PUBLIC POLICY, MITIGATION AND ADAPTATION TO CLIMATE CHANGE IN SOUTH AMERICA

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SUMMARY

GLOBAL CHANGES, ADAPTATION AND PUBLIC POLICIES: AN URGENT DEBATE

Climate Change involves many aspects, part of them polemic. However, they are not any longer questioned even if the studies on warming causes and on the consequences that they will engender are still in development. Thus, it is fundamental to intensify the debate on these issues.

It was with these expectations that the III Conference on Global Changes in South America was accomplished, in November 2007, promoted by Environment Sciences Area of the Institute for Advanced Studies of the University of Sao Paulo. At the occasion, more than 500 researchers from many parts of the world were gathered together, prone to explain both the dynamics of climate and the changes that its variation may generate, especially to human activities.

This book aggregates the round-table participants contributions, as well as those who were awarded among the more than 120 papers presented at the event. Divided in four parts, it tries to approach the global changes in different perspectives, as follows: international relations and public policies, mitigation, adaptation and consequences to the natural systems.

In the first part are the considerations that approach the complex web of relations among the countries for a necessary reduction of the greenhouse-effect gases. There are also present chapters that analyze public policies accomplished in Brazil by the Federal government and by the government of the State of Sao Paulo.

In part II are found the articles that discuss the appliance of the Clean Development Mechanism in Brazil. Other texts approach the alterations generated by the use of ethanol on transportation in Brazil and how the cost of opportunity can be used for a policy of combat to deforestation in the country, the greatest source of emissions in Brazil, according to official reports.

In sequence there are contributions turned to necessary actions of adaptations to global changes. The urban areas were emphasized owing to the larger presence of population on risk areas. Further than Brazilian cities, reflections are found on cities in Chile and Argentina.

To close the book, collaborations were gathered from authors dedicated to understand the adjustments of various natural systems. Changes in rainfall pattern and the role of the ocean are highlighted in this part.

Global Changes demand plural responses. The peoples will be affected in distinct ways, as well as the natural systems. Albeit the discussions on the necessary reduction of greenhouse effect gases emissions do not advance as desired in the international sphere, it is mandatory to discuss the adaptations that should be made in the cities and in the agricultural productive systems in Brazil and in the world. It is expected that this book will bring more elements to this debate.

The Editors

INTERNATIONAL RELATIONSHIP AND PUBLIC POLICIES

THE GREAT EMITTERS OF CARBON AND THE PERSPECTIVES FOR AN AGREEMENT ON MITIGATION OF GLOBAL WARMING

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ABSTRACT

The Kyoto Protocol has not been approved as an appropriate architecture to mitigate climatic change. Among the seven great carbon emitters in 2007 – China, USA, European Union, India, Russia, Brazil and Japan, by order of magnitude– only the third (European Union) and the seventh (Japan) have internalized the issue of carbon emission in their legal and regulatory architecture. The study compares the seven countries in population, IGP, emission volume, proportionate participation in global emissions, per capita emission, emissions per IGP unity (carbon intensity), energetic matrix, political regimen and status of public opinion. The combination of dimensions is fundamental to evaluate the relative cost and the degree of accessibility of each country for an effective treaty on global warming mitigation that may overcome the Kyoto Protocol's low efficacy and distortions. The work concludes with considerations on the three future scenarios for the evolution of the international system, having as its main definition variable the obtained cooperation level: the Hobbesian scenario of low cooperation, a continuity of the last decades tendencies: the intensified Kyoto scenario of medium cooperation and the Great Agreement scenario of high cooperation, which eventually would effectively mitigate global warming and achieve planetary climatic security.

Keywords: Carbon emissions, Transition to a low carbon society, Major climate players, Multilayer international negotiations.

CONCEPTUAL LANDMARK OF GOVERNANCE AND CLIMATIC SAFETY

In the last half-century, the combination of world population growth, generalized consumption of fossil energy and technological development in an intensive carbon framework have been the main causes of the global warming process. The human adventure has as one of its pillars the conquest of the material world. The questionable austerity of consumption and the simultaneous capacity of producing wealth have for a long time accompanied the development of world capitalism.

In the last decades modernity has been affected by hyper-materialism, which implies a consumption mode beyond individual necessities and a squandering of wealth, putting at risk the individual and society. There is a profound dissonance in the present international system: on one hand, the carbon emissions rise continuously in most countries; on the other hand the majority of political leaders recognize the magnitude of the issue and assume an international cooperation rhetoric for emission mitigation, albeit distant from the real behavior of the economic agents in their respective societies.

Previous to the Cupola of Rio in 1992 a favorable ambiance was created toward proactive measures in relation to climatic changes, sustained up to 1997. To the end of the 1990 decade there was an attenuation of this favorable mood owing to two factors: the impact of the acceleration of a revolution in information technologies and the establishment of a strong opposing lobby led by oil, electricity and automobile corporations. The strong global surge concerning the expansion of the environmental movement (particularly from 1985 to 1997) was based on a critical course of action against the impact of economic prosperity and scientific development on environmental quality. The environmentalism demanded a self-critic attitude from science and a decrease in the pace of the material and technological progress and a rising attention was given to these requests from the chief segments on a technological and social aspect. (VIOLA; LEIS, 2001).

This cultural atmosphere changed with the acceleration of the informative revolution during the second half or the 1990 decade, which promoted a rising conviction in the technological capacity to resolve the problems raised by technology itself. Simultaneously, a technological abyss was dramatically rising between developed and emerging societies on the one hand and the poor ones on the other. In addition, the capacity to create technological environment– by generalized use of air conditioners, as well as extremely fast transportation and communication means – produced, in the 1998-2005 period, a new post-environmentalist insensibility in relation to transformation of nature by the human being. The dramatic acceleration of innovative technology disseminates in the developed countries the impression that the negative consequences of climatic changes could be avoided. This phenomenon has undermined the idea of a common destiny- in the confrontation of climatic change - for all humanity, an idea that had ample acceptance at the time of Rio 92 (VIOLA, 2004a).

This process has deteriorated as a result of the terrorist attempts of September 11, 2001, creating severe issues of survival and immediate security (the threat of catastrophic terrorist profile attacks) in a hyper central locale of the international system, moving long term issues to a secondary status. The environmentalist movement has met great difficulties for a better understanding of this period of technological affirmation adopted by western societies (with greater emphasis in the USA, Canada and Australia than in Europe and since 2005, a series of events opened a new period in the perception of the climatic change more freq. Japan) and most of the emerging countries. These difficulties were enlarged by a naïve attitude concerning democracy, which prevailed among the environmenent and intense hurricanes talists. in the USA and Caribbean countries, big fires in vast areas of the USA and Australia, deaths on account of extreme heat in Europe, intensification of tornadoes and extremely severe storms in Japan, China, the Philipines and Indonesia, catastrophic floods followed by extremely severe dry periods in India and Africa, intense dry periods in the Brazilian Amazonia, and the first hurricane registered in the South Atlantic. Along with these natural events, international public opinion of higher educational level was struck by many events of high relevance:

- The Al Gore movie “An Inconvenient Truth” which pedagogically communicates the severe impacts of long term global warming on our civilization, released in September 2006.
- The Stern report on the economic cost of climatic change, officially assumed by the British government in 2006.
- The special edition of The Economist “The World in 2007 (followed by many others) predicting that climatic change would be at the center of the dynamics of the international system, beginning in 2007.
- The publication of the fourth report of the International Panel on Climatic Change in February 2007 asserting that there remains practically none uncertainty on the fundamental anthropogenic origin of global warming and highlighting that it will happen faster than it was previously evaluated (IPCC, 2007)
- The meeting to debate the issue of climatic change for the first time in the history of the Security Council of the UN in April of 2007, called upon by the British Government, which had been launched by Kofee Annan since 2005 (ANNAN, 2005).

- The G8 Reunion in Germany in June 2007 having as central theme the first incisive proposition to mitigate global warming produced in the up to now short and intense history of the governmental forums on this issue.
- The meeting of State Officials at the beginning of the General Assembly of the UN of September 2007 having as central agenda the climatic change.
- Thus we get to the end of 2007 under a political and cultural atmosphere increasingly receptive to a recognition of the necessity of incisive efforts to manage global warming, such an atmosphere that would allow the advent of a climax in 2009, with the swearing in of the new president of the USA. Whatever the predominant responses to the threats of the climatic change may actually come up in the sense of post-materialist and rationalist character, there still may arise in the future anti-materialist responses of fundamentalist nature, associated to religion or to ecological radical tradition, particularly in poor and emergent countries every time extreme climatic phenomena may occur. In this case there would be a risk of polarization in the international arena, which would undermine cooperation, with two severing lines: pro mitigation forces versus anti mitigation forces and rationalist pro mitigation forces versus pro mitigation fundamentalist forces.

Global warming is presently the greatest political, economic, legal and environmental challenge to mankind. However, in spite of the rising scientific and political consensus on the gravity of the problem, marked by the partial publication of the IPCC reports in 2007, the governance and governability related to the problems are still lacking. Global Governance (KEOHANE; NYE, 2001; CHAMBERS; GREEN, 2005) or International Governance (LE PRESTRE; MARTIMORT-ASSO, 2005) are not synonyms. Governance does not correspond to government or to governability. Global Governance may be explained as “an ordination system” (ROSENAU, 2000) and implies reconnoitering the rising importance of non-state players, including those of the market, with active participation in decision-taking processes as well as in those of legislative engineering nature, or as addressees of more transparent public policies (BARROS-PLATIAU, 2006).

In this sense, governance was accepted to be analyzed from two dynamics: first, governance from top to bottom means that public authorities become more “accountable” to the eyes of national and international public opinions; second, they respond to the demand for a greater social control and pay account to other national and international players in general. Otherwise, from bottom to top governance is created when non-state players offer possible solutions of a problem to public authorities or solve them by themselves (ROUSSEAU, 2000; ARTS, 2003; BODANSKY, 1999).

Furthermore, there also are discrepancies in reference to the nature of governance. While more engaged and cosmopolitan authors, next to scientists, militants and UN system authorities use the word “global” to stress the dimension of the necessary reaction to the problem, diplomats, public and rational authorities, *grosso modo*, assert that the right word would be “international” since the official agenda is predominantly interstate. Normally, authors that follow this track first analyze the role of Nations and Intergovernmental Organizations within and outside the UN.

As for governability, as its suffix indicates, it corresponds to the capacity to govern, or else, the ability of a government to reach established goals. In this sense the concept of governability is subsidiary to the concept of governance (VIOLA; LEIS, 2007). Governability is important for the governance but climatic security will depend on effective parameters of governance as it has been made clear above. Governability implies the analysis of structures, systems, institutions and forces, installed or emergent, which will allow applying policies for identified problems to be resolved. Thus, it is not enough that there be a government; it is necessary to investigate what is its actual capacity to take action.

The concept of environmental security was developed at the end of the l990 decade by Barry Buzan, Olé Weaver & Jaap de Wilde in a seminal work (Security: a New Framework for analysis), which is up to now the most important systemic theory on international security developed since the end or the cold war. Environmental Security refers to having common characteristics with international security of global and regional environmental problems - depletion of the ozone layer, global warming, oceanic and international rivers pollution, acid rain, biodiversity erosion and risk of radioactive contamination. The environmental security can be differentiated not only in regional terms but also national. The incipient concept of climatic security tries to illuminate not yet differentiated problematics, but of fundamental importance to understand the issue of environmental governance in general. The concept of climatic security began to be developed in 2006 and is directly associated to the prominence and centrality of global warming within the classical list of global environmental problems. Climatic Security refers to the maintenance of the relative stability of the global climate - which was decisive for the construction of civilization from the time of the last glacial period, twelve thousand years ago – significantly decreasing the risk of global warming via mitigation and promotion of the adaptation of international society and its national units to the new conditions of a warmer planet, with more frequent and more intense existence of extreme climatic phenomena.

The relation between climatic governance and climatic security is established in terms of a more objective (hard) character, creating limits beyond which it is not possible to think in terms of adaptation. Climatic Security implies a clear choice of humankind for the priority of mitigation of global warming over adaptation. According to the best current climatic analyses we will need one decade to change the course of dynamics in the international system and produce an effective mitigation; or else, progressively reduce the rate of growth of the emissions -3% per year in the 2000-2005 period – leveling it around 2020 and from this point on, begin to reduce progressively until 2050, with a global level of emissions of approximately 40% of year 2000 total emissions.

Climatic Security is set on a new level when compared with the greatest challenge ever experimented by humankind: the risk of a nuclear war during the cold war which would have ended civilization or even extinguished the human species. Really, the intensity, scope, profundity and pace of international cooperation required to obtain climatic security is much superior to the peak reached at the 1960 decade to avoid nuclear war. In this circumstance there was a combination of five crucial events: 1- the red telephone communicating the president of the USA with the secretary general of the Soviet Communist Party; 2- The treaty of prohibition of atmospheric nuclear explosions; 3- the START and SALT treaties between the USA and the Soviet Union to regulate the growth of nuclear arsenals; 4- The treaty of non nuclear proliferation; and, 5- the development of refined mechanisms of alert to avoid accidental nuclear war. Security is correlated with a strong global governance of global warming. In a scenario lacking climatic security the climatic governance is liable to remain limited to regional and national spaces and is centered on adaptation. *De facto*, in a process of uncontrolled global warming (rising of the mean temperature of the earth by more than 2C°), only developed countries would have conditions of a relative adaptation, nevertheless, at strong material and human costs. Countries of medium and poor income would go through catastrophic and irreversible disasters.

It is important to stress that in the present context, environmental security – in a short term connotation, to combat air and water pollution that deteriorate quality of life – does not prevent the development of climatic security. Thus, the mitigation of greenhouse effect of gases emission and the adaptation to climatic extremes via training the population and strengthening civil defense are totally compatible with the objectives of environmental security.

THE PROFILE OF THE GREAT EMITTERS

It is important do draw a short picture of the main carbon emitters, comparing population, GDP, emissions volume, proportional participation on global emissions, per capita emissions and per unit of GDP emissions (carbon intensity). It is convenient to highlight that most of political economic analyses on global warming fragments the reality because they do not compare all these dimensions. The combination of these dimensions is fundamental to evaluate the relative cost of each country for a serious and effective treaty of mitigation that surmounts the low efficacy and the extraordinary distortions of the Kyoto Protocol. It calls for a general review of carbon emissions around the world in the year of 2006[1]. In 2006, the world population was of 6.7 billion people, the GDP was of 48 trillion dollars and the carbon emission was 26 million tons. China surpassed the USA as the main emitter in 2006. The European Union, India, Russia, Brazil and Japan are also great emitters that necessarily need to assume and/or deepen their compromises of carbon emissions reduction.

China has a population of 1,3 million inhabitants, a GDP of three trillions of dollars and a per capita GDP of 2.300 dollars. It emits 5,7 billion tons of carbon, corresponding to 20% of global emissions, 5 tons per capita and 2,1 tons of carbon per each 1000 dollars produced. It is a very intensive economy in carbon due to its energetic matrix, strongly based in coal and oil and, notably, due to its low energetic efficiency. Nevertheless its GDP carbon intensity falling at 5% per year at the last decade, it still has carbon intensity 15 times superior to Japan and 6 times superior to the USA. Contrary to common sense the per capita emissions of China are medium and not low. The total emissions of China rise at a frightening rate of 8% per year. The cost of emission reduction in China is high if it continues to adopt the current model of industrialization, nonetheless viable if with an orientation toward a more based on productivity growth model instead of the gross production and with the international technological cooperation of the developed countries. The technology of fossil carbon capture and sequester (clean coal) and nuclear energy are very important for China. The perception of the Chinese government has been of negligence during the whole history of international negotiations, denying to take up its rising share of responsibility on

1 Information comparing the main variables were obtained from diverse official sources and from estimations of independent institutes – World Bank, The Economist, the secretariat of climatic change convention, UNEp, UNDP, World Resources Institute - as final results processed by the authors. The information of the countries GDP correspond to what is measured by the exchange rate. The author recognizes that there exist plausible reasons to consider GDP per parity in power of buying to consider the GDP as unity of measurement, which would give important variations of carbon intensity, for less, in the countries of medium and low revenue (particularly China and India). The field of information on greenhouse gases emissions is still limited and goes under significant variations among diverse sources and estimates. Nevertheless temporary and subject to errors the combination of information here presented is considered by the author as fundamental for the transmissions of a basic panorama in the proportions of the present reality.

global warming. Only last year did China take for granted the significance of global warming via a national plan of promoting wind and solar energy and contention in growth of emissions, which begins to be perceived via an incipient change in its foreign policy. There is a division in China between global and nationalist forces, the force of the first continually rising and showing an increased engagement into changing the Chinese position towards the course of global responsibility.

The USA comes second with a population of 300 million inhabitants, a GDP of 14 trillion dollars and per capital GDP of 47.000 dollars. It emits 5,6 billion tons of carbon, corresponding to 20% of the total emissions, 19 tons per capita and 0,4 tons of carbon per each 1 000 dollars of GIP. It is one of the countries with the greater rate of per capita emission in the world, overcome only by Australia, Luxembourg and the small oil exporters of the Persian Golf. It is an economy with high energetic efficiency and low carbon intensity in global terms, nonetheless among those of highest intensity- surpassed only by Canada and Australia – due to the combination of an energetic matrix with its axis on coal and oil, as well as a high utilization of airplanes and individual automobile in transportation. The emission of the USA rises 1% per year in this century. After having led the negotiation of the Kyoto Protocol, jointly with the European Union, during the Clinton administration (1993-2000), the American government has been extremely irresponsible during the Bush administration (2001-2007). The democrat opposition has been permanently critic of the executive position, nonetheless with little impact at the federal level. At state level many of them have assumed a policy favorable to reduction of emissions, with the eminence of governor Schwarzenegger in California, reelected in 2006 with an incisive discourse in favor of mitigating climatic change, having a cabinet and a bipartisan state parliament that has been able to approve a new legislation and regulation on many sectors (transport, construction, energy, industry and urban planning). The USA detains an important margin to reduce emissions by a technology change from thermoelectric to clean coal, rise of wind, solar, bio-fuel and nuclear power, decreasing the size and augmenting the efficiency patterns of the automobile; and green edification (buildings and houses designed or remodeled for emission reduction).

The European Union (27 countries) has a population of 490 million habitants, a GIP of 16 trillion and per capita GIP of 33.00o dollars. It emits 4 billion tons, correspondent to 15% of world total, 8 tons per capita and 0,3 tons of carbon per each 1000 dollars of GIP. In terms of per capita emissions, the European Union is very heterogeneous – from 22 tons in Luxembourg down to 4 tons of France and Portugal- and also in carbon intensity, being low in the northern countries, Germany, United Kingdom and France: medium in Spain, Belgium and Italy: and high in Poland, Check Republic, Romenia, Bulgaria and the Baltic countries. The emissions of the European Union rise at a rate of 0,5% per year due to the stability of emissions in Germany, United Kingdom and Sweden, but rapidly rise in Spain, Portugal, Greece and the East European countries (even if these last countries be still below their base line of 1990). The European Union counts with the historic main leadership in latter times, in favor of an incisive action towards mitigation of global warming: the governments of the United Kingdom, Germany and Sweden and their respective public opinion, accompanied in a lower profile by Holland, Ireland, Denmark and Finland. It is convenient to also stress the change in position of Spain last year, reconnoitering the issue of its emissions rise at the last decade.

In fourth place comes India, which has a population of 1,1 billion habitants, a GDP of 930 billion dollars and a per capita GDP or 830 dollars. It emits 1,8 tons of carbon per capita and 2,1 tons per each 1000 dollars of GIP. India is a country of great contrasts, being the second demographic giant with 18 of world population, for such reason being relevant in all compared statistics. However, it presents a very low rate of per capita emissions, since it is a country of low per capita income, very high in carbon intensity, due to low energetic efficiency and high weight of coal and oil in its energetic matrix. The emissions in India rise at 10%/year, being the great emitter that more augments its percent participation in total emissions. The position of the Indian government has been historically almost as negligent as the Chinese, but there are important differences between both societies: India has a democratic regimen with the presence of an important environmentalist movement, which consistently rejects the official position; and the medium population has a less materialistic option than the Chinese, due to religion and for such it is more sensitive to the status of the planet.

The Russian Federation has a population of 142 million habitants, a GDP of 1,15 trillion dollars and a per capita GDP of 8.100 dollars. It emits 1,4 billions of tons, corresponding to 5,5% of global emissions with 10 tons per habitant and 1,2 tons of carbon per each 1000 dollars of GIP. Russia is an economy with high per capita emissions and high carbon intensity, constituting a unique profile among the great economies of the world. It is a society that got much richer in the last 7 years, but has a low energetic efficiency and an energetic matrix highly based on fossil fuels, being a great exporter of oil and gas. Russia occupies an extremely singular position in the world frame for the following reasons: 1- the architecture of Kyoto totally favored the country in parameter terms of emissions because in the base-year of 1990 the Soviet Union was an economy of very high intensity of carbon and very low energetic efficiency: 2- being an economy whose main patrimony is a superabundance of fossil fuels, it reacts as a looser in the process of transition towards an economy of low intensity of carbon; 3- among all the great emitters it is the only country in which part of the elite and opinion formers perceive– very probably wrongly – that global warming could be in its favor because it would augment extraordinarily the agricultural lands; 4- it is favored by the architecture of Kyoto and will strongly tend to oppose to an agreement that would constrain the use of fossil fuels in the world.

Brazil has a population of 190 million habitants, GDP of 950 billion dollars and a per capita GIP of 5000 dollars. It emits 1 billion tons of carbon (2004), correspondent to 4% of the global emissions, 5 tons per capita and 1,1 ton of carbon per each 1000 dollars of GDP. Brazil's emissions in the years 2005 and 2006 went under a strong reduction (around 100 million tons in 2005 and 200 million in 2006 with reference to 2004) due to the dramatic fall of the deforestation rate in the Amazonia. Against common sense the participation of Brazil in global emissions (4%) doubles its participation in total GDP (2%). Brazil also possesses a an extremely singular profile, since that approximately 60% of the emissions are derived from deforestation in the Amazonia and the Cerrado, also peculiar for countries of medium or high income because its energetic matrix is of low carbon intensity, due to high proportion of hydroelectric plants in the generation of electricity and the rising importance of the bio-fuels in liquid fuels, particularly in the substitution of gasoline by ethanol.

Brazil is a very peculiar country in the world and in the region for two main reasons: it is a medium income country with high rate of deforestation. Besides, the regional emissions distribution is very disproportional since the Amazon states represent approximately 40% of the emissions, with 11% of the population and circa only 6% of the GPD. The rest of Brazil represents 60% of the emissions, 89% of the population and 94% of the GDP. The asymmetry in the regional distribution of emissions in Brazil is one of the most extreme in the world (VIOLA, 2004b). Thus the per capita emissions of the Amazon region are among the highest in the world, approximately 20 tons per inhabitant. These data are still more irrational in terms of carbon intensity: 6 tons per 1000 dollars of GDP are emitted in the Brazilian Amazonia, thrice superior to China.

Considering that 18% of the global emissions of carbon comes from deforestation and change of soil use, Brazil and Indonesia with 2% of the global emissions, each one in its ruddy are among the greatest emitters of the world followed by the Congo with 1,5%. An argument against Brazil is that its per capita income is of 5000 dollars, while that of Indonesia is of 1600 dollars and the Congo income is of 600 dollars, currently being next to Malaysia the more affluent among the deforestation agents. As Malaysia has a relatively small territory it little counts among the global emissions derived from deforestation, but the case of Malaysia is proportionally worse than that of Brazil since its per capita income is of 10 000 dollars. In favor of Brazil we have the circumstance that the emissions have remained relatively stagnated for two decades (with a decline in the last two years) and Indonesia and the Congo emissions are still feverishly rising in the latter decade.

Due to its profile of emissions concentrated in deforestation and being a country of medium per capita income, Brazil is the country with the minor cost of emissions reduction among the great emitters. 80% of the deforestation is illegal which turns the objective of zero deforestation (a survey done by a group of NGOs and opinion formers) viable at medium term. In this issue there have been very important advances in the last two years, from a historic average of until 2004 of 22 000 Km² of deforestation in the set of the Amazonian states toward an average of 16 000Km². It can be grossly estimated that by reducing this rate by half in approximately 3/5 years, to around 8 000 Km² would cost would be of approximately 0,5% of the GDP, 5 billion dollars spent in overseeing (federal and state agencies), judiciary and police repression and a payment of a fee to the local population for the practice of keeping the forest intact, thus restoring spoiled forests and reforesting areas for timber industry. This process would incrementally continue until all the use and conversion of forests to other activities could be done with high efficiency: sustainable use of timber by means of permits in auctions of hydroelectric energy, with a good cost-benefit relation between extent of flooded areas and energy production, preservation of agriculture with established previous mapping of appropriate soils and auctioning for use in agro-forestry and yearly agriculture of high productivity. A pilot project to pay for environmental services was launched at the beginning of 2007 in the Amazon State with the establishment of the forest grant (funding) program, to pay local populations approximately 600 reals per capital for their contribution in keeping the forest protected. The new national forest law of 2006 and the creation of the Forest Service creates a legal and regulatory architecture favoring the reduction of disagreement between law and fact, tending to promote a more rational and efficient use of forest resources.

At last, among the great emitter, Japan has a population of 127 million habitants, a GDP of 5,3 trillion dollars and a per capita GDP of 43 000 dollars. It emits 0,8 billion tons of carbon, corresponding to 3% of world total, with 6 tons per habitant and 0,15 tons o carbon for each 1 000 dollars of GDP. Japan is (together with parts of the European Union like France, Sweden and Denmark) the lesser intensity of carbon economy in the world due to the extremely high energetic efficiency and to the great weight of nuclear energy in electrical generation. Japan has had the support of public opinion and of an important sector of its employers (Honda and Toyota are emblematic) toward the mitigation of the climatic change, however its role of leadership in the international arena is bellow its potentialities because of its foreign policy of low profile and its special relation with the USA. The “Cooling the Earth 2050” project, initiated by Japan in 2007 is the first approved by the government of an important country to show detailed and consistent means for a transition of a country towards an economy of low carbon.

And then we have the great emitters that participate in less than 3% of total emissions: Canada, Indonesia, South Africa, Mexico, Australia and South Korea. Canada has high emissions due to intensive use of heating and cars and planes for transportation. Furthermore, in the Alberta province the schist (petrol out of bituminous sand) production has been growing extraordinarily, with high carbon intensity. The Canadian society is historically divided in relation to climatic changes mitigation, like in the USA, but in the last year, there was a significant advance in favorable sectors.

Indonesia has high emissions originated from deforestation and is an important producer of petrol which is central in its energetic matrix. Indonesia is the greatest producer of biodiesel in the world, extracted from the dende, and an important part of this production is a deforestation vector. The cost for reduction of deforestation in Indonesia is not as low as it is in Brazil, due to enormous demographic pressure for land. That is why, to be viable, the efforts for deforestation reduction should have international financing.

South Africa has high emissions due to its very intensively dependent on coal and petrol energetic matrix. The South African government has converged with China, India and Brazil to reject commitments for emerging countries, but there is a strong environmentalist movement that contests the official position.

Mexico has high emissions derived from high proportion of oil in its energetic matrix. Its official posture tends to be much influenced by the American posture; during the Clinton administration it was one of the emerging countries that took a favorable stance toward commitments; during the Bush administration it has adopted a conservative attitude.

Australia has high emissions due to electricity being fundamentally based on coal, nonetheless with a more advanced technology than China and India. It also practices an intensive use of automobiles and airplanes in transportation. The Australian government has been historically negligent and the first to reject the Kyoto Protocol, but last year it changed dramatically its position due to intensive dry periods and forest fires.

