ECO
NOMIA
DO
CLIMA
ESTUDO ECONÔMICO DAS MUDANÇAS CLIMÁTICAS NO BRASIL

The Economics of Climate Change in Brazil
costs and opportunities

EXECUTIVE SUMMARY

This study was inspired by the United Kingdom's Stern Review Report, a comprehensive economic analysis of the climate change problem on a global scale. Conducted by Brazilian public institutions involved in the area, this study was grounded on scientific rigor, free thinking, and the search for a consensus among all its actors, reviewers and members of its Advisory Council. Due to its pioneering nature, the results must be considered as both an initial approach to a complex problem, and a contribution towards discussion of the issue.

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Executive summary

The climate transition projected by the Intergovernmental Panel on Climate Change – IPCC – will affect the world's natural resources, economy, and societies to an extent which is not yet known. The study The Economics of Climate Change in Brazil (EMCB) is a pioneering initiative aimed at analysing and quantifying the impact of climate change on the country's development agenda. Without a greater evidence base of these trends, decision makers do not have the instruments needed to identify the more serious and urgent risks and to evaluate and implement prevention and adjustment measures which are more efficient in terms of cost and benefits.

For the first time in the country, a large interdisciplinary team, comprised primarily of scientists of the country's main research centers, gathered to make projections regarding various sectors. The starting point were computational models that provided projections on future national climate trends, such as temperatures, precipitation levels and hydrologic flows. These projections were used in models for certain sectors of the economy, and translated into economic terms the expected impacts in each sector, according to two future climate trends projected by the IPCC – scenarios A2 and B2.

These IPCC climate trends are based on hypotheses regarding the future behavior of the global economy. This study attempted, to the extent possible, to simulate the future behavior of the Brazilian economy in a manner which was compatible with the hypotheses set forth by the IPCC for the global economy. The scenarios projected for the Brazilian economy were A2-BR, which was simulated with and without climate change according to IPCC's A2 climate scenario, and B2-BR, which was simulated with and without climate change according to IPCC's B2 scenario. Both generated future trends for the Brazilian economy, based on IPCC's economic assumptions for climate scenario A2 and climate scenario B2[1].

Although the climate problems associated with global warming are long-term, the year of 2050 was established as the horizon for the simulations, thus excluding the more severe effects on productivity and Gross Domestic Product (GDP) which will become more severe after the second half of the 21st century. This was necessary since the uncertainties involved – especially macroeconomic – are still too large, and because the database was unable to support long-term projections. Some sector analyses, however, go beyond 2050. In spite of this time restriction, this study concentrated on the average behavior of the variables, given the difficulty to adequately address the uncertainties in the models' extreme climate change situations.

In this summary, we have outlined the main results obtained in this pioneering initiative, which are followed by public policy recommendations. One of the main conclusions is that the worst effects of climate change shall take place in the North and Northeastern regions, the country's poorest, and that, as a result, the cost of inaction today shall be the worsening of regional and income inequalities.

Macroeconomic outlook

- It is estimated that without climate change, Brazilian GDP shall reach R$ 15.3 trillion (2008 Reais), or US$ 8.3 trillion, in the A2-BR scenario in 2050, and R$ 16 trillion (US$ 8.7 trillion) in the B2-BR scenario. With the impact of climate change, GDP values would drop 0.5% and 2.3% respectively.
- Adjusted to present values, discounted at a rate of 1% a year, these losses would range between R$ 719 billion and R$ 3.6 trillion, which would be equivalent to losing at least an entire year of growth over the next 40 years.
- With or without climate change, GDP is always greater in B2-BR than in A2-BR. This means that in the cleaner B2-BR trend, the economy expands more, and not less. In both scenarios, poverty increases a result of climate change, but in almost negligible terms.
- The average Brazilian citizen would lose between R$ 534 (US$ 291) and R$ 1,603 (US$ 874). The present 2008 value of the reductions in Brazilian consumption accumulated to 2050 would range between R$ 6,000 and R$ 18,000, representing 60% to 180% of current per capita annual consumption.

