CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT STRATEGIES: A BRAZILIAN PERSPECTIVE

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FOREWORD

In January 2001, the OECD held an expert seminar as part of a pilot project to investigate interactions between the long term agenda for climate change and sustainable development strategies. Experts from both OECD and developing countries attended. Participants identified issues and approaches, based on their regional perspectives, relevant to an evolving, equitable regime for addressing climate change, given various national circumstances, political interests, institutions and capacities to achieve sustainable development objectives. They stressed the importance of both climate mitigation and adaptation policy within a sustainable development framework.

Discussions and presentations centred around two broad themes:

- synergies and trade-offs between sustainable development objectives and long-term strategies to limit climate change; and
- how to build analytical and implementation capacity in developing countries to maximise synergies at local, regional and global levels of decision-making.

To support seminar discussions, the OECD commissioned several papers (including this one) from non-OECD country experts; authors were asked to comment on key interactions between climate change and sustainable development from their own regional or national perspectives. This paper is being released as an informal working paper in the hope that it will continue to stimulate interest and discussions on these topics in other fora.

The paper expresses the opinions of the author(s), and does not necessarily represent the views of either the OECD or its Member countries. Comments on the paper may be provided directly to the author(s): emilio@ppe.ufrj.br

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EXECUTIVE SUMMARY

The main purpose of this paper is to discuss main issues and approaches to build an equitable international regime to address climate change under a Brazilian perspective. The approach followed considers climate mitigation policy in the context of sustainable development. Three initial sections of the paper discuss the Brazilian case. Section I presents the main Brazilian stakeholders and the activities related to the Climate Convention, and reviews the current state of the national debate on climate change, environment and development. The connections between climate change mitigation and sustainable development strategies in the country are discussed in Section II, which presents some Brazilian programs leading to greenhouse gas (GHG) emissions mitigation as a co-benefit. In Section III some key barriers to integrating climate into national sustainable development strategies are identified.

In Section IV, suggestions are made towards overcoming them and tapping the potential for synergy between climate policies and sustainable development strategies in Brazil. Sections V and VI of the paper use the Brazilian case to assess and discuss the design of an evolving equitable regime to deal with climate change. Section V identifies some key issues and approaches in this field, covering the challenge of harmonising equity and economic efficiency and the analysis of a long-term burden-sharing scheme for such a regime included as part of the Brazilian proposal to COP3 in Kyoto. Finally, in Section VI some suggestions are made for future work in this area.

Some key conclusions of the paper can be summarised as follows:

- The main source of greenhouse gases emissions in Brazil is deforestation caused by the expansion of agricultural frontiers, mainly in the Amazon region. A number of development policies recently implemented by the Brazilian government have led to avoiding a significant amount of GHG emissions. The pace of deforestation in the Amazon has slowed in the nineties.

- Renewable energy production and improvements of the efficiency in energy use have made a significant contribution to avoided GHG emissions. Two original options favoured by Brazilian energy policy, the Ethanol Programme and PROCEL (energy efficiency improvements in the use of electricity), have led to significant GHG emission mitigation.

- An interesting proposal was made by the Brazilian government at COP 3 in Kyoto (MCT, 1997): the burden sharing among Annex I parties should be based upon the contributions to global temperature increase of each country since 1840 up to now, and not simply on their annual GHG emissions.

- Still inspired by the Brazilian proposal approach, a less ambitious suggestion would be to use the cumulative GHG emissions of individual countries since 1990 as a basis for establishing future mitigation targets.

- Taking this proposal's principles as a starting point, further work would explore the new set of SRES and TAR long-term global GHG emission scenarios to illustrate the combined effects of different trajectories of Annex I and non-Annex I GHG emissions. This analysis would supply useful insights to the negotiations on mitigation targets correspondent to different goals for long-term stabilisation of GHG concentrations in the atmosphere.

INTRODUCTION

1. The main purpose of this paper is to discuss main issues and approaches to build an equitable international regime to address climate change under a Brazilian perspective. The approach followed considers climate mitigation policy in the context of sustainable development. Three initial sections of the paper discuss the Brazilian case. Section I presents the main Brazilian stakeholders and the activities related to the Climate Convention, and reviews the current state of the national debate on climate change, environment and development. The connections between climate change mitigation and sustainable development strategies in the country are discussed in Section II, which presents some Brazilian programs leading to GHG emissions mitigation as a co-benefit. In Section III some key barriers to integrating climate into national sustainable development strategies are identified.

2. In Section IV, suggestions are made towards overcoming them and tapping the potential for synergy between climate policies and sustainable development strategies in Brazil. Sections V and VI of the paper use the Brazilian case to assess and discuss the design of an evolving equitable regime to deal with climate change. Section V identifies some key issues and approaches in this field, covering the challenge of harmonising equity and economic efficiency and the analysis of a long-term burden-sharing scheme for such a regime included as part of the Brazilian proposal to COP3 in Kyoto. Finally, in Section VI some suggestions are made for future work in this area.

I. Current state of the policy debate on climate change, environment and development in Brazil

3. As in many other developing countries, Brazil faces many difficulties to translate the growing awareness of the public opinion about environmental issues into concrete measures and sectoral development policies incorporating environmental concerns. This may be partly attributed to several reasons: Firstly, the distorted image of environmental issues disseminated by the media, emphasising the ‘green’ agenda only: fauna (especially endangered species) and the forests (particularly the Amazon). Given that the bulk of the Brazilian population lives far away from these problems, with the urban population now constituting 80% of the total, this has led to low levels of environmental awareness. Secondly, even though the population of the big cities (particularly the poor living in slums) suffer from pressing short-term environmental concerns, such as lack of solid waste collection and proper disposal, absence of sewage systems, poor quality of water, local air pollution, noise, each of these problems is perceived by the majority of the population as an isolated sectoral issue and this “brown” agenda is not widely recognized as a key component of the environment and development link. Both of these factors has lead to a situation in which the action of environmental agencies at the different government levels (federal, state and municipalities) is aimed at either the protection of natural ecosystems or pollution control, with few attempts at promoting an integrated agenda for sustainable development.

4. The situation in the climate change area mirrors these general difficulties, aggravated by the incipient stage of the activities and the debate between the limited number of stakeholders involved so far, as described below.

I.1. The institutional context: the main Brazilian stakeholders

5. During the preparation of the Climate Convention, before the Rio Conference (UNCED-92), the Federal Government established a Climate Change Advisory Unit within the Ministry of Science and Technology (MCT) in 1991. The Brazilian Space Agency, through its chairman, also provides technical support to the Minister and is a member of the Brazilian delegation at the Convention. The Ministry of

Foreign Affairs (MRE) is responsible of the general co-ordination of Brazilian position at the Convention, through its Environment Division. MCT provides technical support to the Climate Change Focal Point, co-ordinating the execution of the national activities carried out under the Convention (described in Section I.2 below).

6. In 1999, an Inter-Ministerial Commission on Climate Change was created, jointly chaired by MCT and the Ministry of Environment (MMA) gathering several Ministries, with the responsibility, among other assignments, to handle Clean Development Mechanism – CDM issues.

7. Until 1999, MMA's role was solely one of providing support to the MRE on the Biodiversity Convention, with no formal responsibility for the MMA within the Climate Change Convention. More recently, in the year 2000, the Secretary of Environmental Quality within the MMA, has started to work very actively in the field of climate change, aiming at growing awareness about its implications among its key target audiences: state and local government officials, industries and NGOs.

8. A Brazilian Climate Change Forum was established in August, 2000 with the president of the Republic, Dr. Fernando Henrique Cardoso, as its chairman. This forum will gather all the stakeholders in the field of climate change, including government institutions, the private sector, the scientific community and NGOs.

9. At the level of municipalities, local governments of the cities of Rio de Janeiro, Curitiba, Belo Horizonte and Porto Alegre have joined the international network Cities for Climate Protection – CCP (see Section II.1 below). The Environment Secretariat of Rio de Janeiro is hosting the Latin American office of CCP.

10. In the business world, the Brazilian section of the World Business Council for Sustainable Development (CEBDS) can be mentioned as having been active on the climate front. Both Industry Federations at São Paulo and Rio de Janeiro states have co-operated with CEBDS in the organization of meetings to increase the awareness within the private sector about climate change issues, including the CDM. Environmental finance consulting firms (e.g. EcoSecurities) have started the identification and design of CDM project proposals in the country and are looking for potential investors abroad.

11. A network of more than twenty scientific institutions is co-operating with MCT in the preparation of the First National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). Among them, those involved in this area since 1990 and the most active in IPCC as well are the Federal University of Rio de Janeiro and the University of São Paulo, in the energy field, and the National Spatial Research Institute – INPE in the land-use change and forestry field. The most recent development in the scientific community was the establishment of the Centre of Integrated Studies on Climate Change and the Environment at the Federal University of Rio de Janeiro in December 2000, sponsored by the MMA. This Centre will bring together the leading research institutes in this field and provide technical support to the ministries and the Forum.