South Korea has a very peculiar position, in virtue of being (such as Singapore and Taiwan) a country of high per capita income and not being part of the Annex 1 of the Convention for Climatic Change. South Korea has a high efficiency energy economy and relatively low intensity of per unit of GDP carbon. Due to not being part of the Annex 1 it has not been constrained to reduce the intensity of carbon in the last decade, and consequently the cost for emissions reduction has been relatively low.

PERSPECTIVES OF INTERNATIONAL NEGOTIATIONS

Facts that occurred since Kyoto1997 explain a great deal concerning the difficulties found in the issue of distribution of costs in mitigation, but an agreement based on conceptual and operational parameters of distribution of costs is a necessary condition, though still not sufficient, for cooperation to predominate over inertia and so that we may seriously advance in the course of emissions mitigation and stabilization of CO_2 concentration in the atmosphere in 2050, at a level that would limit global warming to 2°C . The realization and implementation of a great global agreement on mitigation is the greatest challenge for the globalized humanity in the 21th century and should be based on a combination of three criteria, which are simultaneously complementary and contradictory, described as follows.

First we have the acknowledgement of the global warming problem with differentiated responsibilities among the countries that cannot imply the pretense of distributing the costs according to their historic long duration emissions, because it is impossible to arrive at a minimum consensus on an appropriate methodology. Whenever we intend to go back in time we augment the conflict, and cooperation at international level decreases, in many cases leading to wars of territory and population redistribution. The Middle East is a region nowadays set on the past and on the reassertion of its identities, attributing to the present generations the responsibility for actions of past generations and owing to this it is the most conflicting and one of the most backward regions of the world. The same way, the modern market democracies have played a central role in the produce of global warming, but have also played a central role in the construction of modern technology, economic prosperity and globalization of opportunities. It was also the systemic productivity of the market democracies that allowed to acknowledge in advance the problem of global warming and to create new regulatory architectures – like the carbon market- and the technologies to confront the problem[2]. It makes sense to distribute emissions limits, rights to emit and per country quotas, in function of what has occurred during the last three decades, but not during the last two centuries.

Second we have the differential vulnerability of the countries to climatic changes for reasons of physical geography, types of human settlement and per capita income. This differential vulnerability will distribute the mitigation and adaptation costs, according to different capacities of the countries in terms of contribution for emissions reduction, due to discrepancies in human capital, technological development and governance quality.

In third place we need a realistic acknowledgment that the current international system is founded on a combination of two contradictory vectors: from one hand, the realities of differentiated and asymmetric economic, political and military power of the countries and from the other hand, International laws

2 A systematic analysis on the role of market democracies in the current international system is done in Eduardo Viola & Hector Ricardo Leis (2007).

growingly oriented towards an equity of rights of the countries and the world population, particularly for the use of the “global commons” like the atmosphere. The unbalanced focuses that polarize for one or another direction lead to a situation where all countries loose. A clear example of this has been the policy of power – based on a narrow and immediate definition of national interest –put in practice in the last years by the American, Australian and Russian governments to avoid assuming responsibilities and an effective cooperative behavior. Another emblematic example, in the opposite sense, has been the presumed right to equalitarian use of the atmosphere in per capita terms, an item that has been over dimensioned and strongly used by emerging countries, having Brazil as one of its leaders. The combination of these methods has led to a low cooperation scenario and to a situation where every country loose. Besides, those that demand a utopian equity, have lost much more, compared to those that carry out a policy of power. In other words, Brazil, China, India, Mexico and South Africa are much more vulnerable to climatic changes than the USA, Russia and the other developed countries.

Considering the countries that individually have at least 1,5% of the global emissions as the great emitters and taking as reference the year 2006, there are 13 countries that are great carbon emitters, by sequence of participation in global emissions: China, USA, European Union, India, Russia, Brazil, Japan, Canada, Indonesia, South Africa, Mexico, Australia and South Korea. The European Union should be considered as a country due to its economic and political integration and because it has been negotiating as a unity in the issues of climatic change since l996. The gradual constitution of the G8 Group + 5 in the last years is very close to this since it would only be necessary to aggregate Indonesia, Australia and South Korea.

With heuristic objectives, we can work with three great future scenarios ordained in terms of cooperation capacity in the international system and consequently in terms of capacity to attain climatic security: first the Hobbes scenario of pessimistic character; second, the Kyoto Intensified scenario, of intermediary character; and third the scenario of Great Agreement, of optimistic character.

The Hobbes scenario implies a stagnation at the low level of mankind cooperation capacity achieved by the Kyoto Protocol currently in force. The status quo implies that the great emitters – first (China), the second (USA), the third (India), the fourth (Russia) and the fifth (Brazil)- do not commit themselves with the reduction of emissions, their emissions having been growing in the last 10 years since l997 – particularly in the case of China, India and Russia, which have rapidly risen. This scenario leads to an accelerated increase in concentration of greenhouse gases, over-passing in approximately two decades the limit of 550ppm considered by climatologists as critical to stop global warming at 2°C of temperature rise (LEE, 2007). In this scenario there is no climatic security.

The Intensified Kyoto Scenario implies an agreement on a second period of commitments among the parts based on emerging countries of medium income not having commitments to reduce emissions – only commitments to reduce the curve of emissions growth – and the countries of Annex 1 having commitments only incrementally superior to those of the first period. Obviously for this scenario to succeed, the USA and Australia should enter into the Kyoto regimen, on the contrary we would be in the Hobbes scenario. The Kyoto Intensified scenario seems by and by less adequate to confront the problem, mainly due to the irrelevant results that, from the point of view of the emissions the Kyoto Protocol, have been reached up to now. In this scenario the European Union and Japan would not be able to persuade the USA to lead conjunctively consistent efforts to mitigate climatic change. The Intensified Kyoto would not engender a regional governability of climatic change in South America because it would not generate commitments to a reduction of emissions from the countries of medium income (Brazil, Venezuela, Chile, Argentina and Uruguai), stimulating inertial behaviors of most other governments and economic agents. However less catastrophic than the first scenario, there would not be any climatic security.

The scenario of the Great Agreement corresponds to an international treaty towards a strong reduction of the global emissions of carbon between the great emitters: the USA, Canada, European Union, Russia, China, India, Japan, Australia, South Korea, Indonesia, South Africa, Brazil and Mexico. This will only be possible with the election of the new president of the USA in November 2008 and with a restatement, at a much more incisive level, of the combined leadership of the USA/ European Union/Japan which led to the negotiations of the treaty of Kyoto in 1996-1997. This would be the great opportunity of Brazil to become part of the leading group joining the USA, European Union and Japan and playing a crucial role in the effort to engage and persuade China and India. In this scenario the national interest of Brazil would converge with the general interest of mankind since the country would be a great winner in the transition toward an economy of low carbon due to the importance of hydro electricity and bio-fuels in its energetic matrix and its ethanol exporting potential. It is important to stress that the internalization of the climatic security problematics in this scenario would allow the development of a global architecture of governance of Climatic Change that would impulse the regional and national climatic governance and governability. This process would certainly take Brazil and other medium income countries that are market democracies (Chile, Argentina and Uruguai) to assume commitments toward emission reduction. As to the continuity of the chavista Venezuela regime it would probably resist to assume any commitment, which would be a significant obstacle, however not insurmountable, for the construction of a regional governability of the climate.

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THE FUTURE OF INTERNATIONAL CLIMATE CHANGE REGIME: KEY ISSUES TO BE CONSIDERED

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ABSTRACT

Every strategy, policy and/or procedure that should be adopted in order to pursue greenhouse emission reductions, will mean certain types of involved activities and consequently, some kind of sacrifice on the economy of the societies that implemented those strategies, policies and/or procedures. Therefore, one of the most conflictive issues included in the climate change international negotiations agenda is related to the distribution of the climate change mitigation costs among different countries. Taking a look on some of the alternatives proposed for regulating the functioning of international climate regime, it can be observed that the economic effects of their implementation shall not be neutral for the diverse countries and activities and different social groups associated to them.

Keywords: Climate change, Mitigation, Adaptation, Climate regime post 2012, Mitigation costs allocation.

THE CLIMATE CHANGE REGIME CONTEXT

The degree of vulnerability to these phenomena that different communities show is closely related to the capacity to absorb, mitigate, soften or adapt to the effects of those changes. This situation will be influenced by the possibility of access to technologies, infrastructure and appropriate means for such purpose.

In that sense, poorer populations will probably be the most vulnerable. This situation could lead to extend the gap between North and South, and also increase the inequalities within the countries, independently from the responsibilities of each social group in their contribution to Climate Change.[1]

The presence of such uncertainties and heterogeneity among the different actors involved will influence on the decision taking process. Decisions should be taken in spite of the scarce level of knowledge on the future consequences to be confronted. However, potential effects of Climate Change on ecological (natural or transformed) and socioeconomic systems are of such magnitude (increasing atmospheric surface temperature, desertification of great areas, floods, ocean surface warming, sea level rise, potential changes in agricultural traditional areas, changes in housing conditions of the population, increase of underground water salinity, changes in the amount of hydrological resources, human health impacts, and changes in survival conditions for many animal and vegetal species, among others) to justify certain type of intervention to avoid them through the mitigation of their potential effects. IN this sense, to mitigate the potential effects of Climate Change, the focus should be related to those human activities acknowledged as influencing on the greenhouse emissions.

The main anthropogenic source is fossil fuel burning. However, from GHG emissions point of view, there also are many industrial processes (particularly the fabrication of clinker, aluminum, iron and steel), hydro-carbonate extracting activities, land use changes (mainly deforestation, field and agricultural waste burning), rice cultivation, livestock activities, nitrogen fertilizers use and wastage management, among others. Deforestation is the main anthropogenic cause of carbon sink reduction. Faced by situations in which uncertainties related to future systems functioning prevail, the application of preventive policies on the basis of the *precautionary principle* is recommended, however, precautionary principle also has a cost.

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1 It is clear that nowadays, the so-called North-South conflict is more a sociologic conflict than a geographical one. Katrina's hurricane demonstrated that every North has its own South, as well as the level of consumption and the standard of living of some southern countries elites show that also every South has its own North.

MITIGATION EFFORTS NEEDED TO STABILIZE GHG

Figure 1 shows how much effort is needed to stabilize GHG atmospheric concentrations, to different levels, by 2100, according to the Special Report on Emissions Scenarios (SRES) elaborated in 1992 by the IPCC. To reach each one of those levels implies a different effort regarding the amount of emissions that should be reduced, and obviously, different costs to those economies, sectors and involved social groups.

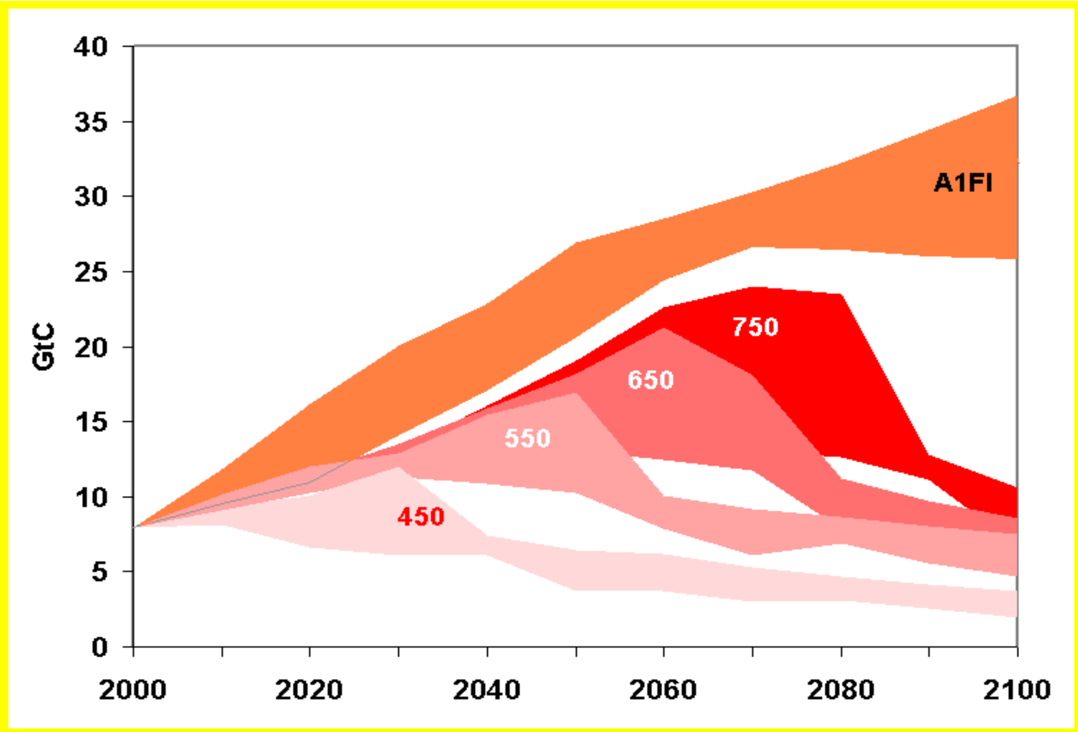

Figure 1 – Mitigation Effort Needed to Stabilized GHG Atmospheric Concentrations, According to IPCC-SRES 1992 Different Scenarios and Different GHG Atmospheric Concentrations Levels (in parts per million)

Source: IPCC (1992).

Nevertheless it is clear that the emissions reductions that are being achieved do not respond to a domestic significant effort from those more developed Annex. I countries. Figure 2 and 3 show that only the so-called EITs (Economies in Transition) are those which are reaching most of the reductions, but on the other hand some OECD countries had increased their emissions.

Figure 2 shows the GHG emission trend without considering LULUCF Sector. Figure 3, include LULUCF. The emission reductions of EITs is greater in the second case, but in both cases, only the behavior of the emissions corresponding to EITs allows to stand near the fulfillment of the objective of the Kyoto Protocol (a reduction by 5.2% by the whole Annex I group).

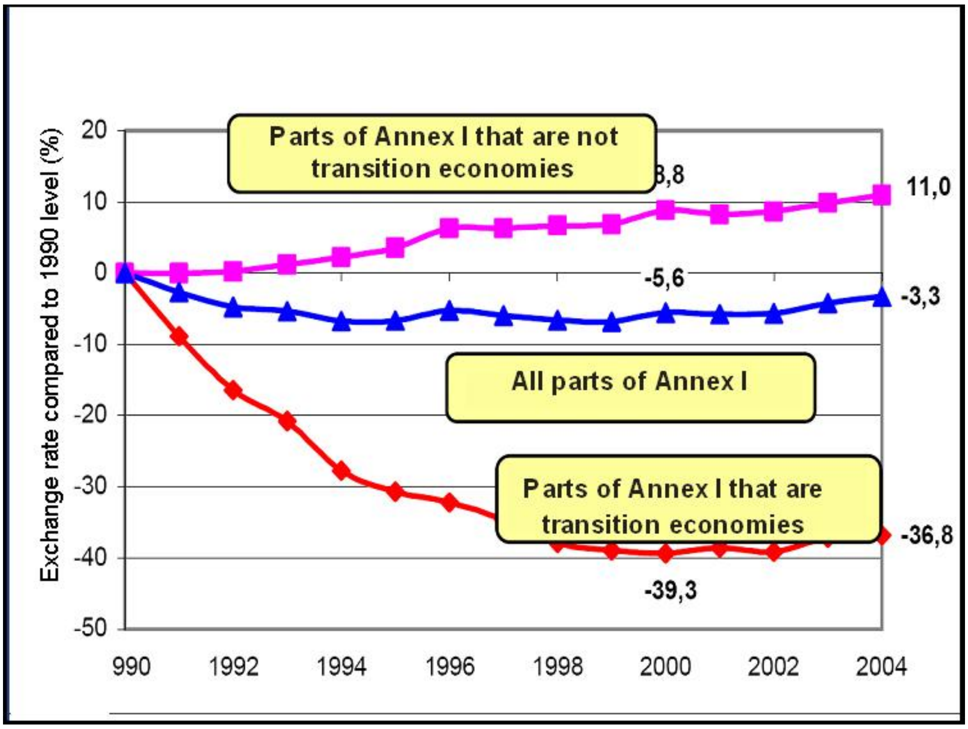

Figure 2 – Evolution of the GHG Emissions from Annex I, EITs included in Annex I and the rest of Annex I countries, excluding LULUCF Sector

Source: www.unfccc.int.

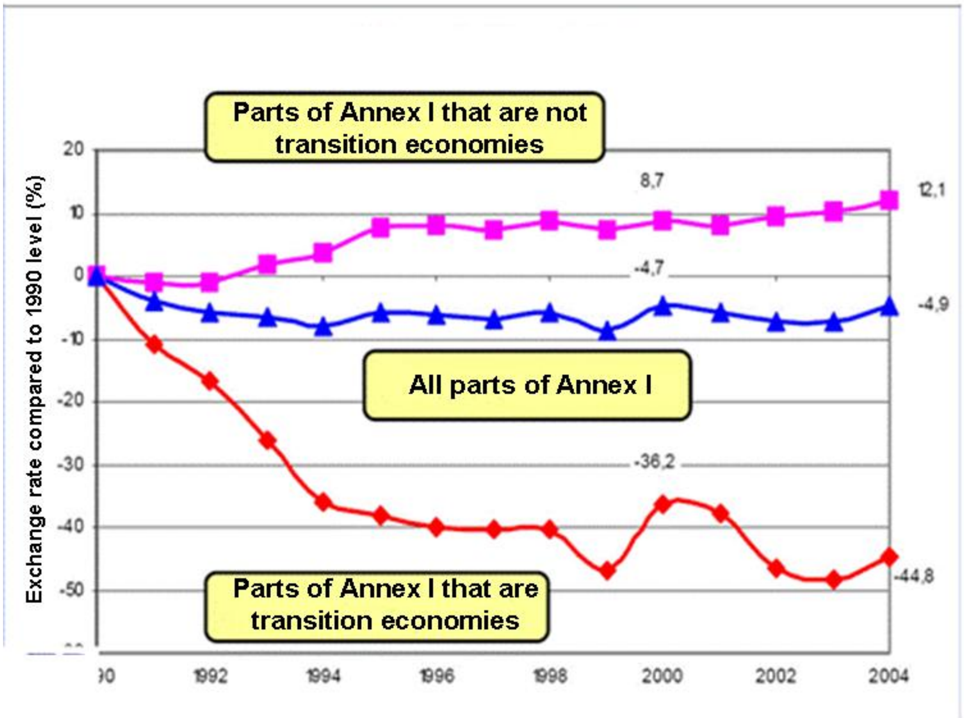

Figure 3 – Evolution of the GHG Emissions from Annex I, EITs included in Annex I and the rest of Annex I countries, taking into account LULUCF Sector

Source: www.unfccc.int.

Every concrete policy or measure that would be adopted in order to pursue GHG emission reduction will mean certain type of impacts on the activities involved and consequently, certain type of sacrifice on the economy of the societies that implemented those policies and measures. Therefore, one of the most conflictive issues included in the climate change international negotiations agenda is related to the distribution of the climate change mitigation costs, among different countries. In other words, the main conflict regarding mitigation issues is who should pay.

Starting from the traditional economic theory, the climate change issue could be seen as an externality originated in the abusive use of a common good by a few actors, for many years, which did not compensate the rest of the mankind for this way to use de atmospheric environmental services. According to the most traditional neoclassical economy theory, the potential solutions are very simple: (a) to apply Fiscal Policy (Pay Polluter Principle derived from Pigouvian Taxes) or (b) to establish a negotiation without transaction costs among the actors involved (like the method proposed by Coase). Nevertheless, as the main issue is the political one, those types of solutions to correct that externality could not be put in practice in the global climate change negotiation regime.

The issue that each society has to face is different, as well as the degree of vulnerability to be confronted. In that sense, the interest of the diverse stakeholders could be conflictive depending on the modality adopted to address the issue. This situation leads to the adoption of different approaches to face this question.

From the economic point of view, the solution which would be finally implemented will not be neutral in terms of the effects that are shown in the income distribution among diverse countries. Different methodological approaches related to the costs that should be confronted to abate GHG emissions, will determine different results, depending on the models that will be used for formulating and simulating future scenarios and the assumptions included. The same is valid for the methods used to assess the different alternatives to be implemented.

Starting from the close relationship between the assumptions that support the logic structure of the used models and their results, a broad margin of uncertainty exists about the real mitigation costs involved for each participant. However certain consensus exists related to the fact that the cost by ton of the first reductions will be smaller, and the cost probably will increase in the same way the more costless options are exhausted. So one of the most important points of conflict will be *which* strategy each Party will choose and how the burden of mitigation costs will be shared among the different countries.

In this sense, the predominant position among Developed Countries is based in the prioritization of economic efficiency over any other criteria, supporting the idea that mitigation measures should be adopted in those places in which it will cost less. Additionally those countries (jointly whit those so-called Economies in Transition – EITs) are included in the Annex I of the United Nations Framework Convention on Climate Change (UNFCCC) and have assumed commitments related to the stabilization/reduction of their GHG emissions, recognizing their major responsibility for the current GHG atmospheric concentrations.

The rest of the countries (Developing Countries), which had less historical responsibility in the process of atmospheric GHG emissions accumulation and are not yet committed to implement quantitative mitigation measures, support the idea to take into account the different degrees of responsibility and contribution to climate change when the costs of the procedures that should be adopted would be distributed.

The main argument is that the objectives to minimize GHG emission abatement costs should not hide the difference of responsibilities and contributions that exist among the different countries. Developing Countries are afraid that they may be charged with disproportionate mitigation costs related to their less relative contribution to the increase in GHG atmospheric concentrations.

Responsibility in the climate change process is one of the issues of major conflict in the international negotiation process between Developing and Developed Countries in terms of the commitments that each Party will assume and the modalities that will be applied to mitigate climate change. Additionally, positions are not homogeneous not only within both groups but within the different countries as well.

This situation was addressed by the UNFCCC referring to “common but differentiated responsibilities”, recognizing shared responsibilities to reduce GHG emissions, but also the right of Developing Countries to increase their energy consumption in their development process. Regarding to this principle of “common but differentiated responsibilities”, all countries should adopt measures to avoid damages to the atmosphere, but the initiative and the main effort should be provided by Developed Countries.

Figure 4 shows the CO_2 annual emission per capita by Region, in 1970. It can also be seen that the mentioned less responsibility for reaching the current climate situation is particularly notable in the case of Latin America. The Region shows rates that demonstrate that its contribution (not only today but also in the past) to GHG atmospheric concentrations was small and also have been implementing policies and measures that showed an important mitigation effort, mainly in energy supply.

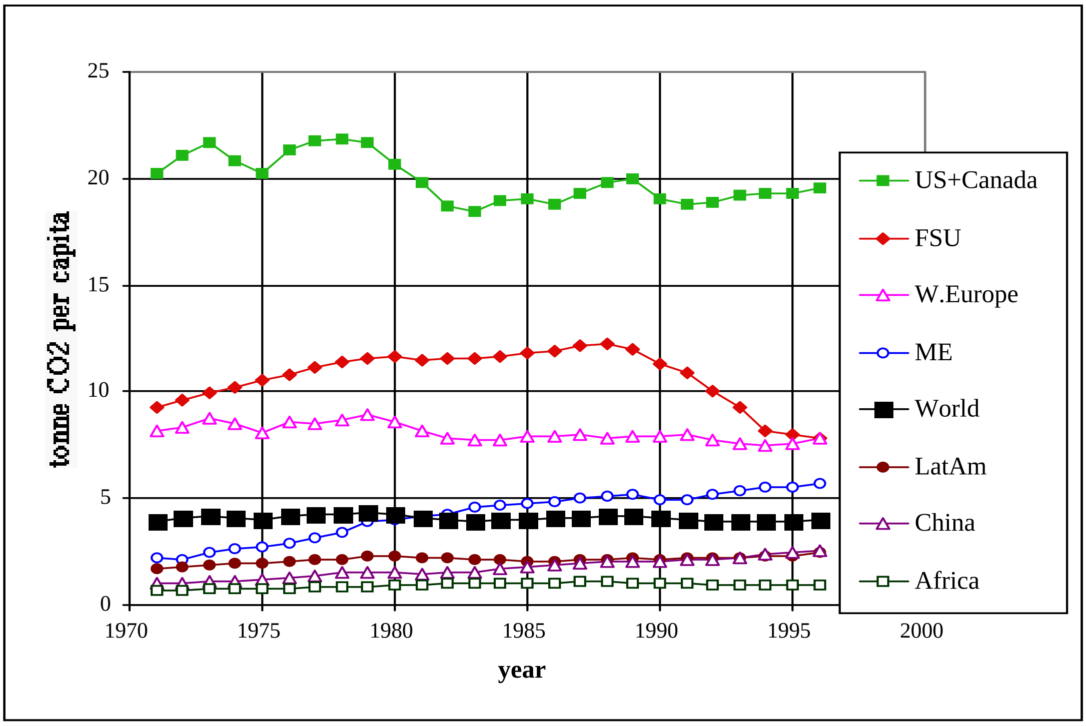

Figure 4 – Responsibility measured by the CO_2 annual emission per capita by region from International Energy Agency (IEA) data

Source: IEA (2005).

Nevertheless the mitigation models that are recommended to be adopted are based in criteria that do not take into account the responsibility of each country to climate change, but only which place it is cheaper(from their point of view)to implement those mitigation actions.

RESOURCES ALLOCATION ISSUES

As the methods recommended to value those activities are strongly influenced by income distribution, the final result may present the paradox to the implementation of mitigation actions in those places with less relative responsibility in terms of their contribution to the problem. It is evident that giving priority to adopt measures in those countries will imply a dilution of the responsibility of the Developed Countries in reaching the current situation.

So, from the economic point of view there are two main issues related to climate change: *who* should pay, and *which* action should be prioritized to allocate the limited available prioritizing funds.

As it was said previously, resources that will be dedicated to certain policies and measures will not be available to allocate them for alternative uses. For Developing Countries the decision between allocating resources for Adaptation or Mitigation to Climate Change is one of the most relevant from economic point of view.

Although Developing Countries are less responsible than Developed Countries to reach the current climate situation, they are more vulnerable to Climate Change potential impacts. Additionally, the effect on GHG emission abatement in most Developing Countries will contribute in a very small quantity to solve the problem. So, they should face some Adaptation costs independent from mitigation efforts that they should do. However, not only small funds are available for them to address this purpose, but they are allocating huge parts of their own resources on mitigation procedures rather than to adaptation ones.

One of the main arguments used by Developed Countries to justify the lack of support for Adaptation measures in Developing Countries is to consider Adaptation as a National or Local-related issue   a Global one (as mitigation is). If Mitigation is considered a Global issue and Adaptation a National/Local issue, no significant grant funding by Global Environmental Facility (GEF) would be expected to be available for financing Adaptation (because the GEF finances the incremental costs of procedures that induce *global* benefits), and most of the funding will be available for Mitigation projects.

So, there exists a paradox from the point of view of funding: Adaptation is the most important issue for most Developing Countries, and the lack of funding is the main barrier for these Countries to adapt to climate change , however funding is available mostly for Mitigation, which is an issue that is mainly a Developed Countries' one.

But Adaptation should be considered as a Global issue that has different forms to be addressed at national and local level, depending on the national circumstances of the diverse Parties involved. These national circumstances are influencing mainly two aspects: the degree of incidence of the potential climate change impacts and the capacity of response from each Party.

Adaptation is a Global issue at least from two points of view: first because Developing Countries must adapt to climate variability and climate change independently of their responsibility and also because without a joint action of all Parties it will not be possible to adapt to changes.

CLIMATE CHANGE NEGOTIATION CURRENT SITUATION

At it was previously said cost-effectiveness is the main argument proposed by Annex I Countries. This argument consists in mitigating in those places in the World which would be cheaper to get GHG emission reductions. This was one of the main arguments to establish the Kyoto Mechanisms. But it is not true that Mitigation Costs are necessarily cheaper in Developing Countries in all situations.