Regional outlook

- The regions most vulnerable to climate change in Brazil are the Amazon and the Northeast.
- In the Amazon, temperatures may increase 7-8°C by 2100, possibly leading to a radical change in the Amazon forest – the so-called "savanization". It is estimated that climate changes would bring about a 40% reduction in the forest cover in the south-southeast-east region of the Amazon, being substituted by a savanna biome.
- In the Northeast, rainfall would tend to drop 2-2.5 mm/day by 2100, causing agricultural losses in all states of the region. The water deficit would lead to a 25% reduction in pasture for slaughter cattle, thus stimulating a return to low-output cattle ranching.
- The decline in rainfall would affect river flows of the Northeast basins, such as the Parnaíba and the East Atlantic, important for electric power generation, with flows dropping by up to 90% between 2070 and 2100.
- There would be severe losses for agriculture in all states, with the exception of the colder South-Southeast states, where temperatures would be less severe.

Sectoral outlook

Water resources. The projected results would be alarming for certain basins, especially in the Northeast region, with a sharp reduction in flows by 2100.

Electric power. Greater uncertainty in the hydroelectric power generation capacity, with firm energy reductions ranging between 31.5% and 29.3%. The more pronounced impacts would

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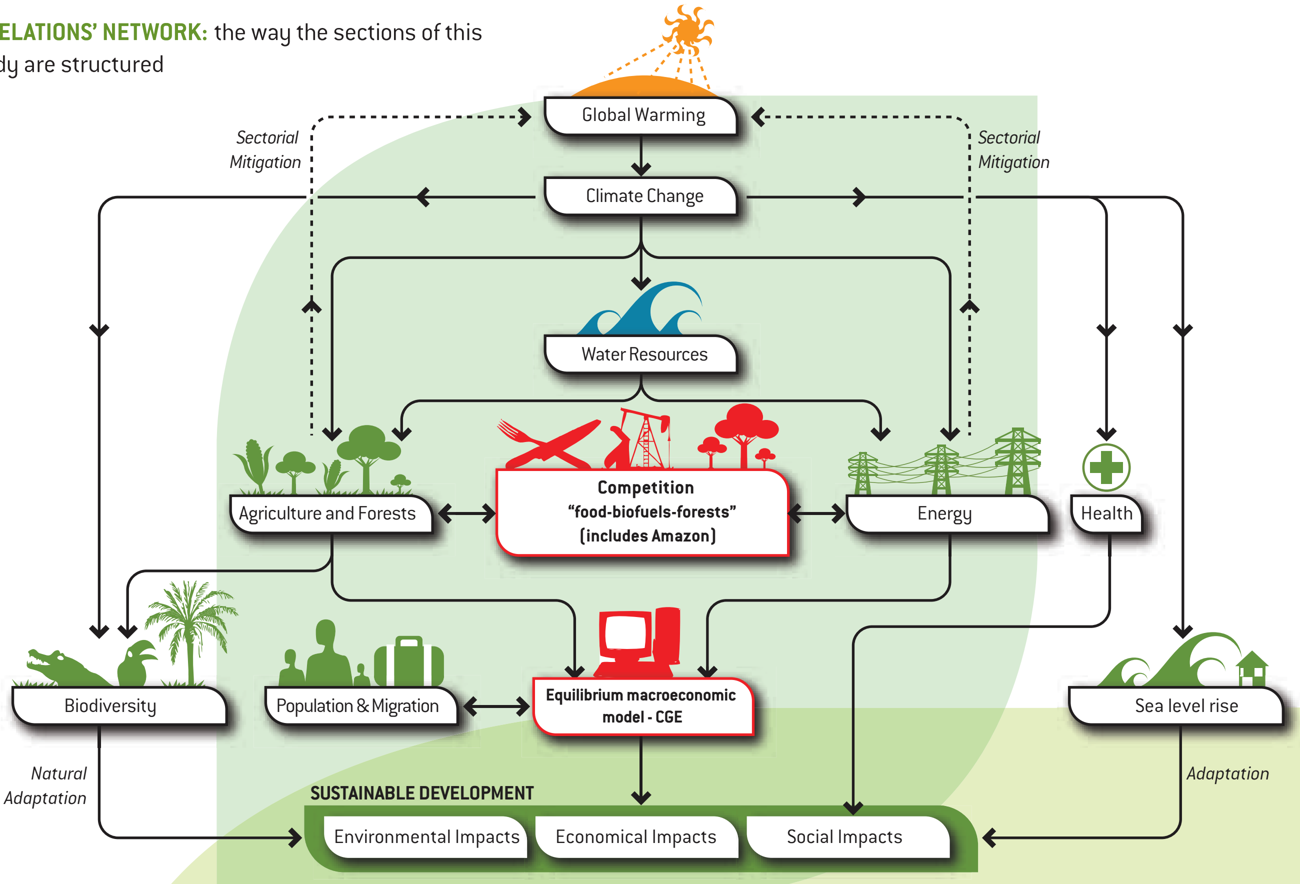
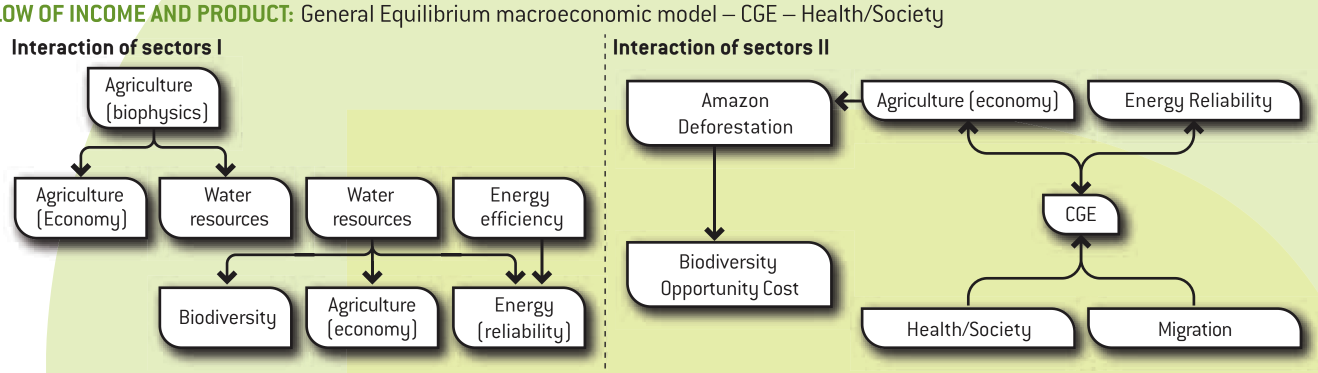
[1] The distinction between climate scenarios and socioeconomic scenarios is an important one. Although most studies refer to national economic trends as scenarios A2 and B2, there is no single trend for the national economy under either of the global economic scenarios. The global economy may follow an A2 trajectory, and Brazil follow a trajectory more similar to B2. Although this study attempted to determine a national trajectory which was consistent with the global one, we maintained the designations A2 and B2 to refer precisely to global climate scenarios A2 e B2; and designated A2-BR and B2-BR as referring to the economic and climate scenarios when applied to the Brazilian case.