12. Within the NGO community, the Brazilian NGO Forum has designated a representative in the Brazilian delegation to attend the UNFCCC official meetings. The Brazilian Foundation for Sustainable Development (FBDS) works closely with different industry branches on developing forestry schemes that could serve as carbon sinks. Finally, some NGOs including Winrock International are very active in promoting renewables in remote areas, and have recently launched a Brazilian Network of NGOs for Renewable Energy, RENOVE (La Rovere, 2000). Finally, a number of NGOs working on forest management in the Amazon are interested in the use of CDM projects to support the protection of the rain forest.

I.2. Activities carried out under the Climate Convention

13. After being the first country to sign the Climate Convention during UNCED in 1992, Brazil ratified the UNFCCC on 28 February, 1994.

14. The Brazilian government has carried out a preliminary inventory of Brazilian GHG emissions under the US Country Studies, from August, 1995 to May, 2000 (MCT, 2000), supported by some key scientific institutions (see I.1 above).

15. Under GEF Enabling Activities Program, the Brazilian government is finalising the First National Communication to the UNFCCC. Project BRA/95/G/31 was signed with UNDP/GEF on June 1996, and is scheduled to end in 2001. Its main focus has been on the preparation of the inventory of GHG emissions in the country. No official work on mitigation has been carried out (only independent studies from the scientific community). An initial study on the vulnerability of hydropower generation to climate change impacts has recently been started jointly by the MCT and ANEEL (The Federal Power Regulatory Agency).

16. Three important R&D projects are currently being implemented with GEF support in the country:

1. Biomass Integrated Gasification / Gas Turbine (BIG/GT) technology.
2. Energy Generation from Sugar Cane Bagasse and Wastes.
3. Demonstration bus running on fuel cell using Hydrogen.

17. The Brazilian delegation has been playing an active role in the Climate Convention negotiations. It must be stressed that Brazil was the single developing country to present a proposal for the assignment of emission limitation targets to individual parties at the Kyoto Conference of the parties. Even if it was not adopted by the COP, it paved the way to the establishment of the Clean Development Mechanism and is being considered by the Convention subsidiary bodies for possible use in the future as an interesting burden-sharing scheme (see Section V.2 below).

18. The Brazilian government was opposed to Joint Implementation projects before the signing of Kyoto's Protocol. Therefore, there were no projects undertaken in the country under the pilot phase of Activities Implemented Jointly. More recently, the CDM has received increasing attention from some large firms, both in the industry and forestry sectors, but the discussion of eligibility criteria at the Inter-ministerial Commission on Climate Change has not started yet.

II. Connections between climate change mitigation and sustainable development strategies: Brazilian programs leading to GHG emissions mitigation as a co-benefit

19. The main source of greenhouse gases emissions in Brazil is deforestation caused by the expansion of agricultural frontiers, mainly in the Amazon region. According to our estimates, CO_2 emissions from the combustion of fossil fuels are 1.5 to 2.5 lower than CO_2 emissions from deforestation, in 1998 (see Section IV.4 below).

20. Emissions from the energy system are very low indeed, in regard to population (0.5 tons of carbon per capita) but fairly high compared to economic activity (0.1 kg of carbon per US$ of GDP). The emission per capita figure is low mainly because GDP / capita is 7 to 10 times less than in industrialised countries.

21. To put it in an international perspective, Brazil is somewhere between the fifteenth and the twentieth place in the world rank of CO_2 emissions due to energy consumption, at a level corresponding to

roughly 1% of total global emissions. Brazilian CO_2 emissions per MWh of electricity generated are more than ten times lower than current US levels and in the car transportation sector CO_2 emissions per energy used are half of US figures.

22. Renewable energy production and improvements of the efficiency in energy use have made a significant contribution to avoided GHG emissions. Two original options favoured in Brazilian energy policy, the Ethanol Programme and PROCEL, have led to significant GHG emission mitigation. Both were conceived and implemented for other purposes than climate change, by different institutions than those active in this field (see Sections I.1 and IV.1). The lessons drawn from these two experiments are analysed below in greater detail.

II.1. The Ethanol Programme

23. One of the major responses of Brazilian government to the oil crisis, at a time when the country had to import over 80% of its domestic oil consumption, was the use of ethanol to reduce gasoline use as a car fuel. Since it was first launched in 1975, the Brazilian Ethanol Programme remains to date the largest commercial application of biomass for energy production and use in the world. It succeeded in demonstrating the technical feasibility of large-scale ethanol production from sugar cane and its use to fuel car engines. Since 1979, 5.4 million ethanol-powered cars have been manufactured in Brazil. In 1998, ethanol powered cars consumed 7.6 Gl (billion litres) of ethanol per year and 5.3 Gl of ethanol were used for the production of gasohol (blend of 22% ethanol with 78% gasoline) for the rest of the cars in the country.

24. After oil prices sharply decreased in the eighties, the major benefit of the Ethanol Programme was its contribution to curbing the increase of air pollution in Brazilian cities and of the greenhouse effect. In 1999, the production cost of alcohol was still higher than petrol manufactured from imported petroleum priced at just below US$ 20 per barrel (bbl), approximately equal to half of its international price in 1980 when the second phase of the Ethanol Programme was launched. The relatively high price of ethanol is the main reason of the financial difficulties faced by the programme from 1986 to 1999. Even in the region of São Paulo, where distilleries are most efficient, oil prices must be at least US $30 per bbl before ethanol is an economically effective alternative. Thus, when this oil price level was reached once more in the international market in the year 2000, most government subsidies to the programme were phased out. However, even if this high oil price is maintained, it will be difficult to resume the production of pure ethanol-fired cars at significant levels while high sugar prices in the international price make it more profitable to use sugar cane for sugar manufacturing and export than for ethanol production (many distilleries have this flexibility). Soft loans are not any longer available to increase ethanol production and governmental support to the programme is limited to the creation of a sizeable market by establishing a mandatory level of ethanol blending in the gasoline.

25. In the long run, the prospects for economic viability of ethanol are much better, considering the double impact of possible petroleum price hikes and of potential productivity gains in the production of alcohol and its by-products (especially through the introduction of improved fermentation technologies and the use of bagasse for power generation surplus to be injected in the national grid). This is especially true when one takes into account the macroeconomic impacts of the Brazilian Ethanol Program. Apart from foreign exchange savings of $18 billion from 1978 to 1990 in 1990 dollars (La Rovere, 1999), the programme has been responsible for the creation of 720,000 direct jobs and more than 200,000 indirect jobs in rural areas. This is important in Brazil where the rural exodus to the big cities is the cause of serious social and environmental disruptions. Finally, another benefit from the ethanol program, which is crucial for its survival, is its contribution to reduce the emission of local air pollutants (CO, NO_x, HC) from cars in Brazilian big cities (see Section IV.3 below). Ethanol production from sugar cane is not exempted of

environmental hazards such as upstream wastes (e.g. vinasses) but substantive technological progress has been made to control them since the beginning of the programme (La Rovere and Audinet, 1993). This evolution has led to the current situation where the overall environmental balance of the ethanol production chain compares favourably with the equivalent gasoline production chain.

26. The net avoided GHG emissions by sugar cane ethanol and bagasse in Brazil are not negligible. The carbon released in the atmosphere when bagasse and ethanol are consumed for fuel is more than compensated by an equivalent quantity of carbon absorbed by sugar cane during its growth. Macedo (1997) supplies some estimates of the annual avoided CO_2 emissions, summarised in Tables 1, 2, 3.

Table 1. Avoided CO2 emissions due to ethanol use as a fuel - 1996

	Ethanol Product. Billion liters/year	Replaced gasoline Billion liters/year	Avoided release* Million ton C/year
Anhydrous **	4.27	4.44	3.37
Hydrated***	9.47	7.58	5.76
Total	13.74	12.02	9.13

* 0.76 kg C / litre of gasoline
** 1 litre of anhydrous ethanol substitutes for 1.04 litre of gasoline in the 22% blend (i.e. 22% ethanol, 78% gasoline).
*** 1 litre of hydrated ethanol substitutes for 0.8 litre of gasoline in ethanol powered engines
Source: Macedo, 1997

27. Accounting for the replacement of gasoline only, the use of ethanol has avoided the release in the atmosphere of an average of 5.86 MtC per year from 1980 to 1990. The total of 9 MtC avoided in the year 1990 corresponds to about 18% of the total emissions of carbon due to energy consumption in Brazil in 1990. In the nineties, as the amount of avoided emissions from gasoline burning has stagnated around 9 MtC/year while total carbon emissions from the energy system have continued to grow, this figure was brought down to 12% in 1996. This still significant contribution to mitigate global warming is increased when the use of sugar cane bagasse (a by-product from the ethanol distillery process replacing fuel oil as a heat source in other sectors (besides supplying the steam needed at the distillery process itself) is also taken into account.

Table 2. Avoided CO2 emissions due to bagasse use as a fuel - 1996

Million tons/year Uses of bagasse	Bagasse Use (Mt) 50% moisture	Fuel oil replaced Million tons	Avoided Carbon MtC/year
Sugar production	28	4.9	4.2
Ethanol product.	37	6.5	(5.5)
Fuel,other sectors	7	1.2	1.0
Total	72	6.1	5.2

Source: Macedo, 1997

28. Adding up the avoided emissions from Tables 1 and 2, and taking into account GHG emissions in ethanol production, the overall results of the contribution of the ethanol programme to mitigate global warming are shown in Table 3 below for the same year of 1996.