In the same way, UNFCCC established clearly that Annex I Parties should take the first steps in implementing mitigation measures and actions. Nevertheless there exists a growing pressure on those so-called “key developing countries”[2] for those countries to assume certain commitments regarding GHG emission limitation and/or abatement, mainly post 2012 or in the second commitment period of Kyoto Protocol. It is obvious that Non Annex I countries will have a growing responsibility in their own process of economic development. In this situation, all the delays in the implementation of any solution increase the future relative responsibility of Non Annex I countries at the same time that dilute the responsibility of Annex I countries.

In the context of the Kyoto Protocol there is an instance of negotiation, the so-called: Ad Hoc Group of Article 3.9. But, nowadays, the main actor (United States of America) is outside the Kyoto Protocol. For the purpose of including the USA in the agreements, a “Consultation Process” was developed in the framework of the UNFCCC. In this group the USA can participate as it is a Party of the UNFCCC. The main reason is that for everyone the inclusion of USA is necessary in every future set of actions that should be implemented.

How would the final definition of the new commitments be is still a question to debate. Quantified Emission Limitations and/or Reduction Objectives (QELROs) plus Sector goals may be one of the possibilities. Nevertheless, the main issue is that we are only four and a half years from the deadline of the first commitment period and there is no definition about post 2012 rules.

For the moment, the main consensus is that there is no consensus.

2 China, India, Mexico, Brazil, Indonesia, South Korea, among others.

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BRAZIL AND CLIMATE CHANGE: PROPOSAL OF A GOVERNMENTAL PLAN OF ACTION

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ABSTRACT

The great global impact of the Fourth IPCC Report, released in 2007, which had an influence on the concession of the Peace Nobel Prize to the IPCC, is due to two main factors: (i) Reduction of the uncertainties on predictions and (ii) Greater notice given to extreme climatic events. The reversion of CO_2 previously emitted is difficult due to the endurance of this gas in the atmosphere (circa 120 years) the fact being that, to the contrary of what occurs in most countries, the great Brazilian contribution for gases emissions to the atmosphere does not come from the energetic system, which possesses an important component of renewable energy, but from deforestation in the Amazon Region. In a meeting between the Ministry of Environment and the President of the Republic, the Executive Secretariat for the Brazilian Forum on Climatic Changes was put in charge to give suggestions concerning the proposal of a National Plan of Action for the Confrontation of Climate Changes. Thirty Procedures distributed in 13 topics, grouped into three great themes: Mitigation Actions (Topics: Environment, Energy, Transportation, Industry); Adaptation Actions (Topics: Environment, Energy, Agriculture, Labor and General) and Vulnerability and Transversal Actions (Topics: Data, Planning, Education, Official Accounts of Avoided Emissions). These procedures are part of the Strategic Axis 1 that deals with the coordinated actions of the Government, involving different Ministries and the connections between States and Municipalities under the supervision of the Ministry of the Environment. Two other strategic axes belong to the Plan of Action proposed by the Brazilian Forum on Climatic Changes: The creation of the Brazilian Net for Research on Global Changes by the Ministry of Science and Technology and the creation of a National Entity of Climate Policies encompassing the Technical Group on Climate Change of the MST.

Keywords: Climate change, Global warming, Brazilian plan of action.

THE IMPACT OF THE IPCC FOURTH ASSESSMENT REPORT AND THE NOBEL PEACE PRIZE

The deserved attribution of the 2007 Nobel Peace to the International Panel on Climate Change (IPCC)[1] was delivered as a result of the publication of the Fourth Assessment Report of the IPCC, which occurred in the beginning of the year, causing a great impact all over the world. Its content was already known except for details and had been publicly discussed beforehand, as well as much of what appears in the film produced by Al Gore, which shared the Nobel 2007 Prize. The intensification of the greenhouse effect, due to human originated emission of certain gases to the atmosphere, imprisoning part of the heat irradiated by the Earth and causing global warming (climate change), was already of public domain. By observing the air confined in the glaciers, it is accepted that there was a rising concentration of the carbon dioxide (CO_2) in the atmosphere. It has been verified that, since the time of the Industrial Revolution, the consumption of fossil fuels (coal, petroleum and natural gas) has grown. When we burn these fuels in industries, thermoelectric plants, stoves or vehicles, CO_2 and H_2O (vapor)[2] are produced.

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1 According to a Survey effected by the Brazilian Fórum for Climatic Changes, based on publication of the IPCC, at different levels participated in the reports of the IPCC, since 1990 until 2007, the following Brazilian researchers and specialist: Antonio Rocha Magalhães – Banco Mundial, Arnaldo C. Walter – Unicamp, Britaldo Silveira Soares Filho – UFMG, Branca Americano – MCT, Carlos A. Nobre – INPE, Carlos Clemente Cerri – Cena/USP, Carlos Frederico Silveira Menezes – Eletrobrás e EPE, Cleber Galvão – AES Tietê, Demóstenes Barbosa Silva – AES Tietê, Diógenes Sala Alves – INPE, Emilio La Rovere – COPPE/UFRJ, Enio Cordeiro – Itamaraty, Frederico S. Duque Estrada Meyer – Itamaraty, Gilberto Januzzi – Unicamp, Giulio Volpi – WWF Brasil, Heraldo Campos – Unisinos, Hézio de Oliveira – Alcoa Brasil, I. Tavares de Lima, Jefferson Cardia Simões – UFRGS, João Wagner Silva Alves – CETESB, José D. G. Miguez – Petrobras e MCT, José Goldemberg – USP, José Marengo – INPE, José Roberto Moreira – USP, Laura Tetti – ÚNICA, Luiz Gylvan Meira Filho – USP, Luiz Pinguelli Rosa – COPPE/UFRJ, M. de Oliveira Santos, M. Fujihara – Price Waterhouse Coopers, Magda Aparecida Lima – EMBRAPA, Marco Aurélio dos Santos – COPPE/UFRJ, Marco Túlio S. Cabral - Marcos S. P. Gomes – PUC/RJ, Maria Sylvia Muylaert – COPPE/UFRJ e Secretaria do Meio Ambiente do RJ, Mauricio Firmento Born – Associação Brasileira de Alumínio, Mauricio Tiomo Tolmasquim – COPPE/UFRJ e EPE, Mauro Santos – MCT, Newton Parcionik – MCT, Niro Higuchi – INPA, Odo Primavesi – Embrapa, Oswaldo Lucon – Secretaria de Meio Ambiente de SP, Paulo Antônio de Souza – CVRD, Paulo Atarxo – USP, Paulo Cunha – Petrobras, Paulo Rocha – Petrobras, Patrícia Morellato – Unesp, Pedro Dias – USP, Pedro Machado, Pedro Moura Costa – Ecosecurity, Philip M. Fearnside – INPA, Plínio Nastari – Consultor, R. Gualda, R. Monteiro Lourenço, Ricardo Leonardo Vianna Rodrigues – TNC Brasil, Roberto de Aguiar Peixoto – IMT, Roberto Schaeffer – COPPE/UFRJ, Ronaldo Seroa da Mota – IPEA, Sérgio Trindade – Consultor, Sônia Maria Manso Vieira-CETESB, Suzana Kahn Ribeiro – COPPE/UFRJ e Secretaria do Meio Ambiente do RJ, Thelma Krug – INPE e Secretaria de Mudança Climática do MMA, Ulisses Confalonieri – Fiocruz, Volker Kirchoff – INPE, Warnick Manfrinato – USP, Y. D.P. Medeiros

2 Although water vapor is also a greenhouse effect gas, its presence in the atmosphere is not, however, substantially affected by human activities, contrary to what occurs with CO_2.

Which was, in such case, the cause for the impact of the last report of the IPCC, considering that it was awarded the Peace Nobel Prize in 2007? We can observe the effects from different aspects. First, there was a reduction of uncertainties. Contrary to popular belief, science coexists with error. A good theory on nature authorizes to appoint errors on predictions, the way they occur in opinion polls statistics, which is not the case in economics. Certainty, almost always, is confirmed in the obvious, but I am not saying any matter of importance, for instance, if I say that it will or will not rain tomorrow, I am anyway right. It will be a matter of importance when meteorology says that there will be a 90% probability that it will rain. To get to this conclusion many calculus have been done with mathematical models that use physics equations and empirical information on the state of the atmosphere. In meteorology, when long term predictions are construed, from a certain situation onward, error augments. We fall on the of grounds of unpredictability, true of chaotic systems. Climate is yet more complicated than weather prediction. Therefore, the fact that the Fourth Report arrived at a consensus on the reduction of uncertainty disarms the skeptic. Second, a greater attention was given to extreme cases on the behavior of the climatic system. Severe phenomena were revealed such as hurricanes, intense raining, etc. The conclusions point to the fact that the intensification of the greenhouse effects by human activity contribute to anomalies that are occurring, like the abnormal defrost of permanent glaciers. This is novel, since beforehand it was expected that climate change would occur 50 or 100 years from now. The possible effects at the end of the century are worrying, like the loss of part of the Amazon forest, the desertification of the cerrado, the elevation of sea level in a few decimeters, the reduction of food production. The necessity of adaptation, an object of another study of the IPCC, fits here.

The Fourth Report of the IPCC emphasized:

- The growth of greenhouse effect of gases emissions between 1970 and 2004:
- Among these, the CO_2 emissions have risen 80% and represent 77% of anthropogenic emissions in 2004;
- The major growth of emissions between 1970 and 2004 was in the energy sector (145%), followed by the transportation sector (120%), industry (65) and soil use and deforestation (40%);
- The per capita emission in USA and Canada in 2004 was of 27t of CO_2 equivalence, in Latin America 8t and in Africa 4t.

It is difficult to reverse launched CO_2 because it has a long life in the atmosphere. Once a certain number of its molecules are added to the air, it will take more than 120 years for nature to reduce it to half. Therefore, if we were to totally stop its emission tomorrow, which is impossible, the warming effect would remain intense for more than a century. Thus we confirm the historic responsibility of the rich countries, since they have been consuming a lot of coal since the beginning of the XIX Century, further on passing to oil and natural gas. The differentiated responsibility between these countries and the developing countries was verified in the Rio 92 Conference, when the UN Convention on Climate was elaborated. Its first goal was for the rich countries and the ex-communist countries to reduce their emissions in 2000. In 1997 the Quito Protocol extended the time to 2008-2012. Therefore, most of the CO_2 today residing in the atmosphere, with origin in fossil fuels, was emitted by these countries. Here we insert the issue of historical responsibility, emphasizing the so called Brazilian Proposition in Kyoto, which gave origin to the Clean Development Mechanism (CDM).

The USA increased their emissions and got out of the Kyoto Protocol and the developed countries are still far from their goals, with the exception of The United Kingdom and Germany. The first substituted coal by the North Sea Natural Gas, and in Germany the a Unification occurred. The communist countries reduced their emissions, as a consequence of their collapse.

Finally, due to the CDM approved in Kyoto there was a reduction in the emissions of the developing countries, which was accounted in favor of the countries of Annex I, owing to the investments of the rich mainly in China, India and Brazil.

THE PRESENT CONDITION AND THE DEBATE ON THE POST-KYOTO PROTOCOL REGIMEN

According to the IPCC results, the Kyoto goals are far from being sufficient. The Climate Convention aims to stabilize the concentration of CO_2 and other gases, but different scenarios of the IPCC indicate elevated levels of emissions. The consumption of energy in China is rising with popularization of automobile use. However, the western countries have a much larger per capita consumption. In the USA it is two fold the European, many times higher than the Latin American consumption and even more in the case of Africa. Here we confront an ethical issue, generally avoided by the individualism of the neo-liberal style globalization. Is it possible to handle the impasse without an adjustment in this consumption pattern?

Some people propose technological solutions – some of them extravagant, like satellites with mirrors reflecting the solar light, other feasible, like hybrid electric cars, batteries charged by fuel, wind energy, solar or nuclear energy, sequester of CO_2, improvement in equipment efficiency, etc.

Independent of possible technological solutions it is necessary to rationalize the use of energy, for example: prohibiting production of big cars or enormous heavy pickups consuming gasoline for personal urban use, a price cut in alcohol, closure of the down town sectors of cities to traffic and stimulating mass transportation; in oil crises the use of cars should be restricted and alcohol encouraged.

Brazil has the advantage of using alcohol combustible on grand scale, in a way that the emitted CO_2 is reabsorbed in the growth of sugar-cane. Brazil uses hydro electric power stations that emit some gases, but less than thermo. However, thermo-electricity has grown in excess due to occurrence of public auctions for expansion of electric energy, nevertheless including coal, oil and diesel power plants.

On the other hand, the per capita consumption in Brazil is low. The consumption of poor families is very low but should increase with governmental acts such as the Plan for Growth Acceleration, Light for All, and the Family Bursary. Meanwhile, the middle and high classes continue to consume lavishly and should not be kept exempt of obligations, either in Brazil or in the rest of the world.

Most of the Brazilian emissions come from deforestation, which was reduced in the last three years, but there is illegal deforestation to be confronted, demanding a coordinated action of the Federal Police and the IBAMA with support of the Army. There is information that this year deforestation in Mato Grosso is increasing.

There is not a unique solution for each country. It should be made clear that if the whole world continues to increase its emissions at the current rhythm, the loss of part of the forest area will still occur, notwithstanding all deforestation be stopped today, given that it contributes with a percentage of the emissions. Therefore, the Amazon Region is a victim of the global greenhouse effect.

In the ambit of the UN Climatic Change Convention discussion has begun on what to do post-2012, when the final deadline will occur for developed countries to reduce their greenhouse effect gases emissions, according to the percentages decided by the Kyoto Protocol. In addition to the fact that the USA and Australia have been keeping out of the Protocol, the developed countries are not reducing their emissions, although there are exceptions, such as England and Germany. Spain, according to its share in the European Union emission reduction had an objective to allow a 15% rise on emissions in relation to 1990, but has increased 38%.

The celebrities in the debate on the Post-2012 regimen were India, Brazil and China, as countries whose emissions have increased in the last years. However, they do not have, as all developing countries do, the obligation to reduce them, within the Climate Convention principle of “common responsibilities, though differentiated”.

Brazil’s position has been in the defense of the Kyoto Protocol as an international law to be valued, and the contribution of the developing countries should be accomplished through the Clean Development Mechanism (CDM). In this sense, instead of referring to a Post-Kyoto Protocol regimen, a post-2012 regimen should me mentioned.

Brazil, counting on its good articulation with South America, South Africa and India, should propose a co-alliance within the Climate Convention, for the acceleration of the emissions reduction in the Annex 1 countries and prepare not only a possible mitigation in the developing countries, but also the adaptation.

PROPOSITION OF AN ACTION PLAN FOR BRAZIL

To the contrary of what occurs in most countries, the largest Brazilian contribution to halt gases emissions to the atmosphere has not been in its energetic system, which has an important component of renewable energy, but in deforestation. This fact was stressed in the report of the Ministry of Environment, avowing the efforts it has been applying on the reduction of emissions, such as the expansion of protection areas for the forest in the Amazon Region. This issue was included in the discussion agenda of the Brazilian Forum of Climatic Change with a discussion on the opportunity to establish goals headed for the reduction of deforestation in the next years.

In a meeting of the Minister Marina Silva with President Lula it was decided that the Executive Secretariat of the Brazilian Forum of Climatic Changes would be assigned to put emphasis on suggestions for the proposal of a National ActionPlan to confront Climatic Changes. After a process of consolidation of the proposals sent to the Executive Secretariat of the Forum an extraordinary meeting[3] was held with the objective of deepening the discussion and approving the suggestions for elaboration of the Nation Action Plan, which was presented to the President and the Minister of the Environment.

Later on, the Secretariat of Climatic Change was created in the Ministry of the Environment, for whose direction was designated the INPE researcher Thelma Krugg, also an integrator of the IPCC. President Luiz Inacio Lula da Silva, in his UN speech in October of this year explicitly referred to the elaboration of the National Action Plan for Confrontation of the Climatic Changes.

The base document proposed by the Forum structures the Action Plan on three strategic areas, positioned in this way:

Concentrating in the Area 1 above, the measures proposed by the Forum for the Action Plan are synthesized below:

MITIGATION ACTIONS

a) Environment:

- Definition of a reduction goal in the rate of deforestation and slash and burn;
- Policies and ecosystems conservation actions, for the mitigation of the emissions and as a strategy for the creation of resilience.

b) Transportation:

- To bind an obligatory checking of vehicular emission levels for an annual permit of vehicles;
- To establish minimum efficiency energetic indexes for vehicles and also fix different taxes according to their gas spending;
- To foment the expansion of mass transportation, emphasizing other non road manners.

3 The meeting was coordinated by the Executive Secretary of the FBMC, professor Luiz Pingueli Rosa, and counted with the presence of coordinator for the Climate Change of the Ministry of Science and Technology, Jose Miguez, of the director of the National Institute of Meteorology, Divino Moura, of the coordinator of Environment Education of the MEC, Rachel Trasber, of the director of Environmental Education of the Environment Ministry Marcos Sorrentino, of the representatives of the Bahia Forum of Climatic Changes and Biodiversity: Osvaldo Soliano Pereira (UNIFACS) and Adriana Diniz (SEMARH), or representatives of the academic community, Eneas Salati of FBDES, Luiz Gylvan Meira of IEA/USP, Roberto Schaeffer, of the IPCC and COPPE, besides the representatives of Casa Civil of the Presidency of the Republic and of the Ministries of Science and Technology, Environment, Agriculture and Education, ass well as of companies, Embrapa, Eletrobras,and Petrobras/CEENPES and of the NGOs, Greepeace and WWF.

c) Energy:

- Consolidate the bio-combustible policy as a contribution to reduce emissions;
- Expansion Program for the use of renewable sources of energy of energy efficiency.

d) Industry

- Creation of an incentive program for de-carbonization of production unities of the companies, with reduction of emissions goals per produced unities; (for instance ton CO_2 per ton of steel).

ACTIONS OF ADAPTATION

a) Environment

- Acceleration of reforestation of permanent preservation areas, specially on river banks.

b) Energy

- Evaluation of possible impacts on hydro-electric power generation given the change on rainfall pattern in the country.

c) Agriculture

- Evaluation of the economic impacts, at short and medium terms, of the different Scenarios of Climatic Change in different sectors of economy, specially in Agriculture.

d) Labor

- Evaluation of climatic change and international agreements impacts on conditions of Labor Centers.

e) General

- Integration of the climatic issues to international cooperation programs;
- Programs for population supply in critical areas.

VULNERABILITY AND TRANSVERSAL ACTIONS

a) Data

- Recovering and digital treatment of historical meteorological series of Brazilian data;
- Installment of systems to collect data on the sea level on the Brazilian Coast;
- Structuring the monitoring of hydro-meteorological data at national level;
- Cooperation with neighboring countries to monitor meteorological events.

b) Planning

- Generation of climatic regionalized scenarios;
- Planning of detailed studies on the vulnerability of the current Brazilian energetic system, and future systems to climatic changes;

c) Education

- Incentives for an introduction of themes on climatic change and its effects on levels of education, formal or non formal;
- Definition of a Managing Organ of Environmental Education National Policy, including Climatic Change;
- Allocation of resources for the habilitation of personnel and fomenting of knowledge on climatic changes;

d) Official accountancy contribution to avoided emissions

- By reduction of deforestation and slash and burn;
- By MCD projects in Brazil;
- By substituting gasoline for alcohol and mineral diesel for bio-diesel or "Hbio";
- By use of alternative sources, including the PROINFA, in the renewable energy electric system;
- By increasing the efficiency, including the PROCEL and the CONPET;
- By anticipation in Brazil of the substitution of gases of the Montreal Protocol with high potential of global warming.

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SUB-NATIONAL CLIMATE-FRIENDLY GOVERNANCE INITIATIVES IN THE DEVELOPING WORLD: A CASE OF THE STATE OF SÃO PAULO, BRAZIL

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ABSTRACT

The divergence of interests between UN Climate Change Convention (UNFCCC) Parties is a crucial barrier to overcome, particularly in view of post-Kyoto negotiations and the growing understanding by the international community that the so-called key developing countries should accept any kind of commitments under the UNFCCC umbrella. Considering that most key developing countries -- inasmuch as they are national states -- are very reluctant to embark on the discussion of the principle of common but differentiated responsibility, it is imperative to envisage alternative environmental governance initiatives, particularly proactive local and regional policies. The objective of this paper is to present sub-national climate-friendly governance initiatives now arising in the developing world, taking as a case study the environmental policy implemented by the State of São Paulo, Brazil. This paper addresses the following aspects of this issue: [i] The inertia and reluctance of key developing countries in assuming specific commitments under the UNFCCC umbrella, focusing on the case of Brazil's federal government; [ii] the role of alternative environmental measures created under regional and local arenas, and [iii] the climate-friendly governance promoted by the state of São Paulo under its environmental policy.

Keywords: Climate change mitigation, Developing countries contribution, environmental governance.

INTRODUCTION

The acknowledgment of global environmental problems, such as climate change, as challenges calling for rapid and effective responses from human society has turned the attention of policy makers to the international spheres of political decision. More and more nation-state governments begin to incorporate the outlining of the so-called climate regime into their strategic decision making.

However, from the perspective of legitimacy and effectiveness, other challenges are added to the climate regime, in particular the complexity inherent to international law governing the adoption and implementation of effective measures to combat global warming, and the interaction that must prevail between international pro-climate policies and the other governance spheres.

The goal of this article is to discuss the extent to which these two challenges can be understood as a factor watering down the perception of the legitimacy and effectiveness of the climate regime, and how the introduction of the concept of environmental governance could minimize this impact. With this aim, the present study resorts to observing the experience of the state of São Paulo, Brazil.

Section 2 discusses the role of developing countries in the evolution of the climate regime, pointing out the reluctance of major emitters in assuming broader commitments in the international climate regime. It is also argued that, in view of the difficulty in developing the climate regime amid a lack of supportive climate-friendly positions from nation-states, thinking about alternative and complementary actions is probably a good initiative.

Section 3 highlights the emergence of alternative environmental policy structures, mainly governmental measures originating at local and regional levels. It shows that such initiatives could lead to important positive effects at the regional level, such as encouraging States to promote climate-friendly measures, acting as centers of environmental education and knowledge to population, influencing the position of nation-states, and applying pressure to the international negotiations arena.

Section 4 shows that such structures can lead to important benefits to the developing world, and presents the experience of São Paulo state. The context of Brazil in the climate change negotiations is outlined, and some climate-friendly measures under implementation in the regional level are described in more detail. It is also highlighted that the effectiveness of such initiatives are intrinsically conditioned to the way in which the interaction between global and local aspects of environmental problems is incorporated into their planning and implementation processes. Some concluding remarks are presented.

THE CHALLENGE OF CONSENSUS IN THE CLIMATE REGIME: TOWARDS POLICY AND POLITICS

The recognition that climate change is one of the most dramatic global environmental problems, and that it is intensified by anthropogenic emissions, has instigated the international community to find measures commensurate with the issue. The United Nations Framework Convention on Climate Change (UNFCCC), approved in 1992, inaugurated an international legal regime aiming to achieve the stabilization of the greenhouse gas (GHG) concentration in the atmosphere at a level that would prevent dangerous human interference with the climate system.

In order to define specific international strategies to face the global environmental problem, the Kyoto Protocol was approved in 1997. This treaty constitutes, along with the UNFCCC, the basis of the climate regime. It elaborates the principle of common but differentiated responsibilities, establishing quantified reduction targets for developed countries listed in Annex I of UNFCCC, to be accomplished in the period between 2008-2012 -- the so-called first commitment period -- after which new rules would be in force.

Almost 10 years have gone by since its approval, and the GHG emission reduction targets imposed by the Kyoto Protocol still seem difficult to achieve for most countries. Even having assumed a legal obligation to advance toward their quantified targets, only a handful of the Annex I countries that have ratified the Kyoto Protocol can claim effective reductions. Except for Germany (18.2% reduction) and the United Kingdom (13% reduction), most EU member countries had unconvincing results, and the EU itself could reduce its emissions by just 1.4% from 1990 to 2003 (UNFCCC, 2005). Among Annex I parties signatory of the Kyoto Protocol at the time of report preparation, the situation of Canada was the most preoccupying: it increased its GHG emissions by 24.2% from 1990 to 2003, and by 26.6% from 1990 to 2004. The situation is still more distressing if we look at the signatories of UNFCCC only: from 1990 and 2003, Australia increased its emissions by 23.3%, and the USA by 13.3% (UNFCCC, 2005). In the developing world, emission levels of the most populous and industrialized countries are cause for concern, particularly China, India and Brazil. According to the UNFCCC database (2006), China is the second largest GHG emitter, ranking just below the USA; Brazil and India are in 5th and 6th places.

For these reasons, the climate regime in general -- and the Kyoto Protocol in particular -- have been harshly criticized. For most authors (BROWNE, 2004, p.20; ALDY et al., 2003a, 2003b; BROUNS; OTT, 2005), both the targets stipulated by the regime and the measures implemented by the countries proved insufficient to combat global warming effectively. For others, the problem lies in the need to conceive long-range goals, more appropriate to address the problem (ALDY et al., 2003a). Some authors point out that the lack of environmental effectiveness of the regime is, to a large extent, the result of the inadequate application of the equity criteria in apportioning responsibilities among countries, since it stipulated differentiated targets only to a group of countries rather than to all (COOPER, 1998; FRENCH, 1998).

The climate regime, and the Kyoto Protocol in particular, have nevertheless been regarded as a first step toward effective and more efficient climate change combat actions (ANNAN, 2004; ASHTON; WANG, 2003; ALDY et al., 2003a; BROWNE, 2004; BUCHNER; CARRARO, 2005; VAILLANCOURT; WAAB, 2004). There is a consensus that the regime, as established, is not sufficient to tackle climate change, and that reforms are necessary, but at least mankind has a path to follow (BAUMERT; KETE, 2002). Effectively, in addition to the revision of targets of Annex I Parties, both the UNFCCC text (Art. 4.2 d) and the Kyoto Protocol (Art.9) foresee periodic revision of measures and rules inserted into the climate regime. As previously mentioned, this treaty advocated reduction targets for Annex I countries only valid in the so-called first commitment period -- from 2008 to 2012.

Official discussions about the future climate regime were started during COP 11, in Montreal, Canada in 2005. As a result of the COP work, it was agreed that the negotiation should proceed simultaneously along two tracks: the Kyoto track, and the so-called "Dialogue on long-term cooperative action to address climate change by enhancing implementation of the Convention" (WITTENEBEN et al., 2005).

Although on one hand the decision to conduct international negotiations of the post-2012 period in two tracks reinforces the role of international institutions as the most adequate arena for international cooperative actions of nation-states to combat global environmental problems, on the other it is indicative of the possible fragility of this regime in dealing with the problem in a convincing way. The message brought by COP 11 is clear in the sense of recognizing the urgent need to implement measures that effectively address climate change (MÜLLER, 2006), which implies the challenge of engaging all the world's major emitters, notably the USA and the so-called key developing countries (China, India and Brazil) in a long-term effort that fairly and effectively mobilizes resources needed to protect the global climate (DIRINGER, 2003).

From the environmental perspective, a broader participation of the developing countries in international mitigation efforts is an important condition to make the climate regime an effective way to address climate change. This statement was reinforced after the announcement, in February 2007, of the Summary for Policymakers prepared by IPCC's Working Group I (IPCC, 2007). The IPCC's message clearly states that continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century, with average global temperatures ranging from 1.1 to 6.4 °C above 20th century levels, and calls for an urgent widening and deepening of efforts to control anthropogenic GHG emissions.