A RELATIONS' NETWORK: the way the sections of this study are structured



FLOW OF INCOME AND PRODUCT: General Equilibrium macroeconomic model – CGE – Health/Society



be felt in the North and Northeast. In the South and Southeast the impacts would be minimal or even positive, but would not offset the losses in the North and Northeast.

Agriculture and livestock. With the exception of sugarcane, reductions in low-risk production areas would affect all crops, especially soybeans (-34% to -30%), corn (-15%), and coffee (-17% to -18%). Productivity would drop particularly for subsistence crops in the Northeast.

Coastal zone. Under the worst scenario of sea level rise and extreme meteorological events, the estimated value of infrastructure and properties at risk along the Brazilian coast ranges between R$ 136 and R$ 207.5 billion.

Adaptation

Agriculture. Genetic modification would be a highly feasible alternative to minimize the impacts of climate change, requiring R$ 1 billion a year in research investments. Irrigation was also considered an adaptation alternative, but with lower overall benefit/cost ratios.

Electric power. Additional installed capacity would be needed to generate between 162 and 153 TWh (25% and 31% of the 2008 domestic electric power supply) a year, preferably from natural gas, sugarcane bagasse and wind, at a capital cost between US$ 51 and 48 billion.

Coastal zone. The cost of coastal management actions and other public policies (14 actions recommended) would reach R$ 3.72 billion by 2050, or nearly R$ 93 million per year.

Mitigation opportunities

Deforestation. An average carbon price of US$ 3 per ton in the Amazon, or US$ 450 per hectare, would reduce cattle ranching in the region by 70% to 80%. At an average price of US$ 50 per ton of carbon, it would be possible to reduce deforestation by 95%.