Table 3. Net Avoided CO2 equivalent emissions due to ethanol and bagasse use as a fuel - 1996

	Million tons C equivalent / year
Fossil fuel use in the agro-industry (e.g. fossil-fuel driven machines)	+ 1.28
Methane emissions (cane burning, necessary for manual harvesting)	+0.06
N_2O emissions from soil (resulting from fertiliser use)	+0.24
Ethanol substitution for gasoline	- 9.13
Bagasse substitution for fuel oil	-5.20
Net contribution (total carbon uptake)	**-12.74**

Source: Macedo, 1997

29. As there are currently doubts about the cost-effectiveness of the Ethanol Program, its future expansion could be ensured through an adequate flow of foreign investment in the framework of the Clean Development Mechanism, given the Program's extensive environmental benefits. Naturally, meeting the additionality criterion required for CDM eligibility will depend upon the baseline in particular with respect to the levels of future oil and sugar prices in the international markets.

II.2. Energy efficiency: PROCEL's actions

30. PROCEL stands for Programme of Electricity Conservation, a governmental initiative created in December 1985 to co-ordinate public and private sector action to improve energy efficiency in the electricity sector, on both the demand and supply sides. Its mandate comes from the Ministry of Mines and Energy and early funding was provided through the Ministry of Planning. ELETROBRÁS, (the Brazilian government holding of public utilities) serves as executive secretariat of PROCEL, in charge of co-ordinating the efforts from governmental bodies, utilities, consumers, manufacturers, research institutes and other stakeholders in the electrical power sector.

31. Between 1985-1994, PROCEL suffered from insufficient budget allocations. After 1994, funding was substantially increased thanks to an important contribution from the Reserva Global de Reversão (RGR), a fund constituted by a share of electricity sales to foster investment in the sector and managed by the power sector governmental authorities in Brazil. Since then, PROCEL has achieved significant results, including the support to varied actions in the field of energy conservation in the country, as shown in Table 4 below.

Table 4. Annual Results achieved by PROCEL, 1986-1997

	1986-94	1995	1996	1997
Actual Investments (R$ million)	31.5	15.8	19.6	40.6
Energy Saved and Additional Generation due to supply efficiency improvements (GWh)	1274	572	1970	1758
Equivalent Power Generation Plant (i.e. capacity of power plant that would have to be constructed without the energy savings / additional generation above) (MW)[a]	300	135	430	415
Peak Power reduction (MW) (power reduction during peak-load periods)	219	103	293	976
Avoided Investment in the expansion of Power Supply (R$ million)	600	270	860	830
Note: [a] Obtained from Energy Saved and Additional Generation, considering a typical load factor of 56% for hydropower plants and including 15% of average losses in transmission and distribution for the energy saved.				

Source: La Rovere and Americano, 1999.

32. The cost-effectiveness of improving energy efficiency in electricity generation and use in Brazil is remarkable, both in terms of avoided investments (see Table 2 above) and costs (estimated at an average of 10 US$ / MWh saved), comparing very favourably with the alternative of expanding power supply.

33. PROCEL's energy efficiency measures are oriented toward both the demand side and supply side. Demand side projects are related to the use of power by final consumers. As electricity is consumed through electrical equipment such as appliances, PROCEL focuses on improving the energy efficiency of these devices. Among PROCEL's initiatives in this area are:

- Labelling programs to inform consumers about the average power consumption of appliances (the information thus provided to the consumers has allowed for a comparative analysis fostering the competition between manufacturers and even discontinuing the production of poorly efficient models).
- Granting energy efficiency labels for appliances to influence the choice of consumers.
- Funding of substitution of less energy efficient equipment by equipment certified as energy efficient in some pilot projects.
- Pilot projects for the energy efficient design of commercial buildings.
- Pilot projects to replace compact fluorescent bulbs (i.e. 'traditional') for incandescent (i.e. high-efficiency) bulbs in the residential sector (low-income households).
- Funding of efficient lighting projects.
- Energy efficiency programs in public buildings.
- Adoption of differentiated electricity prices according to the period of consumption, in some pilot projects (time-of-use tariffs).
- Pilot projects to install demand limiters in electrical showers (low price water heating devices using electrical resistances – an intensive use of electricity to provide low temperature heat) to encourage their use in off-peak periods.

- Retrofitting projects for public lighting.
- Marketing campaigns to modify consumption habits.

34. Supply side projects concentrate on reducing power losses along the generation, transmission and distribution power chain. Among these are:

- The installation of meters to reduce commercial losses due to widespread illegal consumption (theft related, at the distribution to final consumers; different from technical losses in transmission lines).
- Additional generating capacity to make more energy available to the grid through improvements to generation plants.

35. Besides these direct measures at the supply and demand sides, PROCEL has invested in upgrading general infrastructure, in research and development of new technologies, and in educational programs including training courses and workshops.

36. Moreover, PROCEL has also been instrumental in reforming Brazilian legislation affecting the power sector, primarily through a law instituting a National Energy Conservation Policy. In the restructured Brazilian power sector, PROCEL provides technical support to the newly created National Electrical Power Agency (ANEEL).

37. Overall GHG emissions from the power sector and avoided emissions by PROCEL were calculated in a study by La Rovere and Americano (1999). It is interesting to note that, under the assumptions of this study, PROCEL contributes significantly to reduced GHG annual emissions from the power sector. This contribution varies according to the specific year. In the nineties, hydropower has supplied the bulk of electricity consumption in the country and consequently the amount of GHG emissions from the sector was rather modest. In 1997, GHG emissions from the Brazilian power sector were of 17 million tons of CO_2 equivalent. In this same year, PROCEL activities resulted in 1.2 million tons of CO_2 equivalent of GHG emissions being avoided. However, PROCEL's expansion, coupled with the strong increase of thermopower generation foreseen for the next two decades, is estimated to result in avoiding the emission of 830 Mt of CO_2 equivalent cumulatively between 1990 and 2020. Meeting PROCEL targets will allow for a reduction equivalent to 32% of estimated GHG emissions from the power sector during this period.

III. Barriers to integrating climate change mitigation into sustainable development strategies in Brazil and ways to overcome them

38. In general, the restructuring of the energy sector and the deregulation of the economy favouring the deployment of market forces have contributed to increase the carbon intensity of Brazil's development path. This trend presents a major barrier to the incorporation of climate change concerns into development strategies in Brazil.

III.1. The key barriers: the restructuring of the energy sector and the deregulation of the economy

39. The evolution of the energy system in the nineties shows a fast increase in the consumption of oil and natural gas (50% between 1990 and 1998), increasing the share of fossil fuels in the national energy balance to more than 40%, as shown in Table 5.

40. The reversal of the trend toward more use of renewables previously observed in the eighties is due in part to the relative decrease of international oil prices after 1986 until the mid-1990s and the significant increase in domestic oil and gas production following the discovery of important Brazilian off-shore resources. However, financial constraints on the public budget have also severely affected public support for renewable energy production. Moreover, after the break-up of the monopoly previously belonging to Petrobras, the state-owned oil company, the restructuring of the energy sector has given momentum to the oil and gas sector.

Table 5. Brazilian National Energy Balance - 1990/1994/1998

Year	**1990**	**1990**	**1994**	**1994**	**1998**	**1998**
Unit	Mtoe	%	Mtoe	%	Mtoe	%
Source						
Oil	56.6	30.2	65.4	31.0	84.1	33.6
Natural Gas	4.2	2.2	5.0	2.4	6.6	2.6
Coal	9.5	5.1	11.2	5.3	12.3	4.9
Nuclear Energy	0.6	0.3	1.3	0.6	1.5	0.6
Total non renewable.	70.9	37.9	82.9	39.3	104.5	41.8
Hydro-power	67.6	36.1	79.6	37.8	95.9	38.3
Wood	28.2	15.1	24.5	11.6	21.2	8.5
Sugarcane	18.5	9.9	22.1	10.5	25.1	10.0
Others	2.1	1.1	1.7	0.8	3.4	1.4
Total renewable	116.4	62.1	127.9	60.7	145.6	58.2
TOTAL	187.3	100	210.8	100	250.1	100

Notes: part of the wood comes from deforestation and is not renewable
Mtoe = million tons of oil equivalent; 1 MWh = 0.29 toe
Source: MME, 1999

41. Since 1990, hydropower development has been delayed and the building of new plants has been considerably reduced. Due to the insufficiency of public funds to meet the huge investments required for its expansion, the power sector is now being progressively privatised. The effort started with distribution operations and is now reaching the power generation end of the business. The trend points to the building of gas-fired thermopower plants by the private sector, as a less capital-intensive option generally coupled with the availability of foreign capital willing to fund these projects. Petrobras is also acting as a major partner in the new investments required and is being used by the Government to foster the construction of natural gas–fired power plants.