Even though it may take decades until the historical accumulated emissions from developing countries reach the levels of developed countries, from a long-term perspective the contribution to the greenhouse effect from developing countries will significantly increase (GOIÁS, 2005). According to IPCC (2001) and OECD/IEA (2002) among other sources, countries such as China, India and Brazil would, at some future point, have emission levels higher than Annex I countries, particularly in view of their economic development needs.

The importance of the key developing countries in developing the climate regime is not restricted to their role as emitters; their participation with broader commitments is in the essence of economic competitiveness between countries (GOIÁS, 2005). Developed countries hold that they will suffer greater and more drastic economic restrictions and will lose competitiveness if different goals are imposed on them, sparing the developing countries from the mitigation efforts -- thus establishing an unfair relationship between the two groups.

It must be recognized that the economic aspect of the participation of the developing countries in the international regime is at the very basis of the position taken by one of the main actors in the negotiations: the United States (MÜLLER, 2006). Suffice it to say that the American refusal to ratify the Kyoto Protocol was expressly founded on the fact that the entry of the USA into the regime of that treaty would have to be conditional on assigning mitigation goals to countries such as Brazil, China and India (BANG et al., 2005). After almost 10 years, a greater engagement of the key developing countries in the mitigation commitments continues to be seen as a factor that would put pressure on the USA to return to the Kyoto Protocol discussions, and thus lead to a better balance in the mitigation efforts among countries (ASHTON, WANG, 2003).

In spite of growing pressure from Annex I countries, the developing countries, united around the G-77 and China, have almost unanimously held the position of refusing to discuss any specific mitigation commitments. In general terms, they argue that their historic and current emissions are still much lower than those of developed countries (GOIÁS, 2005; ROSA et al, 2003). Furthermore, because of the vast diversity among them, and the socio-economic disparities which imply differences in their mitigation and adaptation capacity, there would be no way of assigning equitable reduction goals to each (IEA, 2003).

Developing countries try to make their participation in the climatic regime conditional on the discussion about vulnerability, adaptation, promotion of sustainable development, resource and technology transfers, and capacity building (GIRARDIN; BOUILLE, 2003). It should be recognized that because of their different adaptive abilities and geographic conditions, these countries are effectively more vulnerable to the impact of climate change. Thus, Najam et al. (2003) sustain that, before about mandatory mitigation commitments, it is necessary to reinforce the instruments for transfer of technology and financial resources, and increase the efforts of developed countries to provide speaking support and promote capacity building. Another strong argument is the claim that developing countries have in fact implemented, to the best of their internal abilities, policies and programs with positive mitigation results (GIRARDIN; BOUILLE, 2003; BAUMERT; KETE, 2002; GOLDEMBERG; REID, 1999).

Thus, the main challenge facing the international climate regime lies in reconciling the effectiveness of its measures with the assurance that equity is the presiding parameter in apportioning responsibilities among countries for the implementation of these measures. In practical terms, what matters most is distributing responsibilities for the major emitters, including the USA and the key developing countries, notably China, India and Brazil.

Furthermore, the need for immediate action to prevent possible irreversible damage from climate change, on the one hand, and scientific uncertainties on the other, have the effect that decisions are permeated with value judgments, since they reflect the degree to which each society is prepared to deal with the problem. This, in turn, is influenced by several factors, such as the perception of climate change risk, the level of adaptive and mitigating capacity of countries (which depends on national circumstances), and even very specific interests of power groups (GEC-CEC, 2004, p.41). In other words, in order to achieve an agreement able to embrace all these often conflicting factors, a complex political negotiation process is inevitable (OTT et al., 2004, p.57). The result does not always translate into policies really aiming at addressing the anthropogenic causes of climate change; instead, it is more often directed to establishing policies to meet specific interests of the States (BODANSKY, 2003).

Just as any system governed by international law, the climate regime and its measures are defined by consensus deliberated by the states, which are thus understood to be the sole formal subjects of international law. According to Bodansky (1999), the international environmental law in general has developed through a consensual process: states realize that they cannot solve some global or transnational environmental problems through individual action, and so agree collective action by means of reciprocal exchange of promises; thus, they negotiate and adopt international rules that they believe are in their self-interest.

From this perspective, the State emerges as the entity holding political and legal authority to sovereign discussion and agreement to international procedures to confront global environmental problems, and this occur via international law. Its role now is that of implementing policies and actions, previously agreed on in cooperation with other States, generally under the coordination of an international institution such as the UN (FRICKEL; DAVIDSON, 2004). In other words, the global environmental problem finishes forcing on international institutions and States the challenge to create institutions and putting in action measures to ensure the effective combat of the causes and the adequate adaptation to the effects (BODANSKY, 1999).

However, in a context of complex and divergent positions of States regarding which measures to adopt to address global warming, the requirement of a consensus can be seen as a threat to the full legitimacy and effectiveness of the whole international climate regime. Attempting to achieve consensus is time-consuming and difficult, and runs against the urgency in implementing effective pro-active climate protection measures. Moreover, in many respects, particularly in the distribution of responsibilities among major emitters, reaching an agreement at all is nearly impossible; so, a consensus requirement in effect precludes collective action, or allows little room for progress in determining deep mitigation efforts (BODANSKY, 1999).

The process of international negotiation, having as its principle the respect for the sovereignty of States, inevitably depends on the voluntary cooperation among countries, and there are no mechanisms of positive law to compel a country to participate in a negotiation process, nor to accept or ratify a treaty. In the context of the post-2012 regime negotiations, this means that the possibility cannot be dismissed that important countries refuse to cooperate, or impose conditions to their adherence to the regime, or even participate in an ineffectual way (HÖHNE, 2003).

Effectiveness ultimately has to do with the ability of international regimes to solve the problems that prompted their establishment (ANDRESEN; HEY, 2005). According to BODANSKY (1999), effectiveness of a regime is a factor that may contribute to a regime being perceived as legitimate. As shown, the difficulty of States in agreeing to ample measures to combat climate change, and the consequent adoption of minimal actions which do not always translate into practical results as expected, reduces the effectiveness required in the international regime. For these reasons among others, the unanimity rule is recognized as incompatible with effective government (BODANSKY, 1999). In this sense, the climate regime is perceived as weak, incapable to effectively face global warming.

Just as the effectiveness of a regime is a parameter by which to evaluate its legitimacy, the reverse is also true. A regime regarded as legitimate is more likely to be effective, due to, among other things, the compliance pull that it is likely to exert (ANDRESEN; HEY, 2005). However, the international path, based as it is on agreements by consensus by sovereign States through international institutions, is subject to the direct influence of particular interests of States. In general, these interests are not consonant with the efforts required to face global environmental problems, since they have a short-term horizon or arise from predominantly economic or strategic perspectives, whereas environmental problems require long-range actions and a broad vision (PERSHING; TUDELA, 2002). That is what Bodansky (2003) calls the contradiction between *policy* and *politics*.

By ignoring that climate balance is a common good, and by prioritizing short-term interests often corresponding to specific economic interests, the position of States in international negotiations fail to reflect that of the societies they represent, resulting in a loss of authority. As Litfin (2000) clarifies, political authority is generally conceived as the recognized right to make rules or to wield power legitimately. A state's authority depends on its citizens believing in the legitimacy of its institutions, which involves a close association with state-society relations. Thus, crucial to authority is the social perception of legitimacy.

As a key component to authority, legitimacy of a nation-state is dependent upon the perception among its citizen that the state is performing its ascribed roles (FRICKEL; DAVIDSON, 2004). Thus, legitimacy requires a reflective subject capable of judging whether an action, rule, or proposal is in accordance either with its interests or else with established rules or principles (LITFIN, 2000). Legitimation largely represents state responses to rapidly fluctuating pressures and priorities defined by interest groups in civil society (FRICKEL; DAVIDSON, 2004). Legitimacy reflects a focus on ongoing systems of governance -- on the institutions that issue directives and the processes by which they do so, rather than on the legitimacy of particular directives (BODANSKY, 1999).

Thus, in a context of inherently complex political decisions requiring consensus, and of prevalence of diverging interests of the States, implementation of the climate regime raises issues of legitimacy and effectiveness. It is to be expected that alternative and complementary mechanisms will emerge as more legitimate ways to effectively address the global environmental problem.

Indeed, these mechanisms have been arising in the inter-state sphere through the formation of networks among non-governmental organizations and among regional and local government agents, and in the infra-state sphere by the initiative of regional and local agents, or still as purely domestic initiatives. As formulated by Jacobi (2000), this characterizes the emergence of the so-called environmental governance.

ENVIRONMENTAL GOVERNANCE AND NEW FORMS OF ADDRESSING CLIMATE CHANGE

By ignoring state barriers, global environmental problems such as climate change give rise to the need for effective cooperation, leading to the understanding that such problems are ultimately those of a global common (BULKELEY, 2005), concretely felt in infra-state levels (BODANSKY, 1999). When contrasted with the complexity of a response through the action of States within the framework of international law, the idea of global commons inculcates a sense of intergenerational responsibility at all levels of social organization (LITFIN, 2000), signifying the emergence of new and complementary structures to face global environmental problems.

These new structures originate from the recognition that facing global environmental issues requires the cooperative and coordinated action of governance systems based on several levels (state, supra-state, infra-state and inter-state) and comprising state and infra-state (regional and local) actors, as well as non-governmental actors, each performing a variety of roles (BULKELEY, 2005). According to Dedeurwaerdere (2005), a network governance can be characterized by an attempt to take into account the increasing importance of NGOs, the private sector, scientific networks, and international institutions in the performance of various governance functions. This author says that there is a combination of the voluntary legitimacy of the civil society sector with the financial power of the business sector and the political authority of States and international organizations.

In this way, the networks become embedded in a logic that demands coordination, solidarity, definition of common objectives, and reduction of friction and conflicts, making the integration of demands a horizontal process (JACOBI, 2000).

When established within the structure of States whose environmental actions are ineffective or lack flexibility, these initiatives, when taking proactive steps in infra-state spheres (even if such steps have been driven by demands from abroad), become a means to press against the inertia of States, as well as an alternative path to face environmental problems. In the first case, according to Bulkeley (2005), the significance of non-state actors lies in the extent to which they shape, facilitate or change the behaviour of nation-states within international regimes. In the second, regional initiatives are deemed more responsive to pressures of inter-locality economic competition and continuous policy innovation, on the one hand, and citizen demands for pro-active measures, on the other (JONAS; PINCETL, 2006).

The idea of environmental governance has been initially fostered by the call in Agenda 21 (BULKELEY, 2005). In the domain of climatic change, infra-national governance initiatives began to gain strength as international negotiations, performed under the coordination of the UN and carried out by national States, became increasingly complex, leading to ineffective practical results and falling short of the requirements for a real combat of climatic change. In addition to the emergence of essentially scientific networks, which yield a strong influence over international decisions, and to the expansion of the activities of non-governmental organizations, regional and local governance initiatives have emerged as new forms of reinforcing the legitimating and the effectiveness of climate-friendly measures.

The common aspect about these local and regional actions is to rescale climate change as an issue with local causes and consequences, while at the same time reframing issues which are institutionalized and imagined as local and regional when in fact they also have global dimensions. In doing so, these initiatives increase the importance of regional and local institutions and practices as an arena of influence, and reduce the role of international and national scales of governance, which gives them the opportunity to highlight the role of local and regional authorities in addressing climate change (BULKELEY, 2005).

From the perspective of the developing world, these initiatives could be viewed as an alternative way to address climate change challenges where the official position of nation-states is still one of reluctance to take early action. As previously mentioned, these initiatives could bring important positive effects at the regional level: encouraging states to promote climate-friendly measures, influencing the position of nation-states, and putting pressure at the international negotiations arena, particularly on the developing world.

However, the legitimacy and effectiveness of infra-national initiatives in tackling climate change depends, to a large extent, on how the interaction between the global problem of climate change and the regional and local problems and environmental impacts is dealt with. Assuming that the main anthropogenic sources of GHG are also at the basis of important regional and local environmental problems, mitigation measures that acknowledge global-local relationship have better chances of succeeding, not only because they lead to real global and regional/local environmental benefits, but also because they place the issue of global warming on a level closer to the everyday reality of people. The common citizen begins to see more easily the correlation between his or her direct actions and the global environmental problems (BULKELEY; BETSILL, 2003). Environmental governance, in this sense, means to conjugate the causes and consequences of environmental problems, and their construction as such, with practices and politics taking place at a multitude of sites and scales of governance (BULKELEY, 2005).

If, on the contrary, actions to combat global environmental problems, such as climate change, focus exclusively on the state/global perspective, ignoring regional/local effects of such measures, then other economic, environmental and social problems may arise on these levels. A conflict between global-local solutions can bring about a lack of effectiveness and a diminished perception of the legitimacy of those measures.

The experience of the state of São Paulo, Brazil, is a case in point. Considering the reluctant position of Brazil's federal government in taking early action to protect the climate, it contemplated many possible proactive measures in the state sphere. The positive results of such measures, and their ensuing legitimacy and effectiveness, depend on whether they will be implemented as part of an environmental governance focus.

CLIMATE-FRIENDLY GOVERNANCE INITIATIVES IN THE STATE OF SÃO PAULO

FEDERAL INERTIA VERSUS REGIONAL PROACTIVE ACTION

In order to contextualize the position of the state of São Paulo regarding climate change issues, particularly its role in facing this problem, it is helpful to clarify the evolution of Brazil's position as a nation-state in this matter. Brazil has been playing a decisive role in international negotiations, putting forward important proposals for the Kyoto Protocol design and further regulations, as well as acting in favor of the interests of developing countries. During the Kyoto Protocol discussion, the country's delegation presented two proposals: the Clean Development Fund, later transformed into the Clean Development Mechanism, and a quantification method to determine the common but differentiated responsibilities, which came to be known as the "Brazilian Proposal".

This idea, advocated at all UNFCCC meetings and COPs, illustrates that Brazil's government shares the main arguments of other developing countries: that incentives are necessary and should encompass the provision of new and additional financial resources and transfer of technology, as well as capacity building. As expressed in the Brazilian Paper Submission to UNFCCC "Dialogue" work (UNFCCC, 2006), "*the Government of Brazil believes that efforts undertaken by developing countries to reduce emissions in different sectors within their territories can only be characterized as voluntary and, therefore, cannot be linked or associated to goals, targets or timeframes*".

The reluctance in assuming more specific commitments under the climate regime may be due to the fact that Brazil is currently one of the major emitters in the world. The country lies in the 19th position in CO_2 emissions from the energy sector. However, considering that the main emission source in the country is deforestation, which accounts for 75% of all domestic emissions (BRASIL, 2004), the country's position in a total emission ranking is much higher: it occupies the fifth place (UNFCCC, 2006).

Although the Federal Government is still resistant to advancing in the international discussion, the challenge to act internally to reduce climate change persists. Even considering domestic actions against deforestation and the reinforcement of existing energy efficiency and renewable energy programs (such as PROCEL and PROINFA), domestic emissions are expected to keep growing.

Some relevant sectors of Brazilian society, mostly NGOs[1] and academics, regard the government's position as intransigent, and are pressing it to show more flexibility and move forward in the international discussions. In the absence of the desired reaction from the government, these groups have organized events and informal meetings to discuss alternatives, and written reports and submitted them to the government.

As pointed out, although on one hand the reluctance of the federal government is seen as an obstacle to taking early action against climate change, on the other it has spurred a reaction from the society at local and regional levels. Such is the case of the state of São Paulo.

[1] The activities of the FBMOS (Brazilian Forum of NGOs and Social Movements) and Observatório do Clima can be mentioned here.

STATE OF SÃO PAULO: GHG EMISSION PROFILE AND INTERACTION WITH REGIONAL/LOCAL ENVIRONMENTAL PROBLEMS

This energy information is important to understand the GHG emission profile of São Paulo state (Figure 1).

Figure 1 - Location of the State of São Paulo in Brazil

Source: IBGE, 2000.

As shown in Figure 2, the transport and industrial sectors are the most important sources of CO_2 emissions in the state, amounting to 83 million metric tons in 2003, or nearly one-quarter of Brazil's total. Ranked alongside entire nations on the basis of CO_2 emissions (excluding land use change), the state would be the 39th-largest emitter in the world (SÃO PAULO, 2005).

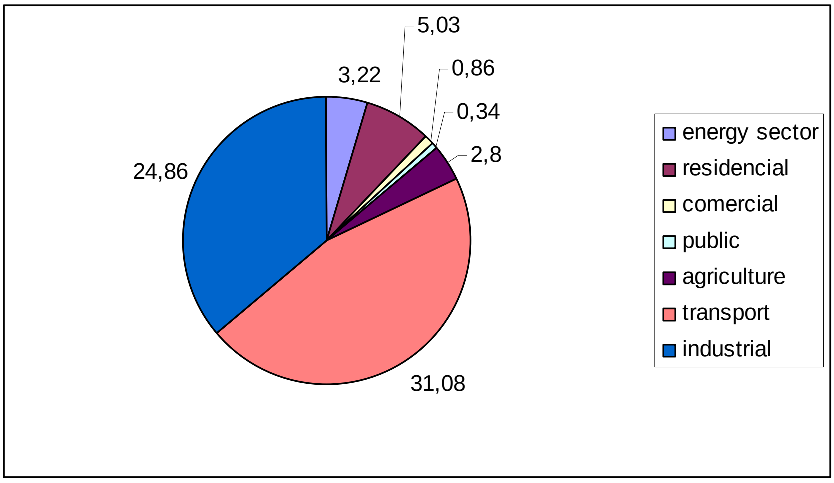

Figure 2 - CO_2 emissions by sector - 2004 (Mt CO_2)

Source: BEESP, 2005.

A considerable part of the emissions from the industrial sector is reincorporated into the biomass cycle, since it originates mostly from biomass -- the sugarcane products. The main problem comes from the transport sector: road transportation prevails, and uses mainly diesel and gasohol powered vehicles (SÃO PAULO, 2002).

In addition to being the largest source of CO_2 emissions in the state of São Paulo, the transport sector is also the main emission source of atmospheric pollutants, accounting for 97% of CO_2 and HC emissions, 96% of NO_x, 40% of MP and 42% of SO_x. Gasoline vehicles were responsible for the emission of 44% of CO, 23% of HC, 12% of NO_x, 21% of SO_x and 10% of MP_{10}. Vehicles powered exclusively by alcohol and flex fuel vehicles were responsible for 12%, 5% and 3% of CO, HC and NO_x emissions respectively; no significant emissions of SO_x and particulates were observed (CETESB, 2002).

According to a recent report of the World Health Organization, *"[..] clean air is considered a basic requirement for human health and well-being. However, atmospheric pollution continues to be a big public health problem around the world. More than millions of premature deaths are caused by air pollution each year. More than half of these occur in developing countries"* (WHO, 2006).

The importance of the state of São Paulo in the context of climate change also comes from the fact that it is Brazil's main ethanol producer -- and Brazil, by its turn, is the world's largest ethanol producer. More than 60% of all the sugarcane grown in Brazil is in São Paulo, and from the 15.93 million m³ of ethanol produced in the 2005-2006 harvest, 9.95 million m³ were produced in the state (MACEDO, 2005).

Because ethanol is a renewable fuel, it has been regarded as an ally in combating climate change. A study by Macedo (2005), examining the energy balance of the ethanol production cycle and its contribution as a replacement for fossil fuels, estimated that GHG emissions avoided by the use of anhydrous ethanol amount to 2.7 kg CO_2 e per liter of ethanol.

This fact is behind the growing interest for the use of liquid biofuels in the transport sector, ethanol and biodiesel being the best short-term alternatives worldwide. Among other factors, concerns regarding emissions of GHG have driven countries to look into biofuel production, especially ethanol, as a potential solution (BP, 2006)[2].

2 It must be highlighted that the fastest growing source of CO_2 emissions is the transport sector. In 2000, GHG emissions of the transport sector corresponded to 28% of total emissions (estimated as 6.3 $GtCO_2$ on a well to wheels basis). About two-thirds of the GHG emissions are associated to passenger transport, while the rest is from freight transport (IPCC, 2001). In 2003 end-use emissions in the transport sector were 5.1 $GtCO_2$, i.e., 21% of the total energy use emissions (IEA, 2006).

For Brazil in general, and for the state of São Paulo in particular, the increase in international demand for ethanol opens prospects of growth of its production. In order to expand its production capacity to 26-31 billion liters in 2010, as needed to supply the domestic and international markets, it is estimated that 160 new industrial plants must be built, and that the cultivated area must be increased by 2 million hectares (PIACENTE; WALTER, 2005).

However, the sugarcane production in Brazil and in the state of São Paulo conceals serious environmental problems of a regional or local nature, the most important being the emission of atmospheric pollutants by the burning of tops and leaves, and the resulting aggravation of public health conditions in the surrounding cities. The practice of burning tops and leaves before harvesting is traditional in the sugar and alcohol production worldwide. In Brazil, data from 2002 for the Center-South region (MACEDO, 2005) indicate that 65% of the sugarcane harvest is manual, and 35% mechanized, meaning that about 80% of the produced sugarcane is still burned. In São Paulo, in 2006, only 25% of the sugarcane harvest was done without burning.

The burning of sugarcane, as of any biomass, is regarded as an important source of pollution, including particulate material and polycyclic aromatic hydrocarbons (PAH), considered to be carcinogens. A correlation between emission of these pollutants and the increase in hospital admissions for respiratory diseases has been verified in published studies (SANTOS et al., 2002; CANÇADO, 2003; CETESB, 2002; ARBEX et al., 2004). In general, these studies point to a coincidence between, on one hand, the occurrence of emission peaks of fine particulate materials ($PM_{2,5}$), dioxins and PAH, and the increase in the levels of tropospheric ozone (O_3) in sugarcane growing regions, and on the other, an increase in hospital admissions due to respiratory problems, mainly among children and the elderly during the sugarcane harvesting season, when burning is practiced.

The recognition of a link between sugarcane burning and health aggravation of the population of adjacent areas led to the institution of legal regulations to address the problem. In the state of São Paulo (STATE LAW 11241, 19-Sep-2002), a schedule has been established to phase out the practice of sugarcane burning, which implies the replacement of manual by mechanized harvesting. Despite this, advances in the process of mechanizing harvesting are considered modest, and the practice of burning still prevails (PIACENTE, 2005).

If the prospects of increased ethanol production materialize, driven by the contribution of biofuels to the mitigation of global climate change, then an intensification of atmospheric pollution caused by sugarcane burning is to be expected in Brazil and in the state of São Paulo, even taking into account the mechanization schedule established by state legislation. In the absence of good evaluation and planning, ethanol production expansion as an alternative to the use of fossil fuels can in fact aggravate the negative impacts on air quality in the local and regional spheres.

CLIMATE-FRIENDLY INITIATIVES AND CHALLENGES

Aware of its role as the main contributor to Brazil's energy emissions, the state of São Paulo began to have concerns about climate change as far back as 1995, when the state government enacted its Climate Change Prevention Program -- PROCLIMA. Under this program, the state created a special administrative department, called Global Issues Division, with the attributions of producing information for the public regarding climate change, promoting seminars and conferences to present the problem and discuss mitigation alternatives, promoting capacity development, and cooperating with federal climate change activities. The most important work by PROCLIMA was the collaboration with the federal government in the preparation of the National Emissions Inventory (SÃO PAULO, 2007).

In 2002 the state published its Agenda 21, in which climate change figures prominently. In the same year, the state government and other regional authorities launched the Network of Regional Governments for Sustainable Development (NRG4SD), with the aim of being an arena to share climate mitigation and other sustainable development experiences, and being the main vehicle of representative participation at international negotiations, as explained in Section 3. Thus, São Paulo, along with ABEMA, the Brazilian association congregating state environmental agencies, is now one of the members of the NRG4SD Steering Committee.

São Paulo state issued a decree in 2002 establishing a 5-year renewable licensing process for stationary sources of air pollutants. This corrected the previous "right to pollute" situation of older enterprises, some of which had been licensed nearly 30 years previously. Such companies are now required to gradually reduce their emissions, either by updating technologies or shutting down facilities. This program to reduce air pollution from industrial sources was significantly expanded in 2004 with the passage of legislation (Decree 48.523) allowing new industrial licenses in areas that have not met air quality standards only if sufficient abatement credits are first obtained from the government. Emissions currently regulated under this legislation are NO_x, SO_2, PM_{10}, CO, and nonmethane volatile organic compounds. In the future, indicative air-quality targets will be applied, allowing better management of sources during license renewal, and providing an incentive for cleaner production and fuels. The government is also discussing the inclusion of CO_2 and other GHG in this scheme. This program is also expected to bring benefits to the transport sector, considering that emission reductions of regulated pollutants from vehicle fleets can be used for compensation.

Two other government actions in the transport sector deserve mention. The São Paulo Metropolitan Region has in place an Integrated Transport Plan designed to increase mobility and increase the share of public transportation (buses, train, and subway). Besides, the government has a program to promote riding groups called Transporte Solidário. As an incentive to this practice, the Secretariat for the Environment of the state of São Paulo developed a freely available software allowing people from the same community to enroll in riding groups. The software attempts to identify potentially compatible people for the purpose of riding the same car by cross-checking data about route (by means of the postal code) and schedule, and personal data such as smokers/nonsmokers, favorite hobby, etc. Participants receives a listing with this information about people on similar routes, and on that basis can initiate one or more riding groups (SÃO PAULO, 2007).

In spite of their still modest scope, pollution reduction and climate change mitigation measures carried out on the regional level can be regarded as examples of attempts to implement, on a regional level, environmental governance actions. In the process of formulation and implementation of these programs there has been and there still is a direct participation of third sector actors and other social actors. Whether as a strategy to gain wider adherence and social acceptance among the population (legitimacy), or as a way of making such programs economically viable, the fact is that the partnership between public authority and other social sectors is already an established reality.

Indeed, it is through such partnerships that the creation of a task force between CETESB (the environmental agency of the state of São Paulo) and EMTU (the metropolitan transport company) is being contemplated, in order to identify possible actions to reconcile the promotion of public transport and the joint reduction of GHG and atmospheric pollutants in the transport sector.

Although the institution of a schedule for phasing out sugarcane burning by State Law 11241 resulted in a broad discussion among the main agents involved in the sugar-alcohol sector in the state of São Paulo (mill owners, municipalities, workers' unions), it does not obviate the need to find other ways of dealing with related environmental and social problems, mainly against a background of expansion of the importance of ethanol in the regional (economic) and international (climate change) levels.

The role of the third sector should be highlighted here as a representative of the interests involved, and as an agent for social pressure. Here, not only local and regional agents are strengthened, but above all those with an international scope. According to Hunt (2006), the way in which potential international consumers will enter the biofuel market is a very important factor to assure the sustainability of its production.

Thus, the course of action open to governments -- both national and regional such as that of São Paulo -- is to evaluate the points of convergence between mitigation measures of global environment problems and their impacts on the regional and local level and, on that basis, to identify opportunities for proactive actions both on the global and on the local level.

CONCLUSIONS

The facts and plans compiled in this paper suggest that, even though nation-states may remain reluctant to assume early climate change mitigation measures, thus making the international arena a complex and difficult path for the convergence of climate-friendly initiatives, there is enough space for alternative structures and approaches in both developing and developed countries.

Local and regional initiatives, though praiseworthy, could hardly gain space in the international agenda of the climate change regime in order to present their contributions, because international relations are still between sovereign States. However, the spread of environmental networks at local and regional levels is an interesting governance example that legitimates regional climate-friendly actions, enhancing closer inter-regional cooperation and acting as a nuclear voice able to make positive impacts at national and international levels. The implementation of climate-friendly measures and the demonstration of their benefits can be used as instruments to pressure nation-states to change their positions.