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Biofuels.

- Fossil fuel substitution would cut between 92 and 203 million tons of CO2 equivalent emissions by 2035. Ethanol exports would cut an additional 187 to 362 million tons of emissions on a global scale.
- Increases of 17.8 million to 19 million hectares of crop land area would not cause the substitution of subsistence crop areas in any Brazilian region, nor not put pressure on Amazon deforestation. In the Southeast and Northeast however, the forests and vegetation of agricultural establishments may be affected if appropriate policies are not adequately implemented.
- In the Center-South region, the exposure of large concentrated populations to high levels of atmospheric pollution would be avoided, if mechanical harvesting systems are adopted in all regions.

Carbon taxation. The study estimated that the impact of a US$ 30 to US$ 50 tax per ton of carbon would reduce domestic emissions by 1.16% to 1.87%, resulting in a 0.13% to 0.08% drop in GDP.

Energy sector. Using the 2030 National Energy Plan as a reference, the estimated potential emissions reduction would be 1.8 billion tons of CO_2, accumulated between 2010 and 2030. At a discount rate of 8% a year, the estimated cost would be negative, i.e., there would be a gain, or benefit, of US$ 34 billion in 2030, equivalent to US$ 13 per ton of CO_2.

Priority actions

- The costs and risks of climate change for Brazil are measurable and would have a greater effect on poorer populations in the North and Northeast. Social protection policies in these regions must be reinforced.
- It is both possible and necessary to associate ambitious growth targets to reductions in greenhouse gas emissions, to ensure access to markets that favor products with low carbon emissions during their life cycles.
- Climate change must integrate government environmental policies (such as including greenhouse gas emissions or sequestering in licensing procedures), with regard to both the brown agenda (pollution) and the green agenda (the rural sector and associated areas) – transport, housing, agriculture and industrial sectors.
- Ensure that the energy matrix remains “clean”, with investments in a variety of highly profitable energy efficient alternatives, and also ensure that domestic GDP growth also takes place in a “clean” manner.
- Currently, the main recommendation is curbing deforestation in the Amazon, in order to avoid the onset of savannization and severe local and regional climate changes, and also to avoid the projected overall 38% loss of species and 12% of environmental services by 2100.
- Increase technical knowledge regarding the problem, through the development of climate models, capable of translating the projected changes in climate into physical impacts on the various economic sectors , mitigation alternatives, and more efficient adaptation.
- Invest in cutting-edge agricultural research, particularly genetic modification of cultivars.
- Conduct further research to quantify the nature and the risks of extreme events beyond 2050 and 2100.

Finally, it is important to note that as part of the national debate on Brazil’s position in the international climate negotiations, it has been discussed the scenarios that take into account the country’s great mitigation potential, as the country »

THE COST OF INACTION: losses due to the impacts of climate change in Brazil.

GDP in 2050	-R$ 719 billion (A2-BR), and -R$ 3,655 billion (B2-BR)	0.5 and 2.3% of GDPs in 2050, in each scenario	
Per capita GDP in 2050	-R$ 534 (A2-BR) and -R$ 1,603 (B2-BR)		
Water balance - Northeastern basins (2041-2070)	-60% (from 7075 to 2833 m³/s, A2-BR) and -56% (B2-BR)	East and West Northeastern Atlantic, Parnaiba and São Francisco basins	
Agriculture	**% variation in low-risk area (2050)**	**Ave. productivity loss**	**Annual loss, Scenario A2-BR**
Rice	-12% in the 2 scenarios	-12% (CO) and +44% (S)	R$530 million/year
Cotton	-14% in the 2 scenarios	----	R$408 million/year
Coffee	-17% or -18% (A2-BR or B2-BR)	----	R$1.597 million/year
Beans	-10% in the two scenarios	-8% (CO) and +37% (S)	R$363 million/year
Soy beans	-34% or -30% (A2-BR or B2-BR)	-0.7% (CO) and +21% (S)	R$6.308 million/year
Corn	-15% in the two scenarios	-27% (NE) and -10% (S)	R$1.511 million/year
Sugar cane	139% or 147% (A2-BR or B2-BR)	+66% (S) and +34% (SE)	----
Firm electric power	-31.5% or -29.3% (A2-BR or B2-BR)		
Average electric power	+2.7% or 1.1% (A2-BR or B2-BR)		
Ethanol demand (domestic + export.) in 2050	169.7 billion (A2-BR) and 118.2 billion litres (B2-BR)	= 16.4 or 13.5 million ha. (A2-BR or B2-BR) ≈ 16% adequate area for sugar cane	
Increase in electricity demand	1,333 ktoe (A2-BR) and1,092 ktoe (B2-BR)		
Loss of forest cover – Amazon Region	354 to 199 million ha (A2-BR) - 40% and 85% (without and with deforestation)	Projections for 2100	
Loss of environmental services	-12.4% in 2100 (A2-BR) = R$ 47 billion/year	Subject to serious methodological/data limitations	
Loss of species in the Amazon	12% or 30-38% (without/with deforestation, 2100)	Subject to methodological/data limitations	
Coastal zone, assets at risk	between R$ 136 billion and R$ 207.5 billion	Subject to methodological/data limitations	