42. The Ethanol Programme was frozen and is now seriously threatened. Following the withdrawal of the Government from the regulation of the sugar and ethanol production and use, market forces are favouring sugar production instead of ethanol production: sugar prices in the international market ensure profitability of its exports while ethanol is not competitive against cheaper gasoline. Eventually, the locally based multinational car manufacturers have favoured gasoline-powered cars and discontinued the mass production of ethanol engines. Small cars of 1,000 cc now dominate the market sales of new cars (70% of the total), and are only made available by the manufacturers running on gasoline (or "gasohol") and not ethanol. Moreover, the ethanol engine has not benefited from the evolution that has occurred in gasoline engines and, in particular, does not have all the "embarked electronics" needed to be competitive in today's market. As a result, sales of new ethanol-powered cars are down to nearly zero (from more than 90% of the total market in new cars in 1994).

43. The deregulation of the economy also reached the steel industry, leading to the privatisation of key mills. Now, charcoal use for pig iron production by the steel industry (partly renewable production from fast-growing planted forests) is being displaced by coke from coal, imported at the low prices recently prevailing in international markets. This trend has been reinforced by the enforcement of constraints on charcoal from deforestation by local environmental bodies, who now require a certificate of renewable production for the use of charcoal in the state of Minas Gerais where the bulk of the production is concentrated.

44. Privatisation of the power sector also menaces the continuity of energy efficiency improvement efforts supported by PROCEL. Domestic financial resources made available for Eletrobras to run the programme were substantially reduced. In the short and medium term, the continuation of PROCEL efforts was recently secured by a loan from the World Bank (150 million US$ matched to an equivalent amount in domestic currency from the Brazilian government).

45. The restructuring of the energy sector and the deregulation of the economy are thus contributing to a faster increase of Brazilian GHG emissions from the energy sector. As a consequence of the shift from renewables to fossil fuels, if the trends observed in the nineties persist, sometime between 2010 and 2020 CO_2 emissions from the energy system are bound to overtake emissions from deforestation. Economic growth will substantially increase energy needs followed by the consumption of oil and natural gas increasing faster than renewable energy production and use.

46. Current CO_2 emissions due to the energy system were calculated by PPE/COPPE/UFRJ for the government in the process of preparation of the First National Communication following the IPCC guidelines adapted to Brazilian circumstances (IPCC, 1996).

47. The preliminary results using the top-down methodology are available for the years 1990 and 1994 from the First National Communication draft posted in the web site of the Ministry of Science and Technology (MCT, 2000). Using more recent data from Brazil's National Energy Balance, we have estimated emissions for 1998 using the same IPCC top-down methodology. Table 6 shows the evolution of Brazilian CO_2 emissions due to the consumption of fossil fuels in the nineties.

Table 6. CO2 Emissions due to Fossil Fuels Consumption in Brazil – 1990-1998

(million tons of carbon per year)

	1990	1994	1998
Oil	42.9	49.6	67.0
Coal	10.2	12.3	14.8
Natural gas	1.9	2.3	3.0
Others	0.2	0.2	0.2
TOTAL	**55.2**	**64.4**	**85.0**

Source: PPE/COPPE/UFRJ, for 1990 and 1994; own estimates for 1998 (La Rovere, 2000)

48. Short-term prospects of Brazilian energy policy now point in exactly the opposite direction to a mitigation scenario which would minimise CO_2 emissions. Under current market trends natural gas, oil and coal use are favoured over the deployment of the huge potential for renewable energy production and energy efficiency improvements available in the country.

IV. Suggestions to tap the potential for synergy between climate policies and sustainable development strategies in Brazil

IV.1. The role of Regulatory Agencies in integrating environmental concerns into the restructuring of the energy sector

49. In order to overcome the barriers to integrating climate change mitigation into sustainable development in Brazil, it is crucial to take into account environmental concerns in the implementation of the national energy policy. To this end, the federal regulatory agencies recently created for the power sector (ANEEL) and the oil and gas sector (ANP) have a key role to play. They can work together with the federal and state agencies to signal environmental protection requirements to the private sector, through the setting and strict enforcement of environmental standards, laws and regulations. In other words, the restructuring of the energy sector must be adjusted to incorporate environmental goals in the performance of private firms monitored by the regulatory agencies.

50. Some recent developments illustrate the potential of this approach. ANEEL has directly contributed to fostering the implementation of small-scale hydropower plants (< 30 MW) creating a fast track for bidding and licensing of such projects: some 1,500 MW will be added to the power generation system thanks to the installation of dozens of small units in the coming years. Similarly, ANEEL has also become a key institution in the promotion of energy efficiency in the power sector through a regulation requiring that utilities invest 1% of the sales in energy efficiency (supply and demand sides) and R & D projects. Initially, 0.25% of the sales should be invested in end-uses allowing for the utilities to spend 0.75% of sales in the supply side. More recently, the minimum level of expenditures on energy efficiency measures on the demand side has been increased to 0.5% of the utilities' sales. Thus, after an initial phase when utilities were allowed to privilege in-house investments to reduce power generation and transmission losses, now an unprecedented market has developed for energy efficiency at the consumer end-use.

51. ANP has recently established an Environmental Agenda to be jointly pursued with the Ministry of Environment. The agenda includes a number of measures to prevent oil spills and to enforce the environmental regulations imposed on the sector, while simultaneously speeding up the process of issuing the environmental permits for the new oil and gas exploration, production and transportation facilities, which are expanding at very high rates. A similar initiative is being undertaken by ANEEL, mainly

interested in avoiding further delays in the expansion of power generation capacity due to environmental licensing problems.

52. In the future, these joint initiatives of the Ministry of Environment and the energy regulatory agencies could be broadened to include policies and measures to limit GHG emissions from the power and oil and gas sectors.

IV.2. Working with states and municipalities in the field of urban planning

53. Urban planning activities undertaken by local governments can contribute to mitigation of GHG emissions as a co-benefit. Some examples in Brazil are briefly summarised below. The case of the city of Curitiba is now known worldwide. More than two decades of ecologically driven local administrations have turned Curitiba into an urban planning model. Some distinguished features of the local government initiatives there include the design of the expansion of the city along selected transportation axes. The latter have allowed for the installation of express lanes where large buses run frequently, complemented by small buses for short trips. Bus stops were especially designed to allow for fast ticketing and passenger flow. A single ticket can be used for different journeys in a given time period, making it easier to commute within the transportation network. Thus, a fast and comfortable mass transportation system was created allowing for considerable reduction in traffic congestion and transportation time. Among the positive externalities of this system are significant reductions of local air pollution and also of GHG emissions, not to mention avoidance of congestion and noise in urban areas.

54. More recently, Curitiba and a few other Brazilian cities (Rio de Janeiro, Belo Horizonte and Porto Alegre) have joined the CCP – Cities for Climate Protection network established by ICLEI – International Council for Local Environmental Initiatives. One of the initial outcomes from this initiative is the inventory of GHG emissions from the city of Rio de Janeiro prepared for the local Secretary of Environment (SMAC and COPPE/UFRJ, 2000). Results are compared with GHG emissions from other cities from industrialized countries in Table 7.

55. In spite of a 15% increase between 1990 and 1998, per capita GHG emissions in Rio de Janeiro are considerably lower than in other world big cities.

Table 7. GHG Emissions from Rio de Janeiro and Selected Cities in the World

City	Year	Emissions (million tons of CO2 eq)	Population	Per capita emissions (ton CO2 eq /person)
Rio de Janeiro, Brazil	1990	10.889	5,435,952	2.0
Rio de Janeiro, Brazil	1998	12.906	5,633,407	2.3
Rome, Italy	1993	13.923	2,693,383	5.2
Berlin, Germany	1990	30.926	3,471,418	8.9
Los Angeles, USA	1990	32.133	3,485,398	9.2

Sources: SMAC and COPPE/UFRJ, 2000 for Rio de Janeiro;
ICLEI/CCP for other cities.

56. Besides the inventory of current and past GHG emissions, the study also quantified the amount of GHG emissions avoided by local government policies and measures (e.g. urban afforestation schemes) and identified a number of additional mitigation options (such as methane recovery from landfills and the improvement of bus transportation system) that will be included in a Climate Action Plan to be adopted by the local government of Rio de Janeiro. If implemented, it will be a pioneer effort to mitigate GHG emissions in Brazil, specifically because of climate change concerns. Emission reductions of about 25% in 2020 compared to a reference scenario could be achieved with this plan (SMAC and COPPE/UFRJ, 2000).

IV.3. Coupling climate change concerns to the struggle against air pollution from transport in big cities: win-win opportunities

57. Besides the above mentioned urban planning measures (design of the expansion of cities, methane recovery from landfills, urban afforestation, improvement of mass transportation systems), the synergy between climate change mitigation and reduction of air pollution from cars in big cities deserves special attention.