These alternative environmental instruments are particularly important to the developing world. It was presented that countries like Brazil, among others such as China and India, are already included in the list of the major GHG emitters and thus, their broader participation on the international climate regime is necessary to get more effective results in combating climate change. However, the reluctance from these nation-states, including Brazil, in assuming formal international mitigation obligations may be viewed as a factor to reduce the effectiveness of the international environmental law. In such a context, infra-national and regional proactive initiatives inside these countries can add not only effective results against global warming but also can be considered legitimated alternatives to face this global environmental problem.

The experience of São Paulo state is illustrative of the fact that early action in climate mitigation can bring about good results -- and this is particularly meaningful with regard to developing countries. It also demonstrates that without appropriate planning, i.e., if global and local aspects of mitigation measures are not taken into account, benefits might be limited, particularly in relation to its legitimacy and effectiveness.

In spite of their still modest scope, pollution reduction and climate change mitigation measures carried out on state level can be regarded as examples of attempts to implement, on a regional level, environmental governance actions, particularly in the case of transport sector.

One of the main challenges to an adequate environmental governance to be implemented by the State of São Paulo concerns to the necessity to envisage both global and local environmental aspects of ethanol production and use as an alternative to fossil fuels. In order to guarantee both global mitigation benefits and local environmental quality, it is indispensable that the government incentive a broad and participative discussion among all sectors and stakeholders involved.

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MITIGATION

OVERVIEW OF APPROVED CDM PROJECTS IN BRAZIL: PARTICIPATION OF NATIONAL ECONOMIC SECTORS AND GAPS

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ABSTRACT

This article evaluated the performance of Brazil in developing project activities suitable to CDM, based on Project Design Documents (PDD) submitted to Interministerial Commission on Global Climate Change – ICGCC (Comissão Interministerial de Mudança Global do Clima - CIMGC, in Portuguese), the Brazilian Designated National Agency (ADN). Through the PDDs the performance of the country in developing CDM projects in the different scopes determined by the Convention were verified, and a history of what has been done was reported as well as the opportunities in new project activities.

Keywords: Clean development mechanism, Public policies, Mitigation of climate change in Brazil.

INTRODUCTION

The United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992, is an international convention whose main objective is to stabilize greenhouse gases (GHG) concentration in the atmosphere in a level that avoids dangerous interference in the climatic system. In 1998, the Kyoto Protocol detailed how country Parties of the Convention could achieve their objectives, establishing limits for emissions to a group of countries that shall reduce their emissions in the commitment period 2008-2012. For facilitating the accomplishment of this obligation, the Protocol also created flexibility mechanisms which allow the trade of emission reduction among Parties and the implementation of actions or projects by different countries together, even if it does not have obligation of reduction (case of the developing countries). In that way, the Clean Development Mechanism (CDM), one of flexibility mechanisms of Kyoto Protocol, allows countries with limits of emissions and the ones without limits to joint efforts in developing projects that mitigate emissions. The objective is to help developing countries to promote sustainable development and improve their industrial processes in the same time that helping developed countries to achieve their obligations with the Convention.

Although being not obligated to reduce emissions, Brazil has conditions to significantly mitigate greenhouse gases through combating deforestation and forest burning and changing “climatic outdated” technologies. Industry emits GHGs from fossil fuel combustion and in industrial processes. Fossil fuel combustion is the second main contributor to carbon dioxide (CO_2) emissions in Brazil, the first is forest and land use (BRASIL, 2004). Industry is not the main responsible for GHG national emissions, but represented 38% of final energy consumption in 2006, 37% of this energy being originated from fossil fuels (BRASIL, 2007). As climate change effects get worse, the use of renewable alternative energy sources, such as wind, sun and biomass, would become a profitable activity as mitigation costs get bigger than the costs of these new technologies. Besides improving the country image internationally, emission control can impact positively the economic sectors opening access to financial sources, improving prices from insurance companies and making the company more valuable in the international market. The generalized use of the CDM represents an opportunity for Brazil to develop a sustainable development policy in the climate area. This mechanism helps in disseminating the use of technologies climatically healthy and increase financial capacity by attracting resources to make projects of cleaner industry processes viable, which could not be possible without this mechanism. As a result, energy and industry sectors in a country that does not have obligations, as Brazil, can explore the climate as a business opportunity, increasing its benchmarking in an international competitive market.

METHODS

Until July 2008 it was analyzed 204 PDDs submitted to ICGCC. These documents are available in electronic page of Brazilian AND, as determined by UNFCCC. All analyzed projects were organized in worksheets containing a set of characteristics, such as scope, scale, quantity of certified reduction, methodology used, among others. The evaluation of potential of CDM projects was also based in information of associations, such as UNEP; UNIDO (2003); BRASIL (2004); BEN (2007), and other relevant secondary sources cited along the text.

RESULTS

SITUATION OF PROJECT ACTIVITIES IN ICGCC AND UNFCCC

Among projects submitted to ICGCC, 186 were approved, 10 were approved with reservation, 7 are being revised and 1 was not evaluated yet. At that moment, 142 Brazilian project activities were already registered in UNFCCC, 39 were validated,1 is under correction, 2 are being reviewed, 1 was withdraw, 16 were rejected and 3 were not evaluated yet, totalizing 70% of acceptance (Figure 1).

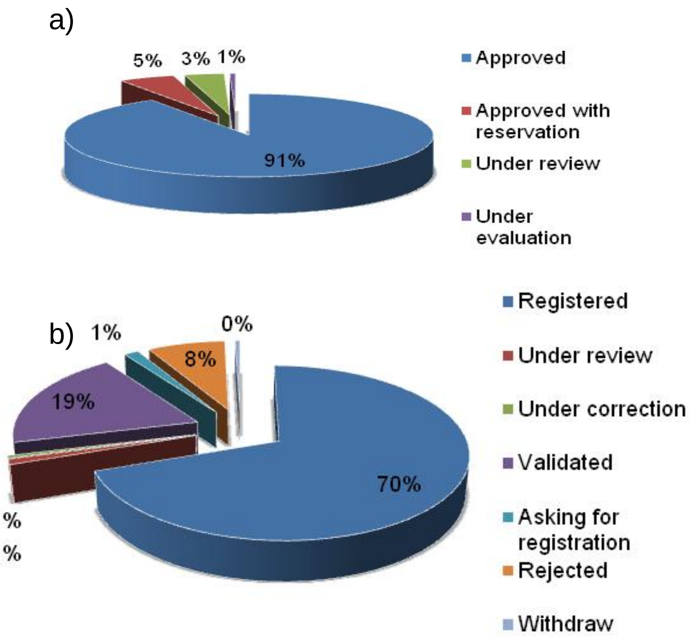

Figure 1 - Situation of project activities analyzed in ICGCC (a) and UNFCCC (b)

METHODOLOGY APPLIED IN CDM PROJECTS[1]

Some projects have more than one activity suitable for CER calculation, what is expressed through combined methodologies. Important to emphasize is that the methodologies are being constantly improved so it is necessary to verify the most recent versions when elaborating the PDD. Figure 2 shows the distribution of PDDs per methodology applied.

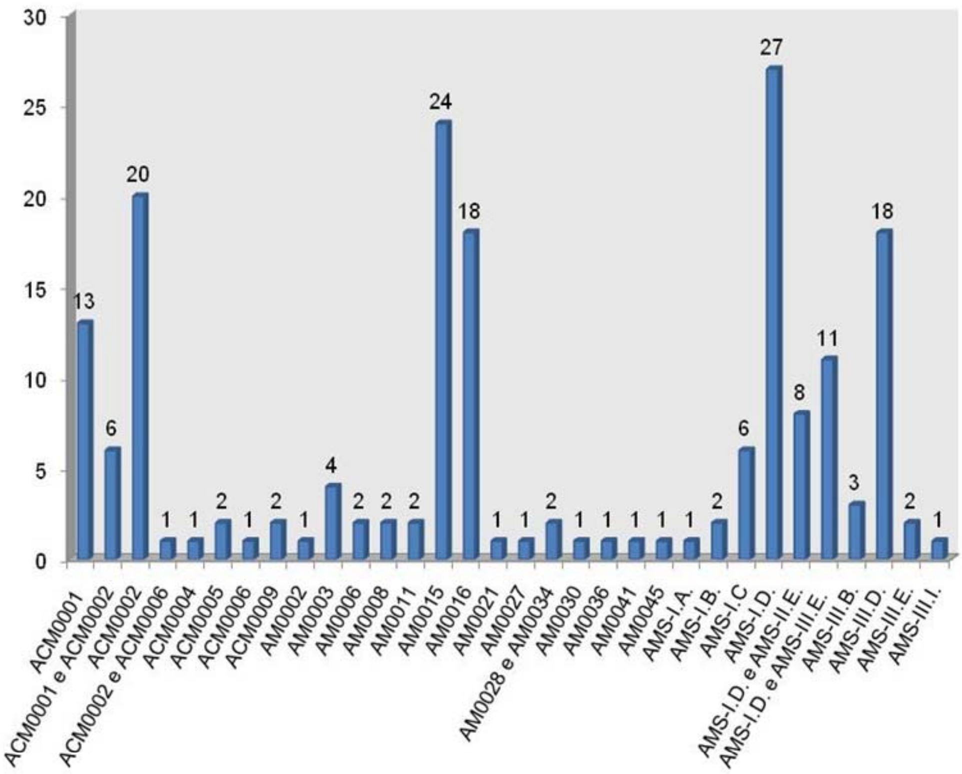

Figure2 - Distribution of CDM project activities per methodology applied

Until July 2008, the most practiced methodology was AM0015, with 24 projects. This methodology was replaced for ACM0006 - Consolidated methodology for grid-connected electricity generation from biomass residues. Both are distinguished in the graph because of the moment when project activities were approved by CIMGC. Together they totalize 25 projects. This project activity refers

1 The methodologies are designated bay UNFCCC as follows: AM – Approved Methodology, ACM – Approved Consolidated Methodology and AMS - Approved Methodology for Small Scale. The description of all methodologies can be found in UNFCCC site (UNFCCC, 2008).

to co-generation with sugar cane bagasse, usually obtained by modernization of boilers or construction of new generation plant.

The most used small scale methodology is AMS-I.D. - Grid connected renewable electricity generation. A total of 46 project activities used this methodology, 8 of them combining it with AMS-II.E. - Energy efficiency and fuel switching measures for buildings and 11 with AMS-III.E. - Avoidance of methane production from biomass decay through controlled combustion. In the case of AMS-II.E., projects were about efficiency in energy consuming in supermarkets. AMS-III.E. refers to projects of energy generation from waste biomass of different industries.

The third methodology most practiced is ACM0002 - Consolidated methodology for grid-connected electricity generation from renewable sources, which is the same as AMS-I.D. Grid connected renewable electricity generation. Both sum 66 projects, one of them about wind power.

AM0016, replaced by ACM0010 - Consolidated methodology for GHG emission reductions from manure management systems and AMS-III.D. - Methane recovery in animal manure management systems totalize 36 projects. Both refer to improve animal wastes management through replacing aerobic lagoons and differ from each other only because of scale. ACM0001 - Consolidated methodology for landfill gas project activities, with 13 project activities, refers to recovery and flare of CH_4 in landfills and deserves attention because the first project presented to UNFCCC was from Nova Gerar Brazilian landfill, which proposed this methodology.

SCALE

Figure 3 shows CDM projects according to scale. Proportion between scales in Brazil is likely world numbers registered in UNFCCC, but in the beginning most of the projects were large what is different now. It is possible to note that along the years the numbers changed and since 2007 there are more small scale projects.

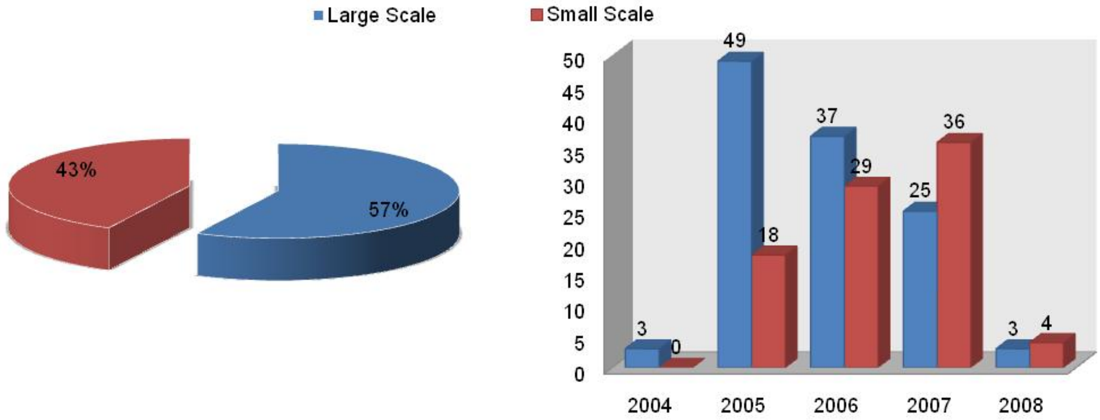

Figure 3 - Distribution of total project activities in relation to scale and submission through time

Although in total numbers there are still more large scale projects, it can be noted that small scale ones have a considerable potential.

QUANTITY OF CERTIFIED EMISSION REDUCTIONS

In this analysis the first 7 years of emission reduction for projects with possibility of renovation and the 10 years for those defined as such were considered and those projects rejected by UNFCCC were excluded. Figure shows distribution of CERs per scope and total estimated for projects analyzed and the relation between quantity of projects and CERs.

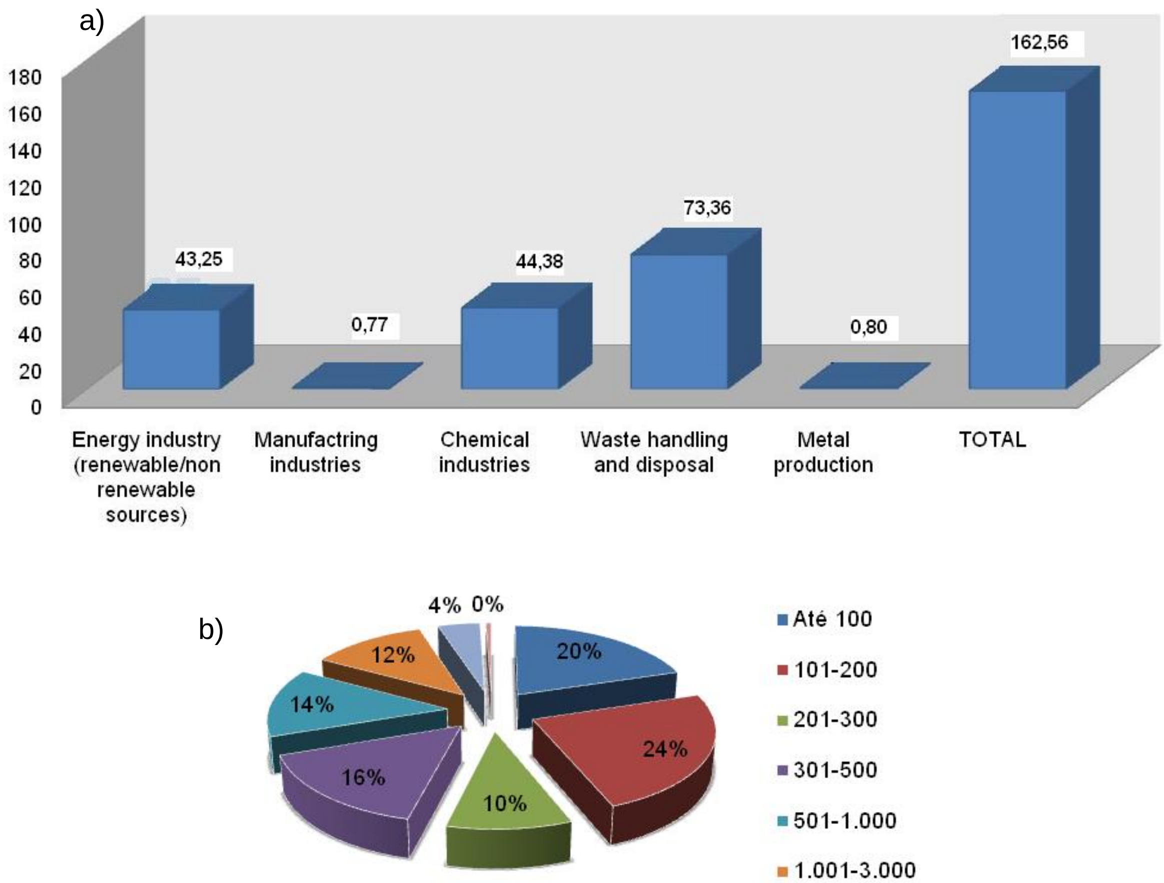

Figure 4 - Total emissions avoided (CERs) by scope (million tons of CO_2) (a) and projects per quantity of emission avoided (thousand tons of CO_2) (b)

Most projects, 44%, do not overtake 200,000 ton in CERs. However four big projects are responsible for almost 40% of Brazilian reduction. One, from Rhodia, estimates reductions of 40,000,000 tons CO_2 (the only one with reductions above 10,000,000 tons) and three project activities of landfill gas capture and burn and recovery for power generation sum more than 20,000,000 tons CERs. Among these only one was not yet registered, but is already validated and approved by ICGCC.

SCOPE

Scopes are classified according to a list defined by UNFCCC which categorizes project activities in relation to a type of economic sector. Then the scopes defined by UNFCCC, used in this work, are: 1. Energy industry (renewable/non renewable sources); 2. Energy distribution; 3. Energy demand; 4.

Manufacturing industries; 5. Chemical industries; 6. Construction; 7. Transport; 8. Mining/mineral production; 9. Metal production; 10. Fugitive emissions from fuels (solid, oil and gas); 11. Fugitive emissions from production and consumption of halocarbons and sulphur hexafluoride; 12. Solvent use; 13. Waste handling and disposal; 14. Afforestation and reforestation; 15. Agriculture. Figure 5 shows the distribution of Brazilian project activities among scopes until July 2008.

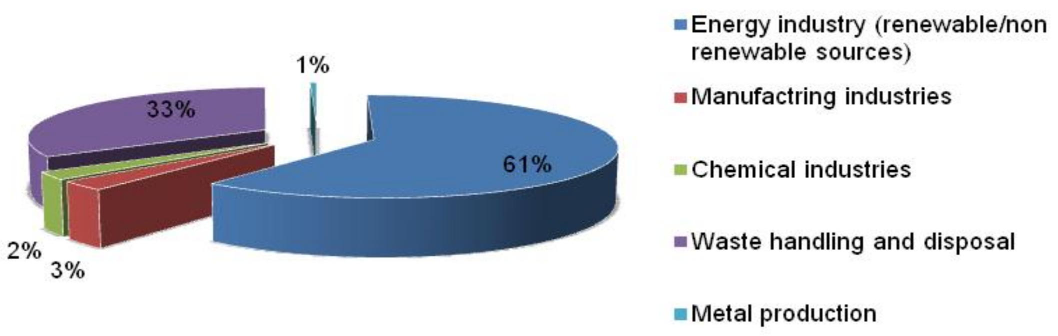

Figure 5 - CDM Project activities according to scopes

Most of Brazilian project activities are from scopes energy industry (renewable/non renewable sources) and waste handling and disposal, 61% and 33% respectively, such as world statistics in UNFCCC – 55% and 20% respectively. Interesting to note that although scope 1 have a great number of projects, contributes to avoid 43.25 million tons CO_2eq, 27% of total avoided emission. However chemical industries, scope 5, which represents only 3% of Brazilian projects, contributes also to 27% of emission reduction. Waste handling and disposal has 68 projects and potential do reduce up to 73.36 million tons CO_2eq, approximately 45% of total avoided emission. It is important to highlight that world statistics include other scopes not explored in Brazil, such as afforestation and reforestation, agriculture, energy demand, fugitive emissions, etc. This reinforces Brazilian possibilities to increase participation in CDM projects.

CDM PROJECT ACTIVITIES PER FEDERAL STATE

Figure 6 shows the occurrence of CDM projects according to the State of Brazil. It can be noted that the development of project activities is concentrated principally in states from Southeast/South axis, excepting Goiás and Mato Grosso. São Paulo has most projects, followed by Minas Gerais, Rio Grande do Sul, Santa Catarina, Paraná e Rio de Janeiro. Among the 69 projects from São Paulo, only 18 were elaborated in association with other States, what is not usual as most projects from this group of States cited above was resulted from interstate partnerships.

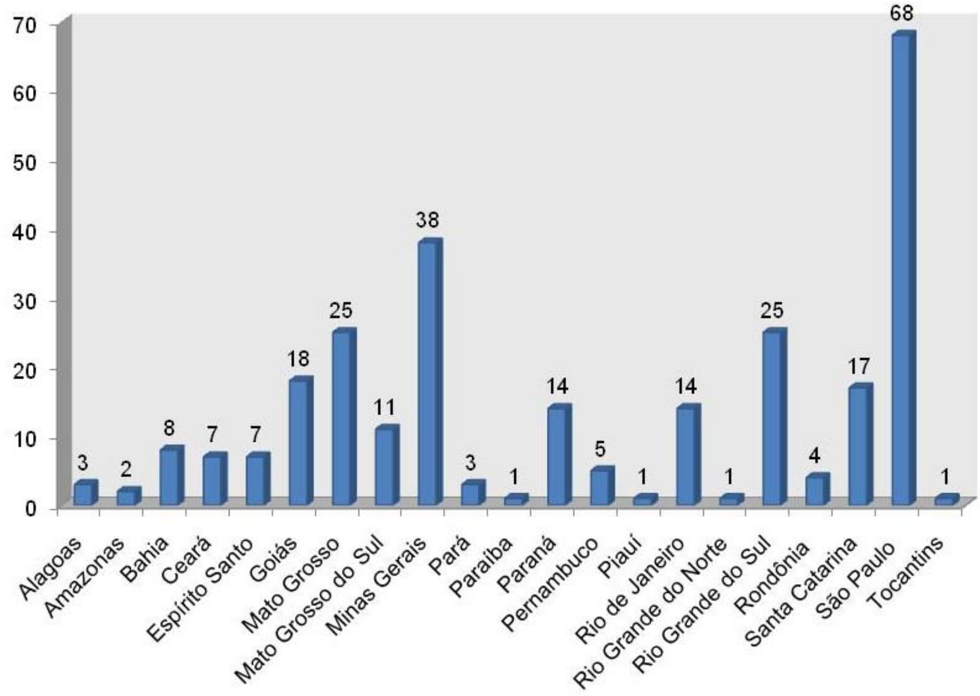

Figure 6 - Number of CDM project activities per federal State

ANNEX I PARTIES TO THE CONVENTION PARTNERSHIPS

Developed countries are the most interested in potential credits generated by CERs obtained by developing countries with CDM, so in Figure 7 it was evaluated the participation of Annex I Parties in Brazilian CDM project activities. The principal partners of Brazilian projects are orderly United Kingdom, Netherlands and Japan. Although 101 project activities have support of some Annex I Party, others 103, almost 50% of Brazilian projects, does not, which may means that these projects does not have potential buyers for their CERs yet.

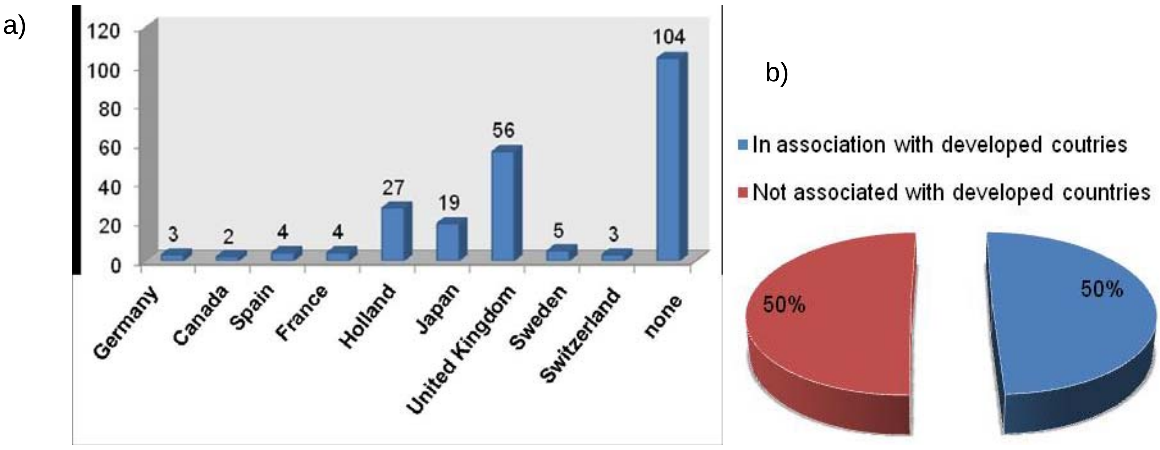

Figure 7 - Number of project activities with or without participation of Annex I Parties to the Convention (a) and proportion between projects with or without this participation (b)

DISCUSSION AND CONCLUSION

Evaluating business opportunities coming from climatic change discussions, the present study identified the potential of several industry sectors in Brazil for the implementation of CDM projects. Analyzing project activities approved by ICGCC it was verified that there are still many sectors that are not explored in the country. Projects involving energy and wastes are the most common and there is still a wide space for developing activities in other scopes with potential interesting for Brazil, such as agribusiness and forest services. Opportunities are already increasing to specific types of project activities, but Brazil has also a considerable potential to present new modalities of activity through other methodologies not explored yet by the country.

The development of new technologies, climatically healthy, and the effective involvement in transferring technology between developed and developing countries have capital role to the increase in number of CDM projects in Brazil and other developing countries. Other contribution could be the development of some mechanisms to spread these technologies, making them more accessible to Brazilian productive sectors. It is also necessary the development of more suitable conditions to these sectors. As example these conditions could be improved by improving rules and regulations or even removing some legal barriers reducing the excess of administrative procedures. CDM project activities could have a distinctive treatment, especially tax rules for stimulating external investments and negotiations with CERs. Brazilian Mercantile and Future Exchanges could narrow the distance among investors and project proponents in order to stimulate and make viable partnerships that could become real CDM projects.

Introduction of climatic variable in national innovation program is proper but it must be put on practice effectively. In that sense, the creation of a data base with potential technologies would be very important, such as the systematization of baseline and monitoring methodologies from UNFCCC in a database in Portuguese. These would favor technicians from a range of industrial sectors and institutions in researching the best options of technology for GHGs emission reduction. Using or proposing new methodologies and technologies may help industries to improve their processes and especially may lead to a paradigm change.

According to UNFCCC statistics, until July 2008 from 180,325,947 CERs were already issued from the 189,739,177 requested in the world. However, only 17.7% of total estimated emission reductions of all Brazilian project activities already registered by UNFCCC had the CERs issued. Also India, country with more CDM projects registered, has only 25.78% from CER requested already issued. It means that there is a gap between the request and the issue of CER in UNFCCC that must be considered and must be clear to project proponents. Other important contribution to facilitate project activities in Brazil and other countries is the wide dissemination of important decisions from UNFCCC Executive Board-EB. For example, the possibility of grouping small projects in programs or national plans for submission as a CDM Program of Activities was approved this year by UNFCCC EB and will help small activities that have potential for emission reductions but not financial condition to be implemented separately. Information of this kind must be available to Convention Parties as soon as possible and in an easy language. In specific case of Brazil, it is necessary to formulate and disseminate these and other mechanisms for stimulating CDM as soon as possible in order to take advantage of the first period of Kyoto Protocol, where the country does not have emission reduction goals.