COSTS AND BENEFITS OF ADAPTATION				
Agriculture	**Genetic modification**	**Irrigation/year**	**Cost/benef. Genetic Mod.**	**Cost/benef. irrigation**
Rice	R$ 65 million/year	R$ 197 million/year	8.2	2.7
Cotton	R$ 38 million/year	--	10.7	--
Coffee	R$ 104 million/year	--	15.4	--
Beans	R$ 51 million/year	R$ 494 million/year	7.1	0.7
Soybeans	R$ 378 million/year	--	16.7	--
Corn	R$ 354million/year	R$ 309 million/year	4.3	4.9
Energy	Capital cost R$ 93,6 billion + R$ 12.7 billion/year operational cost, scenario A2-BR		R$ 88 billion + US$ 13.2 billion/year, scenario B2-BR	
Coastal zone	R$ 6.8 billion (total) or R$ 170.6 million/year		Govt. management costs, excluding works	
OPORTUNIDADES DE MITIGAÇÃO				
Amazon deforestation	Deforestation reduction of 70-95%		Based on a cost of US$3 or 50/ton of carbon	
Ethanol production	187 to 362 million tons of CO2 eq.		In 2035, based on destination of exported alcohol	
Carbon taxation	Emissions -1.16% and -1.87%; GDP -0.13% and -0.08%		Based on a rate of US$30 or 50/ton of carbon	
Energy efficiency	Potential of 1.8 billion t of CO2 between 2010-30		Average cost equal to US$-13/t of CO2	

looks into a low-carbon economy. Some have termed such trajectory as “Brazil Environmental Super Power”. The modeling framework proposed here will be useful in the elaboration of a series of economic, social and climate-environmental scenarios which incorporate mitigation actions which one intends to test. It is recommended therefore that in the near term such modeling be incorporated into the recently created research networks, such as Rede CLIMA and INCT for Climate Change, which include the majority of institutions taking part of EMCB.

Limitations of the study

The pioneering nature of this study involved a series of limitations, which should be considered when analysing the study results. The five main limitations were:

- The use of a single global climate model, upon which the sectoral and economic analyses were based. Such decision was taken at the outset of the study based on the available knowledge of simulations with probability distribution functions for several parameters, and the experience of the INPE with the downscaling of global models.
- The study’s deterministic approach, i.e., the explicit non-consideration of risk and uncertainty, and the focus on expected average values, with a view restricted to the immediate costs of small changes in temperature for a limited set of measurable impacts.
- The fact that the precipitation projections estimated by the various climate models did not even agree on their signs (plus or minus), limiting projections of future climate and potential economic impacts.
- The incomplete database and insufficient technical information, ranging from climate models and future climate projections to data on ecological or socioeconomic events, including economic valuation. In more complex sectors, or for which there is more limited technical knowledge (such as biodiversity and the coastal zone), the analyses and economic valuation data are preliminary.
- The non-inclusion of long-term technological change, explained by the lack of scenarios and studies upon which projections could be based, a decision reached due to the incipiency of models, and technical restrictions to linking all the models, from climate change projections, to their socioeconomic impacts.

The present study focused on the national perspective, leaving local, as well as institutional, legal and cultural analyses for future research. Social analyses were limited to what arose during the macroeconomic analysis, and to some extent from the various sector chapters. In addition, the impacts of climate change were not estimated for infrastructure, nor for adaptation alternatives: these and other aspects which may represent very high costs await future studies.