58. In this field, the Brazilian case is of course particularly marked by the Ethanol Program. Besides producing climate benefits, ethanol use in vehicles also allows for a substantial reduction of the main local air pollutants (CO, HC, NO_x) (see Table 8). The use of ethanol in cars has also completely eliminated the use of lead in gasoline and reduced the release of SO_2 (due to the low sulphur content of ethanol based fuels) and of hydrocarbons (La Rovere, 2000). The only environmental disadvantage of ethanol-powered cars compared to those powered by gasoline or gasohol lies in the production of aldehydes which are around five times higher in ethanol based engines than for gasoline. However, ethanol combustion produces mainly acetic aldehydes (acetaldehydes), less aggressive to human beings than formaldehydes found in petrol and in methanol based fuels. Facing high rates of acetaldehydes in the atmosphere, Brazil fixed a limit for aldehydes emissions in new cars in 1992, which was effective in controlling the problem.

59. Another important feature of the evolution of urban air pollution from cars in the Brazilian case is the adoption of limits for CO, HC, NO_x, and aldehydes emissions enforced on new cars within a programme of vehicle pollution control started in 1986 (Proconve). A second phase started in 1992, mandating car-makers to introduce catalysts in new cars manufactured. Tests made on new cars after 1986 showed significant progress due to additional technical innovations. Table 8 shows the evolution of emissions of successive generations of engines and the limits fixed within the Proconve. The success of the programme is illustrated by the large reductions of emissions after the establishment of norms. This has occurred for both the ethanol and gasohol engines, with a narrowing of the advantage of ethanol engines.

Table 8. Brazil - Emission Limits and Average Emissions of Light Vehicles
(Proconve)

Year	**Emissions**	**Exhaust gases** (gr/km)				**Fuel vapours** (gr/test)
		CO	HC	Nox	Aldehydes	
pre-1980[1]	pure gasoline	54.0	4.7	1.2	Na	Na
1986[1]	Ethanol	16.9	1.6	1.2	0.16	10.0
	gasohol[2]	28.0	2.4	1.6	0.04	23.0
1990[3]	**Limits**	24.0	2.1	2.0	-	6.0
	Ethanol	10.8	1.3	1.2	0.11	1.8
	Gasohol	13.3	1,4	1.4	0.04	2.7
1992[4]	**Limits**	12.0	1.2	1.4	0.15	6.0
	Ethanol	3.9	0.6	0.5	0.03	1.2
	Gasohol	5.9	0.5	0.6	0.01	2.3

1 No emission control.

2 Gasohol: 78% gasoline + 22% anhydrous alcohol.

3 1st phase of the Proconve. Average Values from New Light Vehicles.

4 2nd phase of the Proconve. Average Values from Certification of New Light Vehicle Models.

Source: La Rovere & Audinet, 1993.

60. The Ministry of Environment is now undertaking an evaluation of Proconve and aiming to suggest recommendations for the next phases of the program. Preliminary results from case studies of the car industry show a very good cost/benefit ratio for the two initial phases of Proconve. The discussion of new measures with the ministry of economics requires some monetary valuation of the benefits from reduced air pollution. In this case the positive health and improved quality of life benefits induced by more efficient cars and ethanol engines contribute to local and environmental protection. A good example of this positive synergy has arisen from the results of vehicle inspections that were recently enforced in the country, which have confirmed that older gasohol vehicles are more polluting. A programme to fund the replacement of these vehicles by new ethanol cars (allowing to foster the Ethanol Programme again), is under consideration. A double environmental dividend would thus arise, both at the local and global levels.

IV.4. Exploring the positive synergies with the implementation of other international conventions

61. The implementation of other international conventions can strengthen the integration of climate change concerns into sustainable development strategies. Besides the clear example provided by the experience with the Montreal Protocol, the Biodiversity and Desertification conventions deserve special attention in connection with Brazilian needs associated with adaptation to climate change.

62. So far, the Brazilian government has not officially started any vulnerability assessment by projecting regional temperature increase and sea-level rise. This stems from a lack of data, due to the Southern hemisphere's poor representation in general circulation climate models.

63. Some main concerns about the country's vulnerability, however, can be raised, including:

- Vulnerability of fragile ecosystems such as the tropical rain forest in the Amazon and the Pantanal flooded area.
- Changes in the rainfall pattern, especially in the North-eastern region of the country, already affected by droughts, with negative impacts on water resources and water supply as well as on agriculture, aggravating the risk of famine.
- Interaction of climate change with El Niño - southern oscillation effect (ENSO), amplifying its effects.
- Negative health effects of temperature rise associated with the expansion of certain disease vectors, such as mosquitoes transmitting dengue fever (*aedes aegypti*) and malaria (*anopheles darlingi*), and "barbeiros" (*tripanosomiasis americana*) transmitting Chagas disease.
- Vulnerability to sea-level rise of coastal areas where the bulk of population and economic activities are concentrated.
- Vulnerability of the energy supply, especially hydropower, to changes in rainfall patterns.

64. The biodiversity of the country, and particularly of the tropical rain forest in the Amazon, is impressive. Climate change can become a menace to its integrity. On the other hand, the current major source of GHG emissions in the country is deforestation, which is mostly intensive in the Amazon region. Accordingly, there is an obviously important synergy between the implementation of the biodiversity and climate change conventions in Brazil.

65. Good estimates of deforested land surface are available from satellite image recovery. However, the corresponding CO_2 emissions are very hard to quantify due to lack of reliable data concerning the biomass densities of the different kinds of forests and savannahs affected. Official governmental estimates will be available later this year, when the First National Communication to the UNFCCC will be delivered. The main source of uncertainty has been CO_2 emissions corresponding to different biomass densities of rain forest ecosystems affected by deforestation. Estimates have been employed based upon a range of biomass densities of typical rain forest ecosystems similar to those found in the Amazon region.

66. A wide spectrum of values is found in the literature for this highly controversial issue. Earlier estimates from Reis (1992) used average biomass densities of 270 to 400 tons of wood per hectare in the Amazon region, with roughly 50% of carbon content, giving a range from 135 to 200 t C / ha. More recently, lower values are assumed in revised estimates. The last report by the IPCC (2000a) provides a mean value of 120 t C / ha for tropical forests.

67. The problem is that recent deforestation in the 1990s in the Amazon has occurred mainly in the states of Mato Grosso, Pará, and Rondônia, the so-called "deforestation belt". In these agriculture frontier expansion areas there are transition regions covered not only by forests but also by savannahs with biomass densities that are far lower, down to some 70 t C / ha. Accordingly, in our estimates shown in Table 9, we have used a range from 70 to 120 t C / ha, to indicate the order of magnitude of this phenomenon.

68. A more accurate figure will soon be available from the Brazilian First National Communication. It includes a study based upon better estimates of biomass densities in the Amazon from an aerial photography survey done in the seventies (the RADAM project). Its methodology relies on the overlay of deforested areas (from recent satellite images) superimposed on the type of land cover, under the assumption that biomass densities of virgin land estimated in the seventies would remain constant (a reasonable hypothesis for mature ecosystems).

Table 9. Amazon Deforestation and CO2 Emissions from Deforestation

Period	Annual deforestation (thousand ha / year)	Annual emissions (million t C / year)	Annual emissions (million t CO_2 /year)
1978-1988 (average)	2,113	148 – 253	542 – 930
1989	1,786	125 – 214	458 – 785
1990	1,381	97 – 166	356 – 609
1991	1,113	78 – 134	286 – 491
1992	1,379	97 – 165	356 – 605
1993-1994	1,490	104 – 179	381 – 656
1995	2,906	203 – 349	744 – 1,280
1996	1,816	127 – 218	466 – 799
1997	1,323	93 – 159	341 – 583
1998	1,738	122 – 209	447 – 766
1999	1,693 *	119 – 203	436– 744

Note: * INPE estimate

Source: Own estimates (La Rovere, 2000) based upon INPE (2000) data for deforested area and on biomass densities ranging from 70 to 120 t C / ha; they include all the area where forest removal occurred (and not only where the forest was burnt) but do not account for the carbon content losses in the topsoil.

69. A number of development policies recently implemented by the Brazilian government have led to avoiding a significant amount of GHG emissions. The pace of deforestation in the Amazon has slowed in the nineties. Governmental policy shifted from favoring land clearing to limiting the removal of forest cover to a maximum of 20% of the surface of rural proprieties in the region. The total area of protected land under different kinds of conservation entities has reached 100 Mha (39 Mha in environmental protected areas and 61 Mha of Indian reserves) or 12% of the country's surface (MCT, 2000). Of course, the enforcement of these regulations must be improved and deserves top priority.

70. Reducing the pace of Amazon deforestation remains a major objective of Brazilian society and also a tremendously difficult challenge. Preservation of this natural resource can also maintain the possibility of long-term sustainable development in the region. Huge difficulties from technical, economic, financial, social, political and cultural concerns arise in the struggle against Amazon jungle-clearing. The expansion of the agricultural frontier in the Amazon Basin has traditionally been a rather complex issue in Brazil. In the past, ill-conceived policies to favour the occupation of the region have granted fiscal exemptions to big national and multinational industries installing huge farms and cattle raising activities, leading to extensive forest clearing. After the removal of these subsidies, the contribution to forest clearing from small farmers migration has increased its relevance, and is currently still fed by the lack of access to land by small farmers in the rest of the country due to insufficient agrarian reforms. The cost of stopping deforestation or shaping its development could hardly be quantified on purely economic grounds.