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IMPLEMENTATION OF THE CLEAN DEVELOPMENT MECHANISM IN BRAZIL: THE CASE OF THE COGENERATION PROJECT WITH ALTA MOGIANA BAGASSE

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ABSTRACT

The objective of this study is to analyze the implementation of Clean Development Mechanism in Brazil, throughout a case study, the Cogeneration Project with Alta Mogiana Bagasse. This study indicates that the CDM opens great opportunities for the utilization of the country energy potential and can be applied in other localities. Despite the fact that it is a modest contribution to the mitigation of greenhouse effect, according to the models of the Intergovernmental Panel of Climate Change (IPCC), it is an experiment, transient, very important in the context of the new international environmental order, despite the uncertainties regarding the post-2012 period, when the establishment of new goals for the Kyoto Protocol Parties will be discussed. Facing several initiatives, Brazil has assumed, in turn, leadership position among the G77/China countries, as an important interlocutor between them and the developed States in the climate negotiations.

Keywords: Clean development mechanism, Public policies, Mitigation of climate change in Brazil.

INTRODUCTION

The concern on global climate changes grows as scientific studies show, with greater certainties, the intensification of the greenhouse effect phenomenon and the influence of men in increasing concentrations of the greenhouse gases in the atmosphere, such as dioxide carbon (CO_2), methane (CH_4) and nitrous oxide (N_2O). We can see the results of the different working groups of the Intergovernmental Panel of Climate Change (IPCC), especially in its fourth and latest report, released in 2007, whose data show an increase of around 1.8 to 2.0 ºC by 4.0 to 5.0 ºC in the planet average temperature by the end of the twenty-first century, which can cause serious impacts worldwide, regarding the ecosystems, the water and food supply, the health and the coastal areas (IPCC, 2007).

The Clean Development Mechanism (CDM) is a flexible instrument defined in Kyoto Protocol. Its purpose is to help countries listed in its Annex B to reach their targets of greenhouse gas emissions reduction and promote the sustainability in countries that receive project activities that aim this reduction.

The Cogeneration Project with Alta Mogiana Bagasse is developed by Alta Mogiana Plant, localized at São Joaquim da Barra City – SP, together with Econergy Brazil, the company responsible for services related to emissions reduction, and also the World Bank, buyer of Certified Emissions Reduction (CERs). The carbon credit is obtained from the sale of excess energy, produced by sugarcane bagasse utilization to the national electric network, substituting energy produced by thermal power stations that use fossil fuels. The project, with initial planned duration of seven years, is estimated to reduce emissions of 84,165t/CO_2e. The infrastructure investments enlarged the installed capacity of energy generation, provided a considerable reduction of greenhouse gas emissions, moreover solved the bagasse handling problem. Besides, the power station approached research institutions, and attracted external resources for Brazil.

To understand the context of the creation of CDM, this article analyses the International environmental order. Afterward, the Brazilian politics about mitigation is commented to introduce the context of the case of The Cogeneration Project with Alta Mogiana Bagasse.

THE INTERNATIONAL ENVIRONMENTAL ORDER ABOUT CLIMATE

The United Nations Framework Convention about Climate Change (UNFCCC), established in 1992 during the United Nations Conference for Environment and Development, in force since 1994, was the first major step towards international cooperation on climate change, agreement that obtained the ratification of more than 175 States. Based on the precautionary principle, its main goal was the stabilization of concentrations of the major greenhouse gases in the atmosphere at a level that would prevent a dangerous anthropogenic interference in the climate system. It was aimed to allow the natural adaptation of ecosystems and ensure the food production and the development. Despite having shown itself insufficient to reach such purposes, from the point of view of international relations, it meant a starting point for future negotiations because it has created a way by which governments began to meet regularly – the Conferences of the Parties (COPs) – the supreme body of the Convention. It has also established principles that permeate, so far, the discussions on the issue, as the principle of "common, but differentiated responsibilities", that considers the historical emissions of greenhouse gases in the atmosphere, since each greenhouse gas has a certain life time in the atmosphere, which impacts on the positioning of each country in the negotiations.

Giving the necessity of establishing firmer and more binding commitments on the issue, the Kyoto Protocol, established in 1997 and in force since 2005, set effective goals to reduce emissions of the main greenhouse gases[1] for developed countries listed in its Annex B, enforcing the ideals of the Convention. The average emission reduction was determined by 5.2% for levels of 1990[2] (BRAZIL, 2001, Art.7). Emissions from each country will be calculated by the average of the years 2008-2012, called the first commitment period.

Developing countries, although not yet committed to any aims of greenhouse gases emissions, took responsibility for taking actions in their territories and producing national inventories of emissions, to be used in negotiations (BRAZIL, 2001, ART. 10.a). The Protocol, like UNFCCC, encourages the transfer of cleaner and more efficient technologies, environmental education, besides the generation of a fiscal and political panel that discourages the emissions of greenhouse gases.

1 Carbon dioxide (CO_2), methane (CH4), nitrous oxide (N_2O), sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

2 For the gases SF6, HFCs and PFCs, the base year for achieving the calculations of emissions can be the 1995.

The big news of the Kyoto Protocol was its approximation to the market mechanisms. It eventually allowed the creation of a market for carbon credits, through three additional mechanisms of implementation, which enable countries with goals to reach to reduce their emissions in other countries, where they face lower costs, however in an additional way to their domestic reductions. This is because, with the global consequences of the greenhouse effect, attempts to remove or reduce gases emissions could occur anywhere in the world (GOLDEMBERG, 2000).

The Emissions Trade allows that a part of Annex B acquires from another Party its emission reduction units in excess. The Joint Implementation pleats the financing of emission reduction projects among countries with goals to reach, where costs are lower, in a manner to promote investment flows and technology transfers between the industrialized countries.

The third is the Clean Development Mechanism (CDM). Its importance stems from the fact of representing the only means of cooperation between countries in Annex B and those not belonging to the same scope of the Protocol, at least during the first period of commitment. The same is the development of project activities in countries non-Annex B, aiming to reduce emissions or to increase the removal of greenhouse gases (sinks), through the use of more efficient and more environmentally sustainable technologies. Three broad types of projects are eligible under the CDM: renewable energy projects that reduce fossil fuel use, carbon sequestration projects that compensate emissions of greenhouse gases (sinks) and energy efficiency projects that reduce emissions of these gases. It is possible to make combinations of these initiatives.

The reductions attributed to the project activities developed in these countries result in Certified Emission Reductions (CERs)[3], i.e. marketable securities that serve to further assist the Parties included in Annex B to reach their reductions goals. The participants of these activities – public and private sectors, non-governmental organizations, can directly invest in the project activities, or indirectly, buy the CERs in the carbon credits market in a growing global expansion.

3 A unit of CERs is equal to one metric tonne of carbon dioxide equivalent, calculated according to the Global Warming Potential (Global warming Potential – GWP), index released by the Intergovernmental Panel on Climate Change – IPCC, and used to standardize the quantities of various greenhouse gases in terms of carbon dioxide equivalent, enabling that reductions of different gases are added (LOPES, 2002).

BRAZILIAN PUBLIC POLICIES

Despite the long way to go toward a national policy on climate change, it is possible to identify some structures in the country dedicated to the implementation of agreements on climate, such as the Inter-ministerial Committee for Climate Change, which is the Brazilian Designated National Authority in the CDM Executive Board. It should, among other functions, approve project activities, following criteria for local environmental sustainability, development of working conditions and net generation of employment, regional integration and linkages with other sectors (IPCC, 2007).

It was also created the Brazilian Forum of Climate Change, aiming to serve as an aid in overcoming problems in implementing the CDM and its wider dissemination. Another important point to be considered is the opening of the Brazilian market for the trading of carbon credits, pointing out that the Goods and Futures Stock of São Paulo held on a pioneer first auction of carbon credits in the world in 2007, when credits were offered amounting to 800,000 tCO_2 generated by the Bandeirantes Landfill Gas and Power Generation Project, of São Paulo city, which arose from the need for processing the seven tons of toxic waste produced by the council every day. Fortis Bank, a Dutch bank, acquired CERs by 16.2 euros each, bringing profits of around 34 million reais to the city of São Paulo, which will use this value in investments in areas near the landfill (FOLHA DE SÃO PAULO, 2007).

Regarding the CDM, it appears that Brazil stands out in the global picture respecting to its implementation, actively participating in the elaboration process. This arises as a possibility for attracting investments and technology transfer to the country enabling projects to generate alternative energy that would hardly be made in its absence. Until October 2007, from a total of 2,543 CDM (Figure 1) projects developed around the world, 245 were Brazilian, around 10%. Until then, the country occupied the third place, both in number of projects, behind China and India respectively with 32% and 29% of projects, but also in terms of emissions reductions projected, responsible for the reduction of 254,296224 of tCO_2 for the first period of obtaining credits, which corresponds to 6% of world total (IPCC, 2007).

It appears that the vast majority of Brazilian projects involve the reduction of CO_2, around 66%, followed by methane, with 33%, and nitrous oxide, with 1%, which indicates the activities prevalence in the energy sector. For those types of projects, we can understand the great leadership of the electric generation area, with 60% of all projects, followed by Pigs, with 16%, landfills, with 11%, manufacturing, with 4%, and energy efficiency, with 4%.

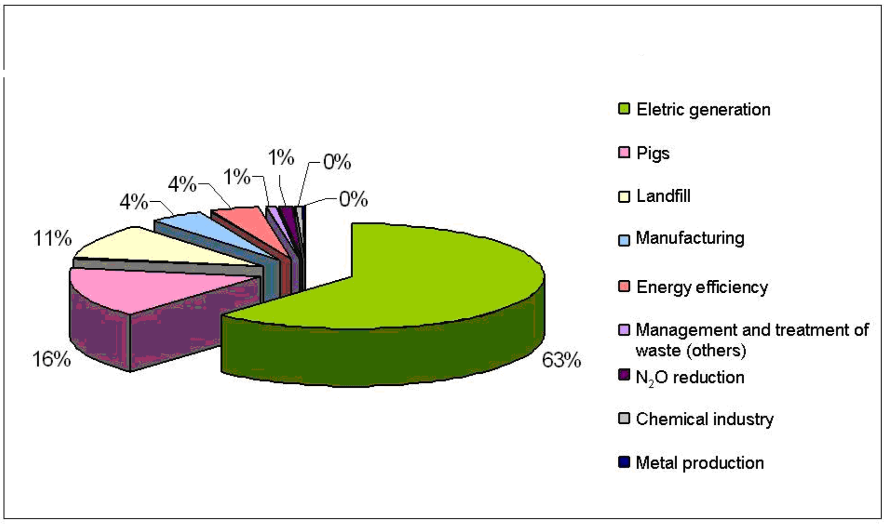

Figure 1 – CDM Brazilian Projects by Sectoral Scope October 2007

Source: MCT, 2007.

The analyzed data indicate a preference for cheaper options for generation of Certified Emissions Reductions that are not necessarily linked to options that bring greater benefits from an environmental standpoint, according to the country needs. Regarding the number of CDM projects in Brazil per federation unit, we can see that the state of São Paulo accounts for 25% of total activity, followed by Minas Gerais, with 14%, Mato Grosso and Rio Grande do Sul, both with 9%.

For São Paulo projects, the activities of energy cogeneration developed by sugar-alcohol industry are highlighted, about 33% of all projects submitted to the CIMGC in 2007. This situation led to the choice of this research case study, the Cogeneration Project with Alta Mogiana Bagasse (CPAMB) pioneer initiative since, despite a not despicable potential for the electricity production for its own consumption and for marketing, the sugar-alcohol industry is characterized by conservatism. In general, the plants have inefficient industrial plants in generating energy.

THE COGENERATION PROJECT WITH ALTA MOGIANA BAGASSE

The Cogeneration Project with Alta Mogiana Bagasse is developed by High Mogiana plant, placed in São Joaquim da Barra town, northeastern region of the state of São Paulo, together with Ecoenergy Brazil, the consultancy firm responsible for technical services related to the reductions of greenhouse gases emissions, and with the World Bank, purchaser of Certified Emission Reductions generated by the project. There was, therefore, direct participation of any country in Annex B in this activity.

The research has grown from references, analysis of the company's documentation and technical inspections at the premises of the plant. On that occasion, interviews were conducted with technicians and directors of the group. It was also used the computers global network for information, reports and other documents.

The Alta Mogiana Plant (Figure 2), since its emergence in 1983, is energy self-sufficient. It was examined, since 2000, the possibility of exporting the surplus generated because the time was quite favorable, the timing of a deep crisis in the Brazilian energy sector. The so-called blackout expanded demand for alternative sources of energy, which would help, in part, the lack of the sector in that period.

Figure 2 – Sugar and Alcohol High Mogiana Plant S/A

Source: Electricity Prodution by PCBAM: Carolina Gamba, based on disponible data in Alta Mogiana website: http://altamogiana.com.br. Access date: Setember, 2007.

At that time opportunities began to emerge arising from the implantation of the Clean Development Mechanism in Brazil. The plant, seeing the acquisition of carbon credits as another reason for more investments in the production process efficiency and for surplus power generation for marketing, initiated the development of a project under the CDM. The plant signed then, a contract for ten years with the Companhia Paulista de Força e Luz (CPFL), which sold part of its production of electricity that would be generated from 2002, with the implantation of CPAMB (Figure 3).

The Project is to increase the efficiency of the cogeneration unit with bagasse (dry residues) of the plant, and the efficiency of steam in the production of sugar and alcohol. The carbon credit is obtained with the surplus energy sell, produced from the use of sugar-cane bagasse, to the national power network, to replace energy from thermal power plants moved to fossil fuel. These are more expensive and requested in the period in which sources that produce energy in the system can not supply the demand – due to limitations by high costs or problems on the fuel stock – in the case of water sources (ECOENERGY, 2005).

In 2001, the Conception Project Document was developed. It received the approval of the Inter-ministerial Commission on Climate Change in 2004 and the certification by the CDM Executive Board in February 2006.

The baseline methodology approved by the CDM Executive Board and used in CPAMB was the “ACM0006: Consolidated methodology for grid-connected electricity generation from biomass residues”. The monitoring consists, basically, in recording the amount of energy sold to the network and the number of hours that each engine operates (ECOENERGY, 2005). As there was no identification of leakage or alteration of emissions in the project network activity, there was no need to monitor variables for these cases. The possible environmental impacts were analyzed by CETESB (SMA), which provided an operating license to the company.

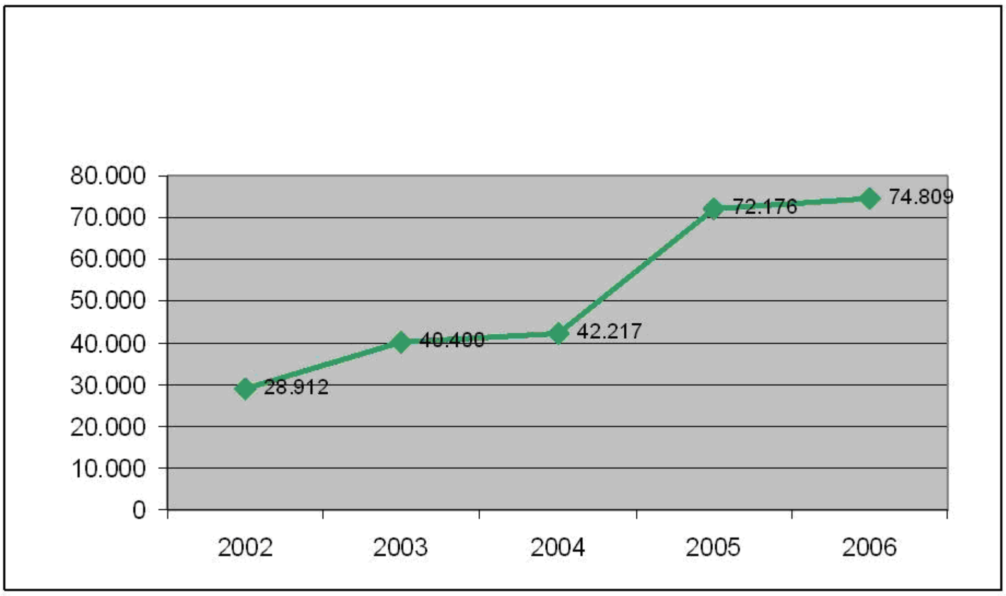

Figure 3 – Electricity Production by CPAMB 2002 to 2006 (MWh)

The Cogeneration Project with Alta Mogiana Bagasse, with initial planned duration of seven years, is estimated to reduce emissions of 84,165t/CO_2e (Figure 4). In 2002, however, date of its implementation, the project provided 28,948 MWh of electricity to the national power network, exceeding the amount of 21,600 MWh that should be produced that year, according to the contract of 10 years with the Companhia Paulista de Força e Luz. The resulting surplus of the improvement can be sold on the wholesale energy market, since the energy by small projects such as CPAMB is not dispatched by the National System Operator.

Estimated Reduction of CO_2 by PCBAM during Term 1, Collection of Credits	
Years	**Emission Reductions (tCO_2e)**
6/5/2002	7.749
2003	11.165
2004	10.951
2005	13.107
2006	13.107
2007	13.107
2008	13.107
5/5/2009	1.872
Estimated total of reductions	**84.165**
Total years of credit	**7**
Average annual reductions	**12.024**

Figure 4 – Estimated Reduction of CO_2 by PCBAM during Term 1, Collection of Credits

Source: Adapted table from PCBAM Project Conception Document. ECOENERGY, 2005.

The project began to be developed before the Kyoto Protocol in force and, given the uncertainties of its certification by the CDM Executive Board, the plant opted for a guarantee of receiving resources with the carbon credits sell. In 2004, the company received an intent letter to purchase the World Bank through Ecoenergy Brazil. The same has undertaken to buy all the carbon credits generated by CPAMB, approved or not under the CDM. This demonstrates the recognition by the World Bank of a carbon market independent of the Kyoto Protocol.

At the risk contract, with duration of 10 years, all Certified Emission Reductions obtained from the selling of electricity to the national power network are traded, since 2002, date of the beginning of the project, about 110,000 tons of CO_2e. The World Bank may sell these CERs for whom they wish.

The value negotiated by the World Bank for carbon credits coming from CPAMB, according to CONEJERO (2006), was U$5.5 per tone of CO_2e, currently well bellow those achieved in international markets for emission reductions, compared with the value of 16 euros for each CERs obtained with the CDM project developed in Bandeirantes landfill. The fact was due to the higher risk in 2004.

Currently, the Power Plant Alta Mogiana is in process of renegotiating the right price. The purchase option is of the World Bank, as agent of the Prototype Carbon Fund. As stated in the contract, or the Bank pays 80% of the market price, or hands over the right of marketing to the plant, according to information obtained in an interview with the directors of the company, which intends to renew the period of obtaining credits for more seven years, with some changes in the project due to its new growth stage.

The infrastructure investments coming from the project expanded the installed capacity of energy generation and provided a considerable reduction of greenhouse gases emissions, and resolved the issue of the bagasse management, industrial waste which storage is considered a problem. We must emphasize that the sugar cane bagasse is a fibrous by-product which is around 25% of the green cane weight and approximately one third of the energy content of the plant. Emissions of greenhouse gases from the use of biomass in the electricity generation are not computed in net emissions of the country, except those arising from leakage of the production process, since the carbon emitted during the process is absorbed through photosynthesis during the plant growth (BAJAY; FERREIRA, 2005).

There is no way to say, for now, that the CDM encourages the expansion of cultivated areas, as the generation of carbon credits is not liable for the core of the plant, whose focus is on the production of ethanol fuel and sugar. The project is treated as a secondary business, which increases, however, the energy marketing attractiveness by the sector.

There was also greater approximation of the company with research institutions, in addition to attracting external resources for Brazil. However, it is questionable the real contribution of CPAMB to increase the offer of jobs in the institution, a process that comes from the sugar production growth and, especially of ethanol fuel, pointing out that the productivity gains stem from a growing farming mechanization.

The plant already had capacity for investment in energy cogeneration. The idealization moment of the project was quite favorable. The remuneration for the generated energy motivated plant investments. Meanwhile, the CDM was more as an opportunity to improve an activity that was already developed.

It was also verified the recognition, by the World Bank, of the existence of a carbon market independent of the Kyoto Protocol, since it offered to plant an intent letter to purchase the carbon credits generated by the project, even before its adoption by the CDM Executive Board.

Through this study, we can understand, among other things, that the CDM opens great opportunities for the utilization of the country energy potential. The Cogeneration Project with the High Mogiana Bagasse indicates it can be applied in other localities. The Clean Development Mechanism, though it is a modest contribution to the mitigation of greenhouse effect, according to the models of heating made by the Intergovernmental Panel of Climate Change (IPCC), is an experiment, transient, very important in the context of the new international environmental order (RIBEIRO, 2001), despite the uncertainties regarding the post-2012 period, when the establishment of new goals for the Kyoto Protocol Parties will be discussed. It is unlikely that the agreement that will succeed it will have similarities with it, closer to the market and extension of the emission reduction goals, according to the ecoefficiency ecological chain (ALIER, 2007). Facing several initiatives, Brazil has assumed, in turn, leadership position among the G77/China countries, as an important interlocutor between them and the developed States in the climate negotiations.

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PERSPECTIVES ON ETHANOL USE BY THE TRANSPORTATION SECTOR IN BRAZIL

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ABSTRACT

In this paper we attempt to contribute to a better understanding some scenarios about ethanol production in Brazil, in particular, by exploring: (a) the effects of the introduction of flex fuel technology on gasoline consumption; (b) the effects of growing ethanol consumption on the area of sugarcane plantations for production of that fuel.

Keywords: Ethanol, Flex fuel technology, Transportation Brazil.

INTRODUCTION

The problem of global environmental and climate changes and their causes has received large attention in the literature, the consumption of fossil fuels by the energy-generation and transportation sectors being one important aspect of the problem.

According to Goldemberg (2006), energy is generated predominantly from non-renewable sources at present, 80% of the primary energy consumption originating in fossil fuels – coal, oil and natural gas. The transportation sector alone is responsible for 50% of the world's total oil consumption (IEA, 2004), while its increase reached 25% in the 1990-2000 period (FULTON, 2004). If such patterns of consumption were to continue in the future, they shall augment fossil fuel consumption, resulting in growing environmental impacts particularly by significantly increasing CO_2 concentrations and their contribution to global climate change.

In such a scenario, Brazilian experience in the ethanol substitution for fossil fuels in its transportation sector can contribute to design new forms of commitment in the Post-Kyoto phase based on cleaner energy-matrixes.

Biofuel substitution for fossil fuels in the Brazilian transportation sector has been reinforced in recent years, by new institutions - in particular, the Inter-ministerial Sugar and Ethanol Council (BRASIL, 2003) regulations establishing a 20-25% ethanol content in regular automobile gasoline and the 11.097/2005 Federal Law mandating a minimum 5% biodiesel addition to diesel fuel – and by the recent dissemination of flex-fuel technology allowing automobile engines to run on any mixture of ethanol and regular gasoline.

In this context, ethanol consumption by automobiles can be expected to increase over the next years, due to the growth in the proportion of *Flex Fuel vehicles* among Brazilian automobiles, resulting in increasing the demand for ethanol and of the area of sugarcane plantations for ethanol production.

THE BRAZILIAN ETHANOL EXPERIENCE: PRODUCTION AND CONSUMPTION

Sugarcane plantation has been a major part of Brazilian agriculture since the XVII century; following a period of decline during the XIX century, sugarcane production started to regain importance in the XX to supply sugar to Brazilian markets (UNICA, 2008).

Large-scale ethanol production from sugarcane was established in the 1970s under the Brazilian Ethanol Program (*Programa Nacional do Álcool, PROALCOOL*), which aimed at both reducing oil imports after the first oil crisis with sugar price fluctuations in the international markets (GOLDEMBERG et al., 2004; UNICA, 2008).

According to Goldemberg and Moreira (1999), ethanol automobile use was successfull until 1990, when several factors including the gradual increase in the price of ethanol relative to gasoline, the introduction of Federal IPI (*Imposto sobre Produtos Industrializados*) taxation on ethanol vehicles, and the lack of a steady ethanol production that resulted in its substitution from foreign sources have significantly harmed the Brazilian programme, and reducing the sales of new ethanol automobiles to nearly zero by 1996 (GOLDEMBERG; MOREIRA, 1999).

Sugarcane plantation in Brazil has increased in recent years for both sugar and ethanol production. Figure 1 depicts these changes for the 1990-2007 period, showing that sugarcane output specifically used for sugar production exceeded the output used for ethanol production starting after 2000, although neither ethanol nor sugar has shown a consistent predominance in the rate of increase during this period. Because this period coincides with a surge in the production of many agricultural commodities, but also, with the beginning of the manufacturing of flex-fuel automobiles, it may be difficult to foresee to which end sugarcane production will grow faster.

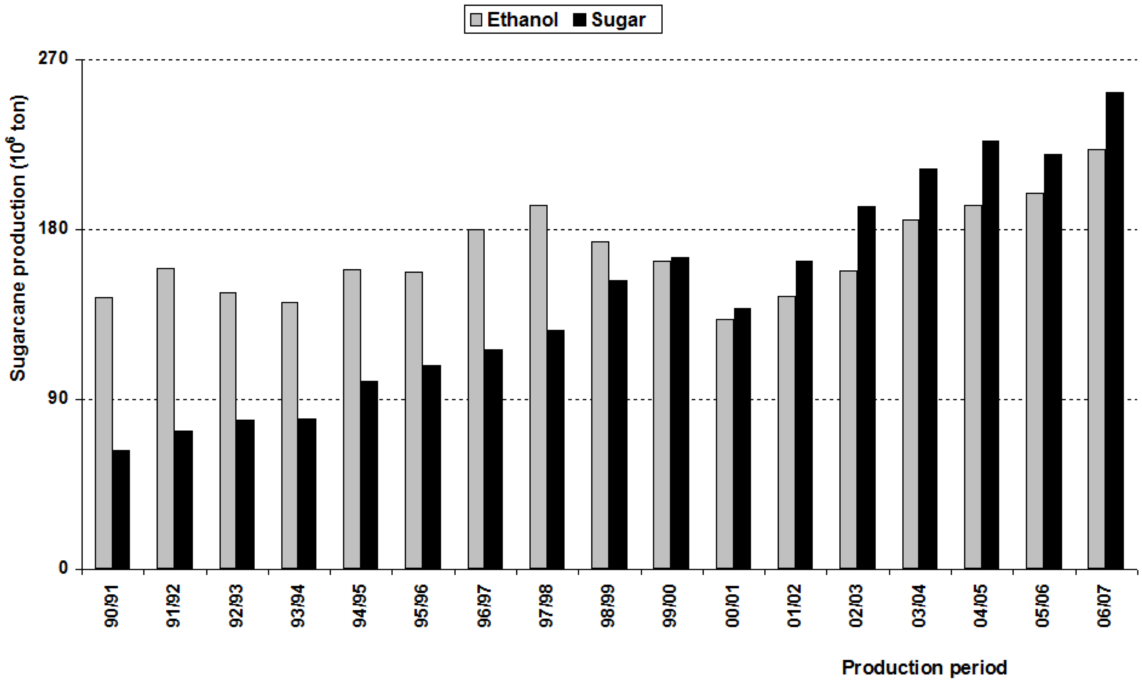

Figure 1 - Changes in Brazilian sugarcane output for ethanol and sugar production in the 1990-2007 period. Based on data from UNICA (2008) and Goldemberg and Moreira (1999) estimates of 8.5 tons of sugarcane for the production of each ton of sugar, and 12.5 tons of sugarcane for the production of 1 m^3 of ethanol

The proportion of gasoline vehicles in Brazilian automobile manufacturing decreased persistently after 2003, following the introduction of the flex-fuel technology in 2003, when total ethanol production has also increased (Figures 2, and 3) (EPE, 2007; ANP, 2007; UNICA, 2008).

