncertainty range is higher for the high biomass case we will chose these scenarios. Although, as shown above, the uncertainty regarding forest biomass is much smaller than the uncertainty in the baseline of the activities.