71. In this case, it is clear that short-term constraints to promote sustainable development and simultaneously contribute to prevent global climate changes should not be underestimated. Policies and measures adopted to implement both biodiversity and climate change conventions could aim to strengthen or enforce the protection of the Amazon forest. Concerning climate change, it seems wiser to place forest protection measures under the umbrella of adaptation policies and measures, in view of the controversial aspects of including it under CDM. The uncertainties about the carbon balance of mature tropical forests and mainly the risk of important leakages would jeopardise the GHG emission reduction credits of such CDM projects (La Rovere, 1998).

72. The same approach can be applied to the implementation of the Desertification Convention, which has a potential synergy with adaptation to climate change of the North-eastern region of the country. The acuteness of the desertification problem in Brazil can be ascertained from the indicators shown in Table 10.

Table 10. Brazil: Some Land-Use Indicators

Total country area (million hectares)	845.651
Forest area – 1980 (million hectares)	585.00
Forest area – 1990 (million hectares)	563.91
Forest area – 1995 (million hectares)	551.14
Average annual change 1980-90 (%)	(0.6)
Average annual change 1990-95 (%)	(0.5)
Total fertile land – including arid land (million hectares)	80.76
Desertification of irrigated, cultivated and pasture land (million hectares) *	69.95
Land affected by desertification (% of total fertile land) *	87

* Note: Includes moderate, severe and very severe desertification, but no light desertification
Source: World Bank, 2000

73. The North-eastern region of Brazil is the poorest region of the country, and its population density is much higher than in the Amazon. It has traditionally suffered from the effects of severe droughts. The changes in rainfall patterns and in ENSO induced by climate change may further affect the already limited availability of water resources and aggravate the risk of famines due to the disruption of agricultural and cattle raising activities.

74. Any policies and measures aimed at implementing the Desertification Convention are likely to go hand in hand with the adaptation of the region to climate change, and vice-versa.

V. Main issues and approaches relevant for an international regime on climate change

V.1. Equity and economic efficiency challenges

75. Mitigating the building-up of GHG concentrations in the atmosphere requires limiting global annual GHG emissions which have grown significantly since pre-industrial times. The case of CO_2, the most important GHG, is illustrative: global emissions have reached today about 7 GtC/year (billions of tons of carbon per year). Around 6 GtC/y are due to the widespread burning of fossil fuels (coal, oil and natural gas) throughout the economy and the balance can be attributed to agriculture and land-use change (including deforestation). Despite natural processes of ecosystems, which remove roughly half of anthropogenic emissions from the atmosphere, CO_2 concentration increased from about 280 to 367 ppmv (parts per million by volume) between 1750 and 1992. Drawing on this and other information, IPCC recently found that evidence points to a significant human interference with the climate system (IPCC, 2001).

76. One of the key features of the UNFCCC is its recognition of the principle of common but differentiated responsibility of its parties. Industrialised countries were responsible for the bulk of GHG

emissions since the Industrial Revolution until now and should take the lead in the effort to limit their amount. But developing countries will also be responsible for a growing share of emissions. Eventually they will need to curb the expected growth of their GHG emissions in the long term due to the future increase in the consumption of fossil fuels and deforestation as their economies expand.

77. The UNFCCC distinguishes different responsibilities for mitigation. It establishes stronger mitigation responsibilities for some countries including most OECD and transitional economy countries. These countries are known as “Annex I countries” as they are listed in Annex I to the Convention. Altogether they were responsible of roughly 75% of the global CO_2 emissions in 1990 (IPCC, 1995). Of these total Annex I emissions, Table 11 shows the relative contribution of individual countries:

- The United States is solely responsible of more than one third of Annex I emissions[1].
- The emissions of the US and Russia add up to over half of Annex I emissions; when Japan and Germany are included, the four countries account for almost 70% of the total.
- Adding the United Kingdom, Canada and Italy the level of 80% of total Annex I emissions is reached.
- Summing up Poland, France, Australia and Spain, the group of only 11 countries is responsible of 90% of total Annex I CO_2 emissions in 1990.

78. Moreover, Annex I countries were also responsible for the bulk of CO_2 emissions before 1990 since the Industrial Revolution began and first developed there. Consequently, their contribution to the anthropogenic increase in atmospheric CO_2 concentration levels, as of 1990, is estimated at 79% (IPCC, 1995), which is higher than the above mentioned values in the case of annual emissions.

79. Finally, greenhouse gases remain in the atmosphere for a long time and CO_2 in particular has a relatively long residence time in the climate system, of the order of a century or more. Coupled with the natural inertia of the atmospheric processes, this introduces an important time lag between changes in emissions, changes in concentration and, finally, warming due the greenhouse effect. Thus, the contribution of Annex I countries to the actual temperature increase due to CO_2 emissions registered in 1990 is even larger, reaching 88% against 12% for non-Annex I countries (IPCC, 1995).

80. It must be acknowledged that the responsibility of non-Annex I countries for emissions, atmospheric concentrations and corresponding temperature increases may be larger than indicated by CO_2 only figures due to other greenhouse gases, emissions of which can be relatively significant in developing countries (e.g. methane emissions from paddy fields and animal husbandry activities). The contribution of non-Annex I countries is also bound to increase in the future due to their development needs, as previously mentioned. Nevertheless, the overwhelming responsibility of Annex I countries is firmly established today for the build up of the greenhouse effect and this will remain the case for some time in the future.

81. The compromise among the parties reached in the final text signed during UNCED-92 duly recognizes this responsibility; Article 3.1 of the UNFCCC clearly states the common but differentiated responsibility of its parties and that developing countries must be compensated for the “agreed full incremental costs” incurred to limit their GHG emissions (UN, 1992).

82. Cheap substitutes for fossil fuels on a large scale are not immediately available, even if the medium and long-term prospects for renewables (e.g. solar, wind, biomass and hydropower) and energy

[1] The US also contributed roughly 27 % of global CO_2 emissions in 1990, more than all the 131 non-Annex I countries taken together.

efficient technologies are increasingly promising. Large short-term GHG emission reductions would thus involve economic costs and/or changes in lifestyles and consumption patterns. This is a main reason why many Annex I countries have been resisting any setting of quantitative targets and deadlines for GHG emission reductions. On the other hand, this position neglects the evidence shown in several studies of a large potential to be tapped through “win-win” or “no-regret” opportunities: e.g., cost-effective energy efficiency measures that simultaneously contribute to GHG emissions reductions and are hampered by non-economic barriers such as institutional distortions, lack of information, inadequate legislation, cultural inertia, etc. (See Hourcade, Richels, Robinson et al, 1996).

83. Other policy tools directed towards limiting the use of fossil fuels, such as a “carbon tax” (imposed on the amount of carbon emissions) or an “energy tax” (based upon the energy content of fossil fuels) have also raised considerable opposition from Annex I countries. For example, the US administration and Congress are very sensitive to new taxes, and vehemently oppose the possibility of making such action obligatory through international mechanisms. It is true that many economic model runs have predicted significant GDP losses and employment level reductions in the US economy as a result of the adoption of a carbon or energy tax. But again, this position does not take account of other studies which have shown positive impacts on the economic growth and employment levels were the revenues of the carbon/energy tax recycled into the economy through the reduction of labour taxes (Hourcade, Richels, Robinson et al, 1996).

Table 11. Relative Contribution of Individual Countries to Annex I Total CO2
Emissions in 1990 as Reported by National Inventories to the UNFCC

Country	% of Annex I
United States	36.219
Russian Federation	17.453
Japan	8.439
Germany	7.410
United Kingdom	4.216
Canada	3.380
Italy	3.134
Poland	3.032
France	2.678
Australia	2.111
Spain	1.661
Romania	1.250
Netherlands	1.225
Czech Republic	1.211
Belgium*	0.757
Bulgaria	0.606
Greece	0.600
Hungary	0.524
Sweden	0.448
Austria	0.433
Slovakia	0.426
Finland	0.394
Denmark	0.380
Switzerland	0.329
Portugal	0.308
Estonia	0.276
Norway	0.259
Ireland	0.224
New Zealand	0.186
Latvia	0.168
Lithuania*	0.161
Luxembourg	0.083
Iceland	0.016
Liechtenstein	0.002
Monaco	0.001

* Oak Ridge National Laboratory data
Source: MCT, 1997

84. Instead, at COP 3 in Kyoto, Annex I countries insisted on the establishment of international flexibility mechanisms such as emissions training, joint implementation and CDM to help them to cost-effectively limit GHG emissions. The wide variety of opportunities to reduce GHG emissions lead to different mitigation costs throughout the world. Thus, an economic efficiency concern on a global basis would prioritize tapping the cheapest GHG abatement measures first, regardless of the country where they are located. A country with expensive abatement options could be brought to invest abroad in cheaper mitigation measures. If and when the Kyoto protocol is ratified, these mechanisms will come into play.

85. However, it is important to avoid the shift away from efforts to change the wasteful lifestyles and consumption patterns of Annex I countries towards the search for cheap and profitable abatement opportunities in non-Annex I countries. Under such a scenario, the whole process of development of low-carbon technologies in Annex I countries and their transfer to non-Annex I countries could be considerably slowed down (IPCC, 2000). Developing countries would have no incentives to discontinue development paths following OECD countries, leading worldwide to wasteful consumption patterns.