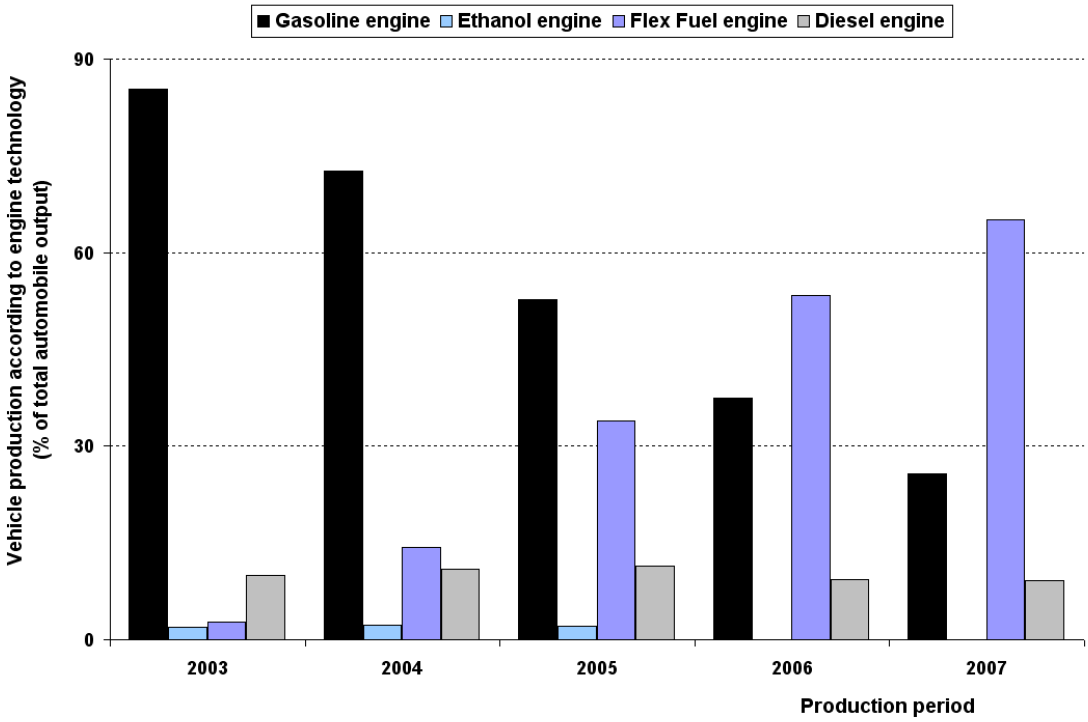

Figure 2 - Changes in automobile output according to fuel technology

Data source: ANFAVEA (2008).

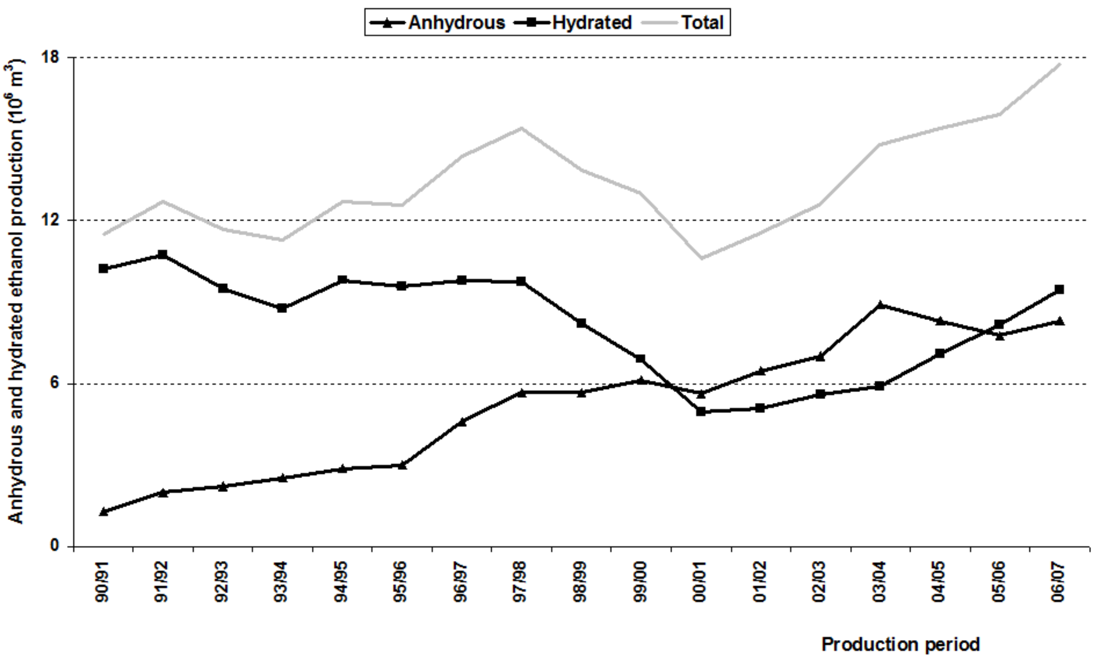

Figure 3 - Changes in anhydrous and hydrated ethanol production in the 1990-2007 period

Data source: UNICA (2008).

The long-term changes in the relative importance of ethanol consumption by the transportation sector is shown in Figure 4.

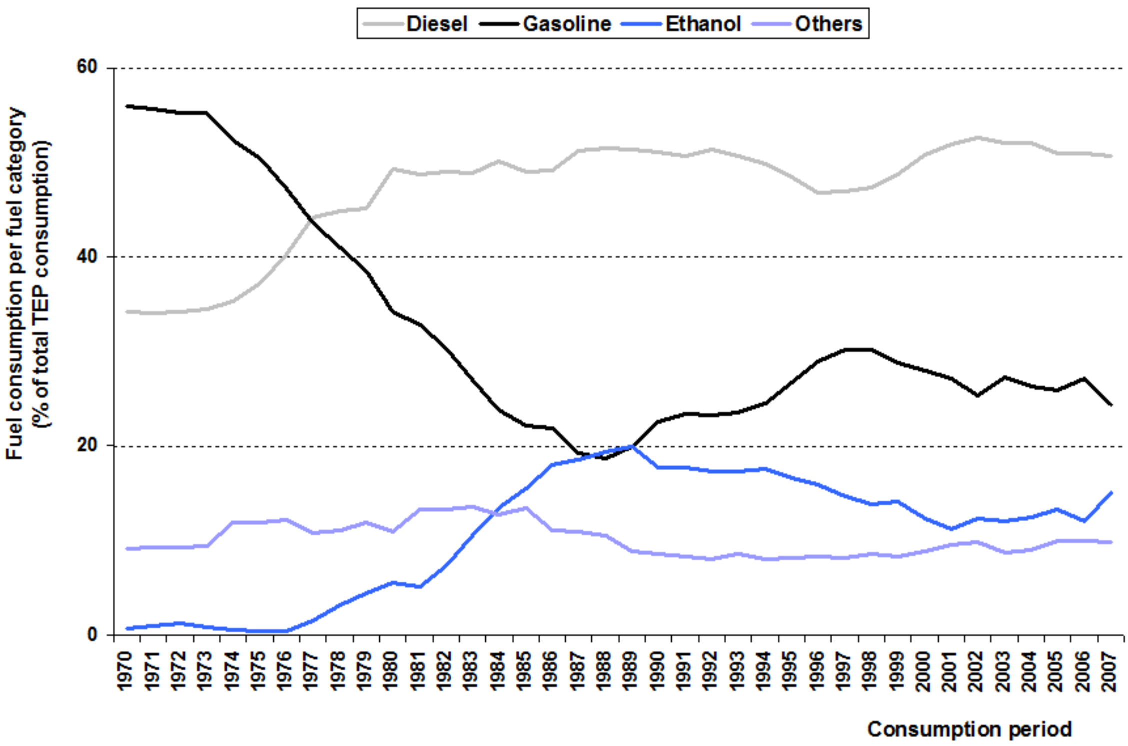

Figure 4 - Changes in fuel consumption by the transportation sector per each fuel category in the 1970-2007 period

Data source: EPE (2007) (TEP – Total Equivalente de Petróleo).

A persistent increase in ethanol's relative importance is shown starting in 1975 after the first oil crisis in 1975 and continues almost uninterrupted until 1990, but continued in relation to decreases during the 1990s, a period of increases in the price of ethanol. At the same time, a new increasing tendency in ethanol consumption is shown for the period that follows the introduction of flex-fuel engines in Figure 5.

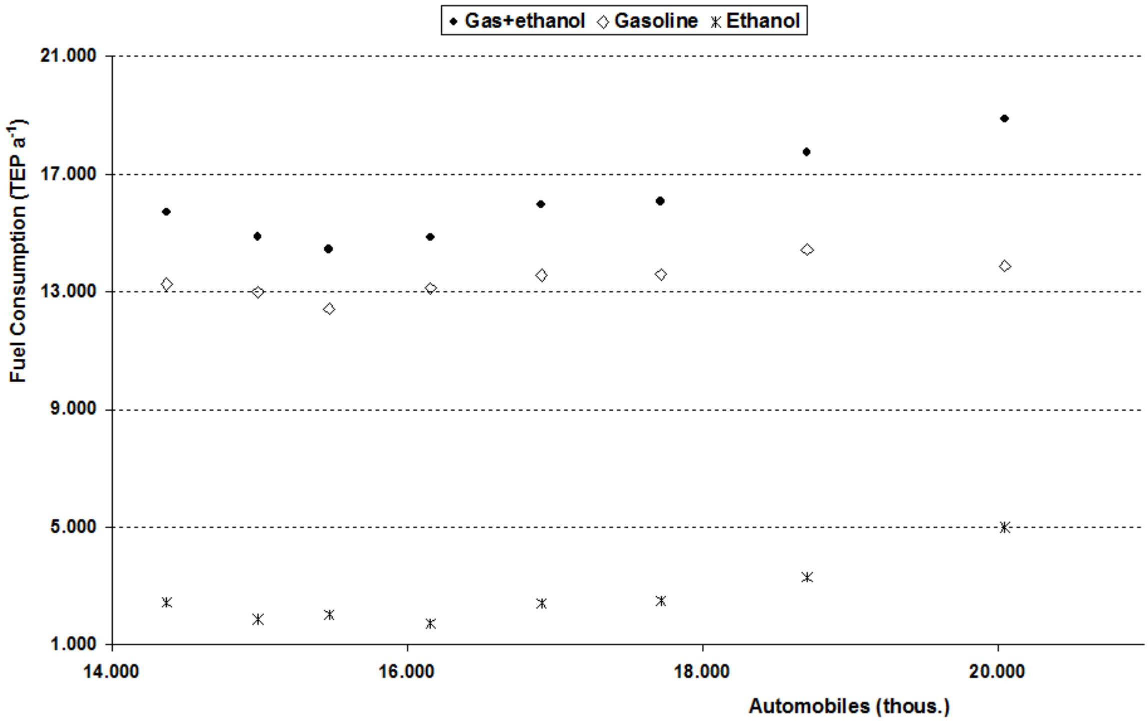

Figure 5 - Relationship between the number of automobiles and fuel consumption in the 2000-2007 period

Data sources: ANP (2007) and ANFAVEA (2008); (TEP – Total Equivalente de Petróleo).

If this tendency is to continue, ethanol consumption can reduce CO_2. emissions from gasoline: in 2003, for instance, gasoline substitution for ethanol avoided the emissions of 27.5 tons of CO_2 according to Macedo (2005). At the same time, the longer changes in ethanol consumption over the last decades indicate that its preference by automobile owners is primarily dependent on its price, in particular, in the presence of the flex-fuel technology, which, contrary to ethanol engines, can be fueled with both gasoline and ethanol. Past history suggests that to guarantee a long-term offset in CO_2 emissions, ethanol prices relative to gasoline might require some form of regulation to remain competitive lest fuel markets show the same behavior during a emission-reductions period. This idea is further explored in the next section.

SCENARIOS OF FUTURE CHANGE IN FUEL CONSUMPTION BY THE AUTOMOBILE SECTOR

This section explores how fuel consumption may evolve in Brazil if fuel markets were to repeat the same behavior observed in the last decades, and investigates how increases in ethanol production and consumption could affect the area of sugarcane plantation for ethanol production in Brazil.

Both automobile production and fuel consumption of different categories have significantly increased during the last decades in Brazil, although several factors like the size of the automobile fleet, engine technology changes, transportation costs, and other, may have caused fuel consumption to actually increase or decrease during one period or another. To simulate consumption patterns in the future decades we attempted to replicate this behavior by calculating inter-annual variations in gasoline and ethanol consumption during the 1990-2007 period based on statistics from the Brazilian National Oil Agency (ANP, 2007), and generating random annual increases in fuel consumption by attempting to reproduce the same distribution over the 2008-2030 period.

A total of 15 sets of simulations were produced, each one including one scenario of long-term increase in fuel consumption and three scenarios of long-term variation of ethanol production, all of them based on randomly generated inter-annual changes that tried to emulate the corresponding distributions in the 1990-2007 period. All 15 sets of simulations predicted a long-term increase in total gasoline-ethanol consumption, although each simulation were marked by different inter-annual changes, that alternated increases and decreases in total fuel consumption in different order.

Here we present the results of two sets of simulations (Figures 6 and 7) that show the largest disparities among the 15 sets produced. The long-term changes in total gasoline-ethanol consumption predicted in these simulations indicate that total fuel consumption can significantly vary: departing from 23.7 million TEP a^{-1} (TEP - *Total Equivalente Petróleo;* EPE, 2008) in 2007, the simulation shown in Figure 6 predicted a total fuel consumption of 32.6 million TEP a^{-1} by year 2030, while the one shown in Figure 7 predicted 50.9 million TEP a^{-1}. These results illustrate how long-term emission targets can depend on the many factors influencing the automobile sector and its fuel consumption. Hence, offsetting CO_2 gasoline emissions by ethanol substitution may depend on some sort of engineering to guarantee its effectiveness in scenarios of growing, but randomly fluctuating, fuel consumption and composition.

Table 1 - Consumption statistics from scenarios shown in Figures 6 and 7

Consumption	Total 2008-2030 fuel consumption (10^6 TEP)	Avg. 2008-2030 annual consumption relative to 2007 total fuel consumption (% 2007 cons.)	Total 2008-2030 ethanol substitution (% of total TEP fuel consumption)			
			50% E	S1	S2	S3
Slow increase (Figure 6)	619.9	1.14	41.2	12.5	15.2	29.2
Fast increase (Figure 7)	767.6	1.42	47.5	9.0	7.4	12.3

To explore this further, we considered the cumulative fuel consumption over the entire simulated 2008-2030 period, and the corresponding impact of different scenarios of ethanol substituting for gasoline as shown in Table 1. The reference scenario identified as 50%E in each set of simulations corresponds to constant increases in the ethanol proportion to achieve 50% of all fuel consumption of the year 2030; hence the cumulative effect of offsetting emissions depends on the actual inter-annual fuel composition (i.e. the actual gasoline-ethanol mix) and produced a cumulative effect on fuel consumption of less than 50% for all simulations (this way of long-term approaching a 50% substitution by 2030 may seem somehow artificial, and it should be taken only as an illustrative example, since we don't know the actual fuel consumption by 2030; at any rate, the occurrence of random increases in fossil fuel consumption over any commitment period appears to be in contradiction with the ideal goal of stabilizing CO_2 concentrations).

Table 1 also shows the cumulative effect of the 2008-2030 changes in ethanol proportion for the three random scenarios S1, S2 and S3, which assume random fluctuations in the ethanol proportion of fuel consumption. These results illustrate that emissions offsetting can not be automatically achieved by increasing ethanol proportions if total fuel consumption increases (it can be noted that results for all 15 sets of simulations produced more frequent higher cumulative ethanol proportions changes in comparison with the “slow” and “fast” consumption increase scenarios from Figures 6 and 7 and Table 1, with a most common value of 15% of the total 2008-2030 fuel consumption).

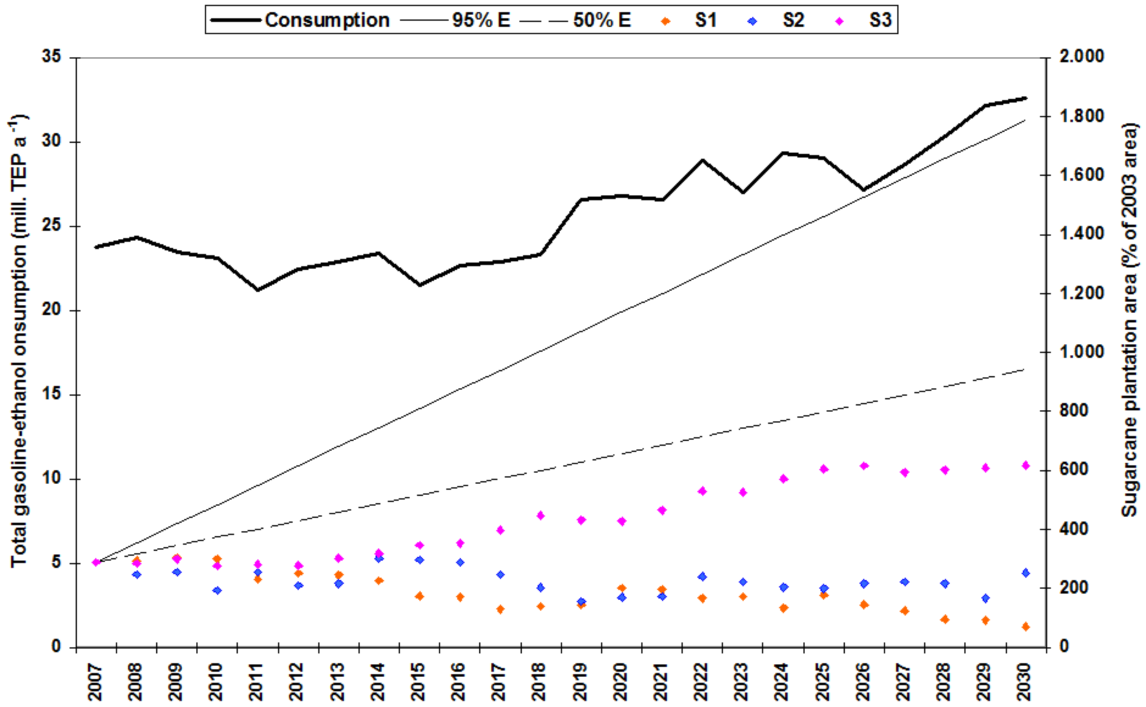

Figure 6 - Annual gasoline-ethanol consumption and sugarcane plantation area simulations for the 2008-2030 period, based on randomly selected sequences of the yearly consumption fluctuations observed in the 1990-2007 period. Lines illustrate one scenario of ***slow increase*** in fuel consumption, and the corresponding increases in sugarcane plantation area to replace 95% (95%E) and 50% (50% E) of gasoline consumption by ethanol by year. Markers represent three different scenarios of changes in sugarcane plantation area for three random sequences of ethanol comsumption change, taking 2003 area as a reference

Data sources: ANP (2007). (TEP – Total Equivalente de Petróleo).

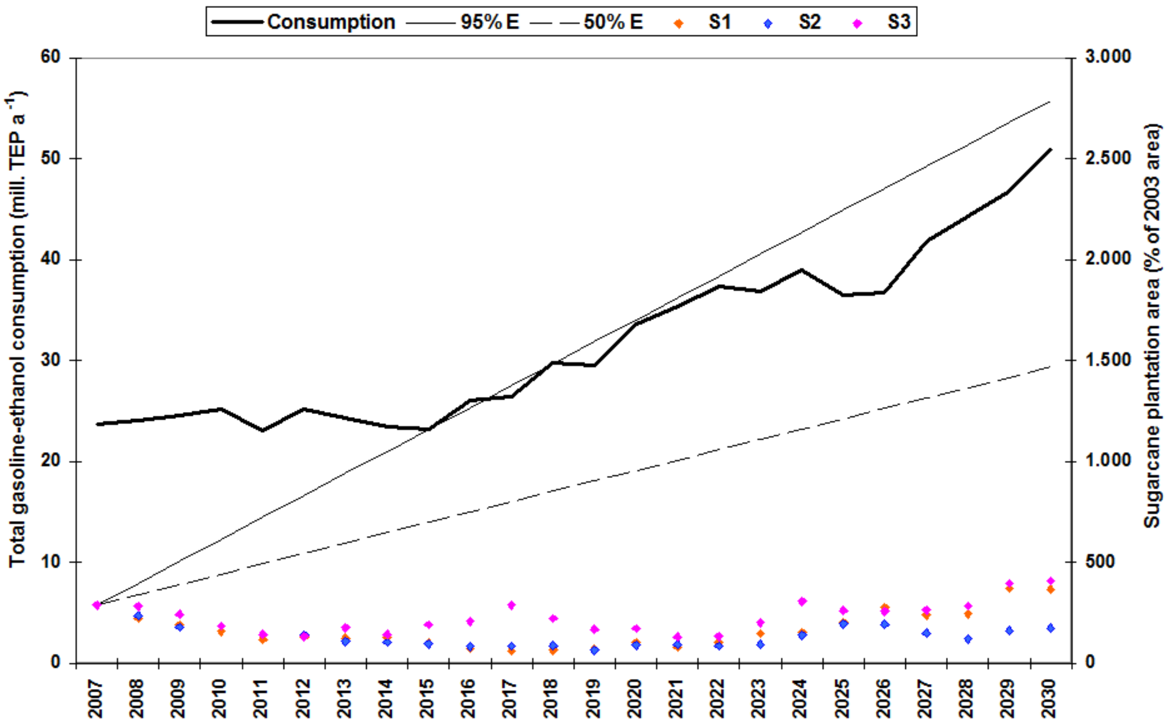

Figure 7 - Annual gasoline-ethanol consumption and sugarcane plantation area simulations for the 2008-2030 period, based on randomly selected sequences of the yearly consumption fluctuations observed in the 1990-2007 period. Lines illustrate one scenario of *fast increase* in fuel consumption, and the corresponding increases in sugarcane plantation area to replace 95% (95%E) and 50% (50% E) of gasoline consumption by ethanol by year. Markers represent three different scenarios of changes in sugarcane plantation area for three random sequences of ethanol comsumption change, taking 2003 area as a reference

Data sources: ANP (2007). (TEP – Total Equivalente de Petróleo).

To conclude the discussion on the simulations, it could be added that increases in sugarcane plantation area can be important if ethanol proportions are to increase significantly. For instance, based on IBGE estimates of 5.377.216 hectares of sugarcane plantations for 2003, and assuming that 50% (MME, 2007) to 60% (GOLDEMBERG; MOREIRA, 1999) of the sugarcane are used for ethanol production, it can be estimated that 2.688.608 to 3.226.330 ha of sugarcane were planted for ethanol production in that year; if we consider the most common value of sugarcane area change among 15 simulations gave an increase of some 300% in sugarcane area by 2030, then a total sugarcane area corresponding to 32-39%

of the territory of the State of São Paulo would be required for a corresponding increase in ethanol proportion in fuel consumption; as a further reference to understand the scenarios predicted in Figures 6 and 7, it could be noted also that a 10-fold increase in the 2003 sugarcane plantation area for ethanol production would roughly result in planting an area equal to that state with sugar cane for fuel production alone. In this context, it should be also noted that significant emissions offsetting by replacing gasoline with ethanol without generating additional environmental impacts may require new technologies for ethanol production.

CONCLUDING REMARKS

The experience of ethanol use in Brazil reveal that the proportion of this fuel in the overall consumption of automobiles varied significantly, largely increasing at the peak of PROALCOOL - the Brazilian Ethanol Program, but diminishing afterwards as ethanol price relative to that of gasoline's increased, and the benefits of buying and using ethanol automobiles were diminished. Although flex-fuel engines have been in use for only a few years, ethanol production and its consumption relative to that of gasoline has increased, although it appears necessary to explore the effect of unusual high oil prices in ethanol consumer preference during this recent period.

Simulations suggest that some level of ethanol substituting for gasoline may "naturally" occur in the next two decades, for example, if ethanol proportions fluctuations are to show a behavior similar to that shown in the 1990-2007 period. However, there are at least two major points in relation to environmental impacts that ought to be considered: first, for an actual reduction in CO_2 gasoline emissions to be effected, the rate of ethanol proportion increase should compensate for overall fuel consumption increases; second, unless ethanol production technology changes dramatically in any commitment periods, significant increases in ethanol proportions will require comparable increases in sugarcane plantation area, which, in turn, can produce environmental and social impacts.

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LAND OPPORTUNITY COST: A PROPOSAL TO AVOID DEFORESTATION[1]

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ABSTRACT

The Amazon Forest possesses an incalculable biodiversity value, sheltering hundreds of indigenous people and regulating the national and global climate. Although in the last two years a reduction of deforestation in Amazonia has been occurring, this number is still above the level considered as acceptable. Among the states belonging to the Legal Amazonia, Mato Grosso is one the largest soybean planters, one of the main causers of the agricultural frontier growth in the country and consequently of deforestation in the Amazon region. It is accepted that to halt the deforestation it is necessary to complement the mechanisms of command and control with a system of payments for environmental services. The general objective of this study is to estimate the land opportunity cost in strategic regions that are under the greater pressures. The specific objective is to analyze the carbon tonnage cost emitted by the soybean generated deforestation and identify the potential beneficiaries of the instruments offered by the forest to consider the adoption of payments for environmental services in Mato Grosso thus providing the means to prevent deforestation. The data used in the study were furnished by local organizations and institutions. Productivity of the soil will be estimated by the ratio between the soybean production value and the planted area. By National Accounts the value added to agricultural and cattle raising activities is of 10,7%. Thus, it is possible to estimate the land opportunity cost for Mato Grosso. Calculating the emissions and the price of the carbon ton emitted by soybean, deforestation brought by soybean cultivation will be estimated. Induced deforestation having occurred, provoking CO_2 emission and once known the concept of land profitability, it is possible to find a value for the carbon tonnage

1 This work was the result of the research project (Economic Fundaments of the Proposition of thee National Pact for Zero Deforestation in the Amazon Forest financed by the Socioambiental Institute and Greenpeace. Whoever the expressed opinions do not necessarily represent these institutions visions, being entirely of the authors responsibility.

emitted by soybean. Finally, to analyze the potential beneficiaries of the environmental products a summary of the bibliography will be prepared. The expected result is the confirmation of the economic viability of projects for payment of environmental services in the state of Mato Grosso, in order to preserve the Amazon Forest. Additionally, the idea is to find the value of carbon tonnage emitted by soybean, minor or equal to the values of carbon negotiated in the market. In this way, it will be possible to open a range of national or world character solutions to stop the Amazon deforestation. The study clearly shows that it is possible to economically justify the preservation of the Amazon Forest, more specifically the part localized in the state of Mato Grosso, Brazil. Thus, the study is directly related to the viability theme of deforestation prevention for the reduction of emissions.

Keywords: Deforestation, Amazon, Environmental services.

INTRODUCTION

There has been a reduction in the rate of deforestation in Amazonia in the 2003-2006 period, but this number is still above the average level of the 90 decade, considered as unacceptable for the forest preservation. The high rates of deforestation are the result (i) of historical direct and indirect policies of economic incentives that stimulated predatory activities, and the precariousness of monitoring actions, environmental command and control, which in spite of the recent intensification in some aspects, are still precarious and clearly insufficient.

A new conceptual landmark was established and the best synthesis of this new point of view is the “Pact for the Valorization of the Forest and for the End of Deforestation in Amazonia”, launched in 2007 by the following Non Governmental Organizations (NGOs): Socioambiental, Greenpeace, Centro de Vida Institute, Institute of Environmental Research of Amazonia, The Nature Conservancy, International Conservation, Friends of Amazon Brazilian Land, IMAZON, and WWF-Brazil. The “Pact of Zero Deforestation”, as it will be from now on referred to in this text asserts that the efficiency and the efficacy expected from public policies for contention of deforestation demands to go beyond the improvement of command and control actions, and proposes the revision of the financial incentives historically canalized to predatory activities. More than this, the “Pact of Zero Deforestation” suggests the implementation of financial incentives toward conservancy deeds, improving economic activities considered adequate to the bioma, inclusive in private lands. Among the new proposals, the payment of financial services to reduce financial incentives toward a reduction of carbon emissions associated to deforestation is emphasized.