86. Besides this concern about over-reliance on the Protocol's flexibility mechanisms, there is also the concern about the financial additionality of CDM projects, which may just drain resources potentially available to recipient countries through usual aid channels.

87. Today, significant capital resources in the international market flow to developing countries. Investors seek short-term profitable opportunities in financial applications, but are not willing to face the large up-front costs, long payback periods and important risks associated with investments in renewables, energy efficiency and afforestation projects. Moreover, 80% of private foreign investments are concentrated in 12 rapidly developing countries. Meanwhile, ODA has decreased by 25% in the last four years. CDM projects could play a role to reduce this resource gap but not close it (see La Rovere, 1998).

88. How these challenges are addressed in the implementation of the Kyoto Protocol will be crucial and set the path to the subsequent rounds post-Kyoto towards the establishment of an equitable international regime for climate change mitigation.

V.2. The burden-sharing scheme of the Brazilian proposal to Kyoto

89. An interesting proposal was made by the Brazilian government at COP 3 in Kyoto (MCT, 1997): the ceiling of the contribution to the temperature increase of all Annex I countries taken together would correspond to a trajectory with constant GHG (CO_2, CH_4 and N_2O) emissions from 1990 to 2000, and then a constant decrease of annual emissions to reach a level 30% smaller than in 1990 by the year 2020. The interesting feature of this proposal is that the burden-sharing among Annex I parties is based upon the contributions to global temperature increase of each country since 1840 up to now, and not simply on their annual GHG emissions. Targets would be assigned according to this criterion to each Annex I country in 2005, 2010, 2015 and 2020. Table 12 shows the results obtained in terms of GHG emissions reductions required from each Annex I country in 2010 as a percentage of their 1990 levels.

90. It is important to notice the very different ranking of Annex I countries in Table 12 compared with a ranking purely based on annual GHG emissions in 1990 (see Table 11). In Table 12, the top of the ranking is occupied by the United Kingdom, reflecting the accumulated burning of fossil fuels in the past since the Industrial Revolution, while countries industrialising at a later date fall lower in the ranking.

91. Responsibility due to past emissions was first raised during the preliminary discussions on the drafting of the UNFCCC by a group of Indian scientists, under the leadership of Anil Agarwal. At that time, Annex I countries tried to dismiss this argument alleging that they could not be blamed for a negative impact on the world climate of their past GHG emissions if at that time they did not know about the

consequences of burning fossil fuels. According to this view the first year to be taken into account would be 1990, when the IPCC published its First Assessment Report warning that GHG emissions could have been contributing to global warming. However, laws and regulations applicable to other environmental impacts in most countries adopt the legal principle of "objective responsibility;" that is, in US and Brazil alike, a polluter can not escape a penalty by claiming unawareness of the environmental damages caused.

92. The Brazilian proposal at COP3 had also called for establishment of a mechanism to sanction non-compliance: a penalty for Annex I countries not meeting the targets of US $10 per ton of carbon equivalent of GHG emissions above the ceiling calculated at each benchmark - 2005, 2010, 2015 and 2020 (MCT, 1997). The intention here was the creation, using the financial resources from the penalties, of a Clean Development Fund for implementation of projects from non-Annex I countries aiming at climate change mitigation (or adaptation, up to 10% of the total amount of resources). The access of each country to this special fund would also be limited to its relative contribution to global warming since 1990 to date: e.g., according to the IPCC emissions scenario IS92a (IPCC, 1994), considering the period 1990-2010 China would be entitled to up to 30% of the total amount of the fund, followed by India (8.5%), Mexico (4.5%), Kazakhstan (4%), Venezuela (4%) and Brazil (3%) (MCT, 1997).

Table 12. Brazilian Proposal for COP 3
GHG Emissions Reductions in 2010

Annex I countries - (% of 1990 levels)

Country	%
United Kingdom	63.27
Luxembourg	41.69
Belgium	37.39
Germany	27.41
Sweden	24.96
Monaco	24.50
France	24.36
United States	22.76
Hungary	20.26
Netherlands	18.79
Slovakia	18.22
Czech Republic	18.22
Denmark	17.83
Austria	17.56
Poland	16.70
Canada	16.11
Iceland	16.04
New Zealand	16.00
Ireland	13.96
Switzerland	13.48
Liechtenstein	13.48
Norway	12.40
Lithuania	11.51
Latvia	11.51
Russian Federation	11.51
Estonia	11.51
Australia	11.31
Romania	10.93
Bulgaria	10.85
Finland	10.69
Italy (including San Marino)	10.54
Spain	10.48
Japan	9.45
Portugal	8.43
Greece	7.49

Source: MCT, 1997

93. It is well known that the Brazilian proposal was not adopted at Kyoto, but it helped to shape the CDM as one of the flexibility mechanisms of the Kyoto Protocol. Some elements of the Brazilian proposal are also useful in the design of an acceptable burden-sharing scheme for a long-term equitable international regime to address climate change in the context of sustainable development, as discussed below.

VI. Prospects for future work: designing an acceptable burden-sharing scheme and making it operational under the framework of the UNFCCC

VI.1. Main obstacles to the application of the Brazilian proposal in the UNFCCC negotiations

94. The Brazilian proposal faces some major difficulties that hamper its capacity to be immediately operational in the UNFCCC negotiations.

95. First, from a scientific perspective, the calculations made in the Brazilian proposal of the contributions from the different countries to the global temperature do not take into account the response of the Earth's ecosystems to the GHG emissions. Over long periods, these natural responses may result in a significant change to an individual country's contribution to global warming, depending on when they started to release significant amounts of emissions. A study group gathering international experts including some Brazilian representatives was established by the Secretariat of the Convention to review this issue and provide the subsidiary bodies of the UNFCCC with recommendations on how to make the necessary corrections in the calculations to take into account this phenomenon.

96. Second, going back to the nineteenth century presents serious problems due to the reliability of data on GHG emissions from individual countries to serve as a basis for negotiating future mitigation targets. Even for CO_2 emissions from the energy systems it would be rather difficult to reach a consensus on the figures for years far back in the past. For emissions from land-use change and of non-CO_2 greenhouse gases, reliable figures for nineteenth century years seem impossible to obtain.

VI.2. An alternative proposal for a burden-sharing scheme in a international regime on climate change

97. A crucial issue for long-term stabilisation of GHG concentration in the atmosphere is how to motivate non-Annex I countries to engage in less carbon intensive development patterns. The Brazilian proposal can offer a new approach to take non-Annex I countries aboard. So far, negotiations within the UNFCCC have faced a deadlock, with non-Annex I countries trying to establish a connection between the UNFCCC goals and sustainable development, through mechanisms to favour the North-South transfer of financial resources and technology. In contrast, Annex I countries focus on their economic losses due to mitigation of greenhouse gas emissions and emphasise the need of non-Annex I countries to come aboard in order to achieve UNFCCC goals. The Brazilian proposal supplies a starting point to break this deadlock. Focusing on the main goal of stabilising the global climate change, it quantifies the different individual contribution of each party to the temperature increase and consequently to the required efforts to solve or minimise the problem.

98. Still inspired by the Brazilian proposal approach, a less ambitious suggestion would be to use the cumulative GHG emissions of individual countries since 1990 as a basis for establishing future mitigation targets. The rationale for this proposal is based on:

- As illustrated by recent IPCC work (IPCC, 2000), cumulative emissions supply a reasonable "proxy" for the relative contribution to global warming of different parties to the UNFCCC, when considered in a time period limited to a few decades.

- Data reliability problems would be solved through proper review of inventories presented as part of national communications to the UNFCCC, which are due from 1990 on.

- The discussion about objective or subjective responsibility for global warming would be avoided as the harm caused by GHG emissions to the global climate was clearly established by IPCC in 1990.

- This principle can be immediately adopted without defining the exact date when non-Annex I countries would be committed to mitigation targets, which can be left open for future negotiations under the UNFCCC framework. The importance of this first step would be to convey a clear sign to non-Annex I countries that they will be rewarded by any early action towards a lower carbon development style, as it will help them to face milder mitigation targets in the future, no matter when they will be committed to them.

99. Taking this proposal principle as a starting point, further work would explore long-term global GHG emission scenarios to illustrate the combined effects of different trajectories of Annex I and non-Annex I GHG emissions. This analysis would supply useful insights to the negotiations on the initial date of non-Annex I countries commitment to mitigation targets, according to different targets for long-term stabilisation of GHG concentrations in the atmosphere. In general, annual GHG emissions from Annex I countries as a whole would be required to continuously decline, while those from non-Annex I countries as a whole would be allowed to increase during an initial period to eventually stabilise and finally decline until the end of the century. This kind of "safe-landing" analysis would build upon the recent IPCC work results provided by the new set of reference scenarios (Special Report on Emission Scenarios, by Nakicenovic et al, 2000) and the corresponding stabilisation scenarios (Third Assessment Report, Working Group III, chapter 2, IPCC, 2001, forthcoming).

100. Concerning the duration of the grace period for non-Annex I countries to be free from mitigation targets, different approaches can be proposed for the UNFCCC negotiations.

101. In the Brazilian proposal it has been calculated that, according to the IPCC emission scenario IS92a, annual CO_2 emissions from non-Annex I countries taken as a whole will overtake those from Annex I countries in the year 2037. But taking into account accumulated emissions since 1840, the overall contribution to the global temperature increase from non-Annex I countries will equal the contribution from Annex I countries only in the year 2147, according to the same IS92a emission scenario (MCT, 1997).

102. The IPCC Special Report on Emission Scenarios (Nakicenovic et al, 2000) estimated the dates when cumulative CO_2 emissions since 1800 from developing countries as a whole would overtake those from industrialised countries, according to different global reference scenarios. The results cover a wide range of possible pathways and outcomes, with the cross-over dates varying from the year 2040 (under A1 scenario) to 2050 (A2 and B1 scenarios) and 2110 (B2 scenario). Similar analyses could be easily undertaken for cumulative GHG emissions since 1990, and the corresponding dates could be anticipated.

103. The starting year for commitments to mitigate could be established for all non-Annex I countries simultaneously, based upon each individual country's relative contribution to the cumulative GHG emissions since 1990. The basis for establishing a single initial date can be a parallel with the behaviour of Annex I countries. As previously mentioned, the contribution of Annex I countries as a whole to the CO_2 concentration level in the atmosphere in 1990 is estimated to be 79%, which is larger than their contribution to the global annual CO_2 emissions in 1990 (75%) and lower than the contribution to the actual temperature increase due to CO_2 emissions registered in the same year, reaching 88% (IPCC, 1995). These calculations can be updated in the year when Annex I countries will finally start to implement some mitigation targets (2008-2012 if the Kyoto Protocol is ratified). Then, the date when non-Annex I countries would reach a similar level of contribution to global cumulative GHG emissions since 1990 (somewhere between 50% to 90%, to be negotiated) would be set as the end of the grace period for all non-Annex I countries. This approach could also provide an incentive to Annex I countries that are taking the lead, as the sooner they start implementing mitigation targets, the sooner non-Annex I countries will be taken aboard.

104. Alternative approaches are also possible. For example, before any of the deadlines for non-Annex I countries as a whole are attained, some individual non-Annex I countries (those which really matter in terms of contribution to climate change) will reach a given threshold of contribution to global warming. Such a threshold could be established as the end of the individual grace period to which they are entitled. Once a country reaches such a threshold, non-Annex I countries would then be committed to mitigation targets, provided that the corresponding financial compensation guaranteed by the FCCC be duly channeled to them. The specific level of such a threshold could be negotiated and settled according to different criteria. Again, the analysis of long-term global and national GHG emission scenarios would provide useful inputs to this discussion.

CONCLUSIONS

105. Some key findings of this work can be summarised as follows:

- The main source of greenhouse gases emissions in Brazil is deforestation caused by the expansion of agricultural frontiers, mainly in the Amazon region. A number of development policies recently implemented by the Brazilian government have led to avoiding a significant amount of GHG emissions. The pace of deforestation in the Amazon has slowed in the nineties.

- Renewable energy production and improvements of the efficiency in energy use have made a significant contribution to avoided GHG emissions. Two original options favoured by Brazilian energy policy, the Ethanol Programme and PROCEL (energy efficiency improvements in the use of electricity), have led to significant GHG emission mitigation.

- An interesting proposal was made by the Brazilian government at COP 3 in Kyoto (MCT, 1997): the burden sharing among Annex I parties should be based upon the contributions to global temperature increase of each country since 1840 up to now, and not simply on their annual GHG emissions.

- Still inspired by the Brazilian proposal approach, a less ambitious suggestion would be to use the cumulative GHG emissions of individual countries since 1990 as a basis for establishing future mitigation targets.

- Taking this proposal principle as a starting point, further work would explore the new set of SRES and TAR long-term global GHG emission scenarios to illustrate the combined effects of different trajectories of Annex I and non-Annex I GHG emissions. This analysis would supply useful insights to the negotiations on mitigation targets correspondent to different goals for long-term stabilisation of GHG concentrations in the atmosphere.

REFERENCES

Hourcade, J.C.; Richels, R.; Robinson, J. et al. (1996), "Estimating the Cost of Mitigating Greenhouse Gases", Economic and Social Dimensions of Climate Change, IPCC Second Assessment Report, Cambridge University Press, vol. 3, p.263-296.

INPE - Instituto Nacional de Pesquisas Espaciais; Dados do Desflorestamento da Amazônia, 2000.

IPCC - Intergovernmental Panel on Climate Change, Third Assessment Report : Climate Change 2000, Cambridge University Press, 2001 (forthcoming).

IPCC - Intergovernmental Panel on Climate Change; Special Report on Land Use, Land Use Change, and Forestry, Cambridge University Press, 2000.

IPCC- Intergovernmental Panel on Climate Change (Nakicenovic, N. et al); Emissions Scenarios, a Special IPCC Report, Cambridge University Press, 2000.

IPCC - Intergovernmental Panel on Climate Change; Greenhouse Gas Inventory reporting Instructions - Revised IPCC Guidelines for National Greenhouse Gas Inventories, 1996.

IPCC - Intergovernmental Panel on Climate Change (1995), Second Assessment Report: Climate Change 1995, Cambridge University Press.

La Rovere, E.L.; "Scoping of possible CDM project candidates and stakeholders in the Brazilian context", First Report to the South-South-North – SSN Project, October 2000.

La Rovere, E.L.; "Brazil Case Study" in A Climate of Trust Report : Domestic Actions in Developing Countries To Advance Development Priorities While Slowing Down Climate Change, National Environment Trust, Washington DC, October 2000.

La Rovere, E.L.; "Vingt-cinq Ans d'Éthanol au Brésil", Biofutur, 195, p.20-21, Decembre 1999.

La Rovere, E. L.; Americano, B.; "Assessment of Global Environmental Impacts of PROCEL: GHG Emissions Avoided by PROCEL, 1990-2020", Final Report to Eletrobrás, September, 1999.

La Rovere, E.L.; "The Challenge of Limiting GHG Emissions through Activities Implemented Jointly in Developing Countries : a Brazilian Perspective", Ernest Orlando Lawrence Berkeley National Laboratory, LBNL-41998 Report, November 1998.

La Rovere, E.L.; "Climate Change Convention: a Tool of Sustainable Development?", in Economies et Sociétés, Série F, n° 36, 1/1998, p.247-259.

La Rovere, E.L., Legey, L.F. and Miguez, J.D.G.; "Alternative energy strategies for abatement of carbon emissions in Brazil", Energy Policy, 1994, vol.22, n° 11, p. 914-924.

La Rovere, E.L.; Audinet, P.; Environmental Benefits of Brazilian Ethanol Program, Proceedings of the First Biomass Conference of the Americas : Energy, Environment, Agriculture and Industry, Burlington (USA), August 1993, vol. III, p. 1533-1546.

La Rovere, E.L. (coord.); Santos, M.A.; Almeida, M.A.; Schechtman, R.; Rosa, L.P.; Legey, L.F.; Analysis of Abatement Costing Issues and Preparation of a Methodology to Undertake National Greenhouse Gas Abatement Cost Studies. Country Study : Brazil, UNEP/CCEE, Roskilde, May 1993.

Macedo, I.; Greenhouse Gas Emissions and Bio-Ethanol Production/Utilization in Brazil, Centro de Tecnologia Copersucar, Internal Report CTC-05/97, January 1997.

MCT - Ministry of Science and Technology, Brazil; “Brazil and the Climate Convention”, 2000, http://www.mct.gov.br/clima, including :

- MMA; “Unidades de Conservação”, by Dias, B.F.S., Marino, M. and Gastal, M.L.A., Ministry of Environment and the Amazon.
- PPE/COPPE/UFRJ; “Relatório das Emissões de Carbono Derivadas do Sistema Energético”, by Rosa, L.P., Schechtman, R., Santos, M.A. and Ribeiro, S.K., Energy Planning Program, Federal University of Rio de Janeiro.

MCT - Ministry of Science and Technology, Brazil; Proposed Elements of a Protocol to the UNFCCC Presented by Brazil in Response to the Berlin Mandate, http://www.mct.gov.br.gabin/clima.htm, May 1997.

MME - Ministry of Mines and Energy Brazil; "National Energy Balance", Brasília, 1999.

Reis, E.; "An Econometric Model of Amazon Deforestation", IPEA, Rio de Janeiro, June 1992.

SMAC - Secretaria Municipal de Meio Ambiente da Prefeitura do Rio de Janeiro; COPPE/UFRJ - Programa de Planejamento Energético, Instituto de Pesquisa e Pós-Graduação de Engenharia, Universidade Federal do Rio de Janeiro; “Inventário de Emissões de Gases de Efeito Estufa do Município do Rio de Janeiro”, Rio de Janeiro, 2000.

United Nations; United Nations Framework Convention on Climate Change, A/AC237/L14, 8 May 1992.

World Bank; “Esboço de Estratégia Ambiental Regional para a América Latina e o Caribe”, August 7, 2000.