Thus it is necessary to quantify management and the costs of opportunity of land use in strategic regions that are under greater pressure and identify the potential beneficiaries of a system to pay for environmental services, conceiving a system that supports the agents responsible for conservation, inclusive state and municipality agents.

Considering the support that the theme of climatic global changes has been gaining, mainly after the publication of the Stern Report in 2006 and the International Panel of Climatic Changes (IPCC) in February and May of 2007 and the direct correlation, in the Brazilian case, with the deforestations and forest slash and burn in the Amazonia[2], a singular opportunity is opened for an objective debate on the adoption of an Amazonian Regimen (national) of goals to decrease deforestation. The “Pact of Zero Deforestation predicts the implementation of a program for deforestation decrease that prevails over the logics of command and

[2] 70% of the emissions of greenhouse gases emitted by Brazil are originated from deforestation and forest burning.

control, following the rising international consensus circa the inclusion of tropical forests protection in the debate on climatic changes by means of financial compensatory mechanisms in the field of carbon market [3].

The fundamental hypothesis is that the isolated command and control actions are costing too much to society with still little stimulating results, and that the current economic instruments (credits, tributary exemption, and many kinds of indirect incentives) actuate with forces contrary to conservation and sustainable use of the native forest cover. Thus, so that control policies of deforestation is efficient and just, it is necessary, among other factors, that remuneration instruments are developed for environmental services granted by the standing forest.

This includes encouragement for the States, which are nowadays the main operators of forest management, after the coming into force of the Law of Public Forests Management (Federal Law n.11.284/06), as well as support for the social players that are responsible for conservation (indigenous peoples, local traditional communities, family farmers and rural employers).

Based on the above considerations, this study aims to detail one of the aspects associated to the following proposition: the estimation of the cost of land opportunity in the expanding agricultural frontiers, taking as reference the profitability of soybean in Mato Grosso, with the objective of estimating the value to be paid per avoided carbon ton, an initiative that might hold back deforestation. Even in a preliminary and certainly approximate way, the result of this study may contribute to the development of new economic instruments complementary to the existing ones.

FUNDS FOR DEFORESTATION REDUCTION

REDUCTION OF DEFORESTATION ON PRIVATE LANDS

The cost of a deforestation program is not restricted to expenditures for environmental management, since no program for the control of deforestation will be well succeeded if it does not include the cost of land opportunity. From a theoretical point of view, the land-owners at the agricultural frontier areas, such as other economic players, look forward to maximize the income they will obtain from their lands. Thus, the decision for the use of land is equivalent to the decision on the structure of a portfolio, where the forest lands are treated as financial assets; if

[3] In this sense have a look at the executive summary of the reports from the Working Groups of the Intergovernmental on Climatic Change (IPCC) in the site www.ipcc.ch.

the option to a conversion for agricultural or cattle raising activities is more profitable, the owner will tend to deforest. In these circumstances, to keep the forest intact implies in a sacrifice of profitability, denominated land opportunity cost.

Therefore, a drastic program of reducing the deforestation rate should also consider the financial incentives for the landowner to keep the forest intact, in a way to rebalance the financial equation, including the cost of a monitoring system for the benefited lands to know if these areas are being effectively preserved.

CONCEPT OF PAYMENT OF ENVIRONMENT SERVICES (PES)

One of the great consensuses on environment management is that an excessive dependence on budgetary allocation should be avoided, guaranteeing stable flows of financial resources for the protection of the environment. Another consensual element is that a financial penalty should be instituted for the economic agents that may eventually injure the base of natural resources, either by reduction of its quantity or degradation of its quality. The concept of Payment for Environmental Services (PES) emerges as a means to concretize the two mentioned objectives: generation of resources for environmental management by charging the agents that cause damage to natural resources with penalties for its excessive use or degradation of its quality.

The basic principle of the PES is the same that guides the conventional actions of environment policies (“command and control”): the environment provides an enormous scope of goods and services of direct or indirect interest to mankind, but do not necessarily revert into financial benefits for the economic agents that control, direct or indirectly, the supply of these services. There arises, then, what is called in literature the “market failure”: the search for an option that guarantees a better private profitability result in socially worse situations. The difference is in the proposition of solutions: instead of establishing direct ways of regulation based on procedures (emission patterns, licensing, better practices, etc.), the option is for the internalization of the costs (or benefits) that are not privately accounted for, denominated as externalities, so that the primary causes of these damages (or benefits) be penalized or benefited by such actions.

In the specific case of environmental services related to forest conservation, a system of PES can be established when those that benefit from these services effect a payment for the landowner or manager of the area in question, creating a financial incentive to guarantee the continuous flow and the improvement of the demanded service. The payments may be considered as an additional source of income, being a modus of compensating the costs of soil conservation practices that allow the supply of ecosystem services. This model complements the acclaimed principle of the “polluter-payer”, focusing on supplying the service: it is the principle of the “provider-receiver”, when the user pays and the conservationist collects (PAGIOLA et al., 2005).

However, the establishment of the PES demands certain circumstances to occur, so that it becomes effective. One of the premises is that there is a clear identification of at least one environmental service benefiting an agent interested in guaranteeing the maintenance of such service, being ready to pay for it, either voluntarily or by creating a mechanism that obliges payment. It also should be clear who pays and who collects, and the latter should be capable of guaranteeing the preservation of the forest (“rights of property”), in a way that the payer may be sure that the service for which he is paying will be done. On the other hand, this leads to the necessity of efficacious monitoring systems that assure environmental, social and economic effects of the PES and, on the other hand, guarantee the credibility of the system.

As the PES treat externalities that do not have a market price, these services should get a price put on it, through techniques consecrated by the specialized literature (environmental resources valorization). Since these circumstances are not present in many of these cases, it will not be expected that PES be universal solutions or that they prompt up spontaneously. Two elements are always present in well succeeded experiences of PES:

The magnitude of the environmental problem be sufficiently acute so that society accept the cost of some type of instrument (user/polluter – payer), which will be the financial basis for the payment of the environment service (provider-beneficiary).

Adequate public policies should be established to make the system possible; many times the PES systems are described as “market mechanisms”, suggesting a false opposition to the public action. Much to the contrary, the role of public administration is fundamental in the leadership of the process, since what is commercialized is the conciliatory attitude in the accomplishment of goals imposed by a governmental policy of environment protection.

In the absence of these circumstances it is very difficult for an effective PES system to function, since it stays at the mercy of voluntary contributions that are volatile and hardly reach the sufficient value for large scale changes. Many of the PES proposals for forest conservation finished not getting through the training period because their pillars were not consolidated, and many ecosystem services are now threatened because permanent ways of guaranteeing a stable flow for conservation were not created.

The aggravation of global warming represented an alteration of these elements, and today it is believed that the necessary premises are being attended to for the establishment of a system of PES that can lead to a reduction of deforestation emissions. The successive scientific advances on climate determinants and the confirmation of the hypothesis that anthropic action has induced an alteration on the temperature of the Earth are being accompanied by a change of behavior all over the planet, allowing great accessibility for investment in concrete actions to mitigate the problem.

Since it is progressively becoming evident that climatic stabilization will only be possible with a significant reduction of deforestation, clear signals are becoming visible that the forest issue will receive a greater importance in the negotiations on global warming, both in the field of the United Nations Framework Convention on Climatic Change (UNFCCC) and in the voluntary carbon markets ("Out of Kyoto"). The next sections will explore the potential that is called for in the combat of deforestation in Brazil.

CARBON MARKETS: NEW POSSIBILITIES FOR FOREST PROJECTS

The recent reports of the Intergovernmental Panel on Climatic Change (IPCC) shows that deforestation in the Amazon Region is a crucial problem, which demands fast solutions, due to the current immense volume of generated emissions and also because retro-feeding effects will probably occur owing to the drying up of the forest, induced by temperature augment, which promotes burning, generating still more emissions in the near future.

The Synthesis Report of the Workgroup III of the IPCC recognizes that the reduction of tropical deforestation is one the most important and cheaper strategies for emission mitigation:

- 30) from sources and increase CO_2 removal by sinks at low costs, and can be designed to create synergies with adaptation and sustainable development (high agreement, much evidence)30;
- About 65% of the total mitigation potential (up to 100 US$/t CO_2-eq) is located in the tropics and about 50% of the total could be achieved by reducing emissions from deforestation [9.4];
- Climate Change can affect the mitigation potential of the forest sector (i.e., native and planted forests) and is expected to be different for different regions and sub-regions, both in magnitude and direction [9.5];
- Forest-related mitigation options can be designed and implemented to be compatible with adaptation, and can have substantial co-benefits in terms of employment, income generation, biodiversity and watershed conservation, renewable energy supply and poverty alleviation [9.5,9l6,9.7. "IPCC, 2007, p.15].

Even though variations exist on estimations, it can be said that the annual emission of gases of greenhouse effect by means of deforestation in Brazil is around 0.2+/-0.2PgC (HOUGHTON et al. 2000; apud SANTILI et al., 2005), representing 70% of emissions in the country and placing it among the five nations that more emit in the world. It is, therefore, the most important problem to be resolved in Brazil and, without demerit of other possibilities of mitigation, it should be national priority number 1 in terms of actions to fight global warming.

The argument that keeping forests intact would bring problems for the economic growth as well as for national sovereignty can not anymore be accepted. The immense area already deforested is more than sufficient to accommodate any additional expansion of agricultural activities or cattle raising production and the development impasse in Brazil has other structural causes, such as income and land concentration, low educational stage and inadequate economic management, which will not be resolved by adding more land supply.

On another hand, it is not fair that Brazil should carry on its cost of financing programs destined to reduce the greenhouse effect of gases emissions, since all the planet is the beneficiary of such deed. It should be considered that, beyond costs of the public apparatus for environmental control, it is also necessary to fund the system of financial incentives for the landowners to convert private lands into agricultural and cattle raising activities.

The capture of external resources may be a way to complement the actions of zero deforestation, but to turn it possible it is fundamental to change the way in which the theme has been treated up to now in the sphere of the Kyoto Protocol. Currently, it is the not possible to obtain certified credits of reduced emissions by reduction of deforestation, since this option was considered unelectable by the Mechanism of Clean Development (MCD). A maximum limit was also imposed to reforestation actions, restricting to 1% of the total transactions of MCD in a year span.

The practical result of the anti-forest bias of the Kyoto Protocol was the extremely low participation of Land Use projects, Change in Land Use and Forestry (LULUCF) in the carbon markets. According to the Report of Point Carbon (2007), only 1% of the MCD was effected with LULUCF actions, representing less than 0,2% of carbon transaction value. The only market that considers emission reductions as an eligible action for carbon credits is that of the Chicago Climate Exchange (CCX), which acts out of the Kyoto Protocol rules. The CCX has a highly inferior volume of transactions and pays a price much below what is paid in other markets, specially the European System of Transactions (ETS), which concentrates most of carbon trade.

To change this situation, the emerging countries are discussing forms of introducing payments for avoided reductions of deforestation (SANTILLI et al., 2005). In a recent meeting occurred in Cairns, Australia, four propositions were presented to reduce deforestation, three of them explicitly including reduction through avoidance of deforestation as a carbon credit generating action and the Brazilian proposition was the only one based on voluntary donations without copensation credits (CENAMO, 2007). Although the divergence about the final format on how this instrument would work, there is a great consensus that it is necessary to identify sources of additional financing, substantial, predictable and sustainable, to support the necessary actions for reduction of emissions via deforestation. An active involvement of the private sector is essential, thus including greater incentives of different sources (CENAMO, 2007).

The following section was elaborated with the intention of estimating the price associated to carbon emissions reductions through actions of deforestation reduction, considering the land opportunity cost. A most important premise is that there is a great differential in land productivity. Thus, opportunity cost associated to keeping the forest intact should be lower in most of the areas still not deforested. When a system of PES associated to avoided emissions of carbon is operational, it is possible to actually implement what the economic-ecological zoning has not been able to do: a separation among areas with greater agricultural and/or cattle raising vocation, which should be used with maximum possible productivity, and the areas that should be destined to conservation, with low productivity, which will remain forested.

The total amount that can be achieved by this program depends on methodological responses for a series of issues that still need to be resolved in an ample consensus and sufficient to turn into a rule in international carbon markets, involving the definition of basic scenarios and the evaluation of emissions reduction. These issues will be intensified in the next section.

DEFORESTATION OPPORTUNITY COST

LAND PROFITABILITY

The estimation of land profitability is fundamental for deforestation halting propositions, due to the ***payoff*** that exists between agriculture frontier expansion and forest preservation, because the expansion of soybean, cotton fields and cattle raising is encroaching forest areas, causing deforestation (for an detailed analysis, see YOUNG, 1997). The Opportunity Cost of conservation is understood as the maximum profitability that could be expected from a forested area, would it be converted into agricultural or cattle raising lands. For Mato Grosso, the soybean cultivation was considered as the most profitable use of land, and owing to this the opportunity cost estimations are based on profitability aimed for this specific activity.

The following per municipality data were used:

- Soybean production value (R$), given by the IBGE;
- Soybean harvested area (ha.), given by the IBGE;
- Soybean cultivated area (ha.), given by the IBGE;
- Extension of the municipalities categorized by forested area and non-forested area (km^2), given by Centro-Vida Institute;
- Deforestation (km^2), given by Centro-Vida Institute.

The classification of land in two bioma types, forest and cerrado (identified as “non-forested area”) is important because the deforestation emissions are different in each of them. However, reliable sources of information were not identified concerning production costs. Owing to this, it was assumed that the land profitability in forested regions is the same as in the cerrado regions, equivalent to the Brazilian average agricultural areas profitability, which according to the National Accounts (IBGE), is of 10,7%. In practical terms, it means that the profitability variations projected for the municipalities are a function of productivity variations (US$/ha). The detailing of this issue therefore demands future studies that will operate with more precise data on costs and profitability per municipality[4].

Last, the hypothesis that the landowner would accept to halt deforestation if he got a compensation equivalent to the cost for land opportunity was recognized. The specification of mechanisms that result in these payments involves complex issues and is a subject that will deserve reinforcement in later studies.

Considered the premises above, the calculus of the productivity (US$ mil/ha) per municipality was proceeded, and a land profitability factor was applied (10,7%). Due to the great oscillation of soybean international price and the exchange rate at the first half of this decade, the analysis considered two land profitability scenarios (2000-2002 and 2003-2005), whose results are in the graphics below.

4 Transportation costs vary considerably among municipalities leading to large differences in profitability, even in conditions of small productivity variance.

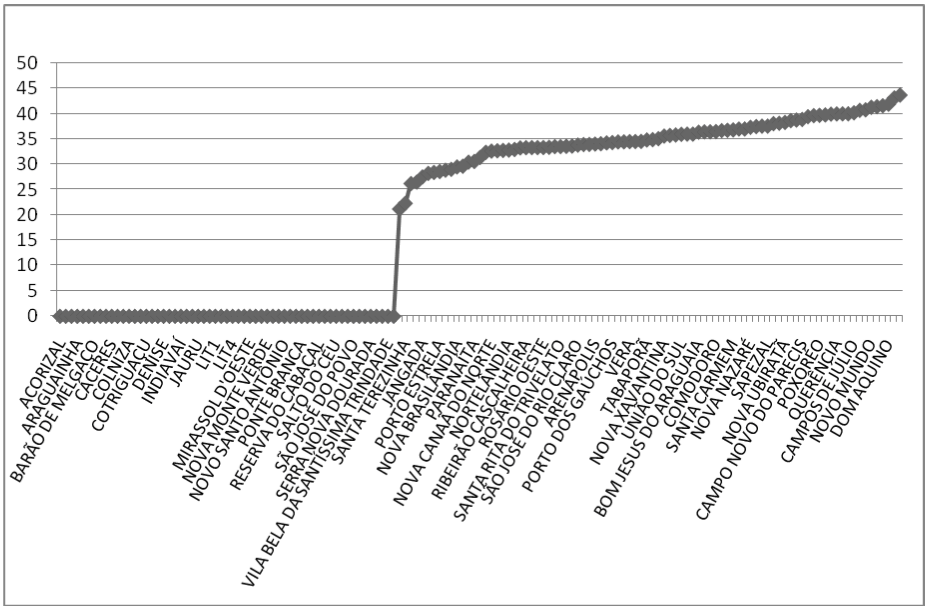

Figure 1 - Soybean Profitability 2000-2002
Soybean Profitability in US$/Ha between 2000 and 2002

Source: Elaboration by the author.

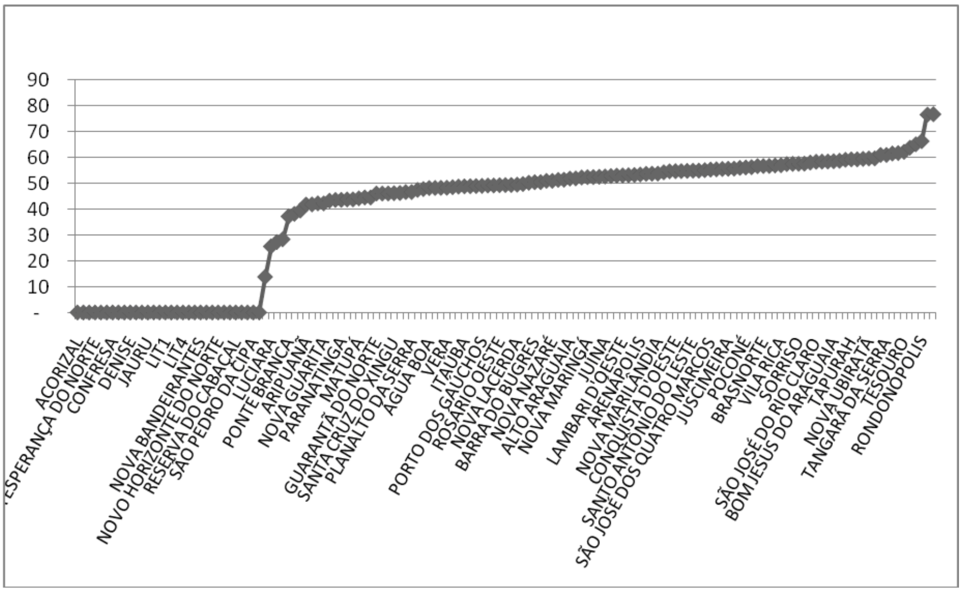

Figure 2 - Soybean Profitability 2003-2005
Soybean Profitability in US$ between 2003 and 2005

Source: Elaboration by the author.

It is interesting to observe that the difference in land profitability among the analyzed municipalities is evident. Or else, although in some parts of the State the land opportunity costs are very high, it is possible to restrain the deforestation in large areas of minor productivity as a strategic and cheaper way.

It is acknowledged that land profitability has risen from the first to the second analyzed periods suggesting more efficient agricultural techniques or smaller production costs. Another possible explanation for what occurred may be increases in the product price in the second period. Given that profitability was maintained constant in 10,7% productivity, it is considered that the rise in prices is the more important variable to justify the land productivity growth according to the above graphics. There follows a comparison between the scenarios.

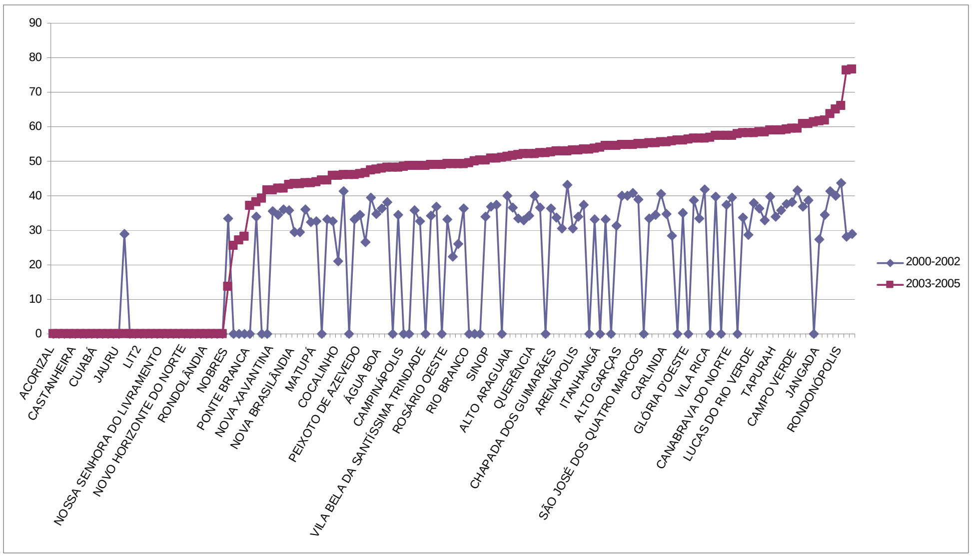

Figure 3 - Comparison between the scenarios of soybean profitability

Source : Author's elaboration.

In the above graphic 3 it is possible to observe that in the period of 2003-2005, many municipalities that did not produce soybean in 2000-2002, from this time started to produce with high profitability, corroborating the hypothesis that soybean agricultural frontier has expanded the deforestation in the state of Mato Grosso.

There follows an analysis of the deforestation induced by soybean planting.

DEFORESTATION AND TC PRICE

The Centro Vida Institute furnished estimations of the total deforestation by municipality, divided in forest and non-forest areas. However, there is no reference of how much was deforested exclusively by soybean expansion in each municipality per type of area. As this information is fundamental to estimate the emissions generated by deforestation, a proxy was adopted assuming that the proportion of soybean planting in areas of forest and of non-forest followed the rate between deforestation (total) in areas of forest and of non-forest per municipality. Therefore, to determine if the deforestation occurred in areas of forest or in areas of non-forest, the soybean generated deforestation was divided (expansion of soybean planted area) between the forest areas and non-forest according to the historical proportion of deforestation in these two types of area (deforestation in forest/total area of forest and deforestation in non forest/total area of non-forest). This exercise was also made for the two scenarios (2000-2002 and 2003-2005).

A subjacent hypothesis is the one where the soybean area expansion leads necessarily to deforestation, though in indirect way: even if the soybean expansion occurs over grazing land occupation, it is presumed that the total grazing area will not be reduced, since cattle raising activity moves around and ends up provoking deforestation. This issue is today one of the great controversies in the proposition to expand the cultivation of vegetable oil plants to produce biodiesel, and also deserves more detailed future analyses.

The emissions of deforestation were calculated using the following emission factors: 110tC/ha for the forest areas and 55tC/ha for the cerrado areas. These factors were determined through analysis of literature and consultation of specialists, and care was taken to adopt values nearer to the inferior found limits to avoid overestimating the carbon emission in each kind of bioma. The graphics below show the emissions originated from deforestation of forest and cerrado.

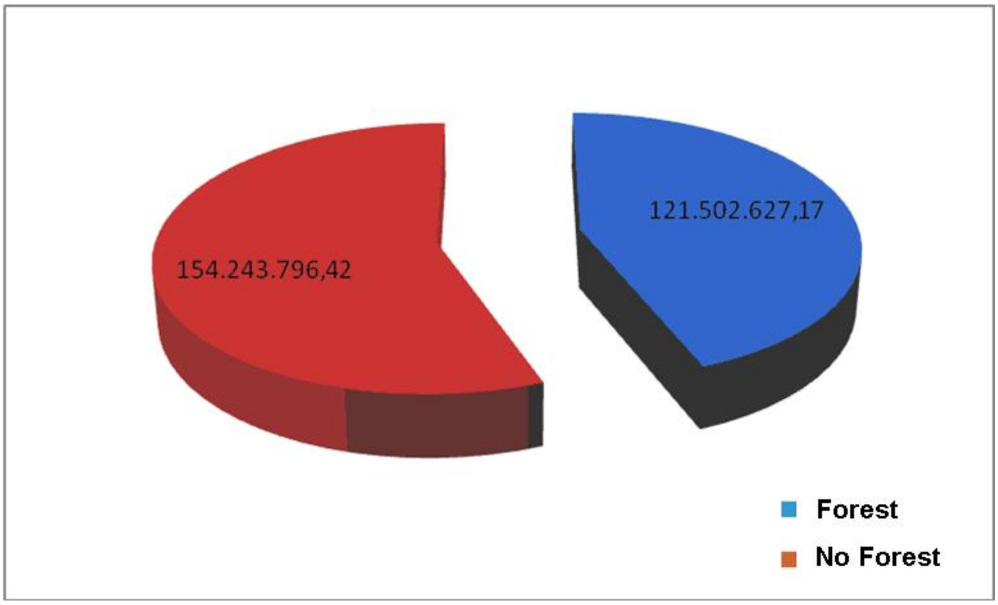

Figure 4 - Emissions generated by deforestation caused by soybean expansion in Mato Grosso between 2000-2002

Source: Elaboration by the author.

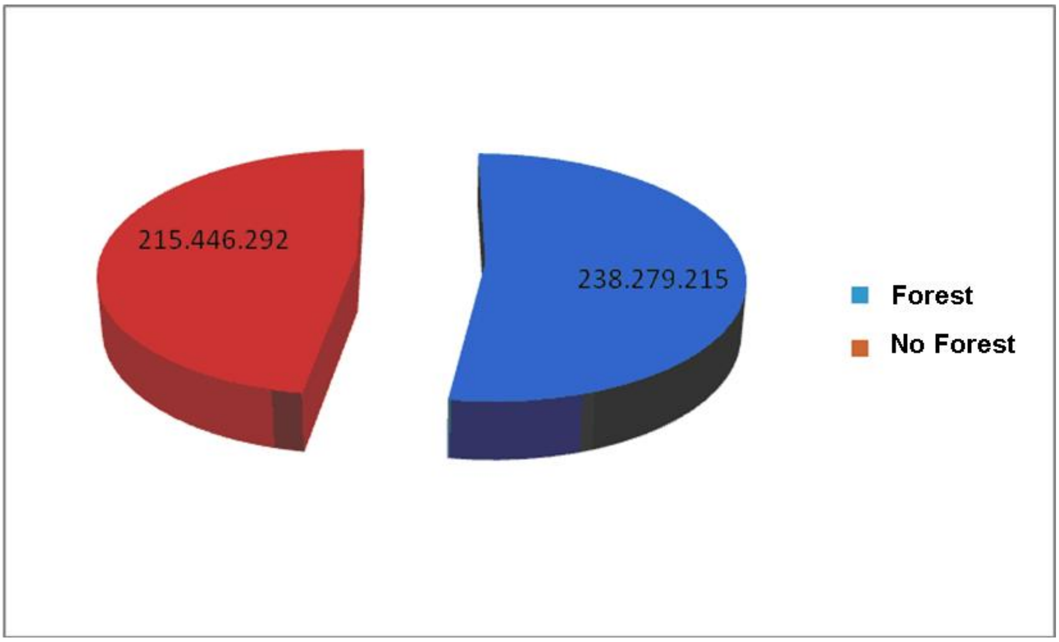

Figure 5 - Emissions generated by deforestation caused by soybean Expansion in Mato Grosso between 2003-2005

Source: Elaboration by the author.

It is noted that the emissions were measured in tons of carbon per hectare. For the first scenario, the deforestation in forest areas represent 44% while the deforestation from non-forest areas are of 56%. However, for the second scenario, the proportions are 53% due to areas of forest and of 47% for those of the cerrado. This is due to the fact that the deforestation augmented relatively more in areas of forest.

To estimate the value of the carbon ton associated to deforestation the following calculus was made: the deforested forest area and the non-forest area (in hectares) was multiplied by the land profitability (mil USD/ha.) for each municipality. The result can be verified on graphics 6 and 7 below.

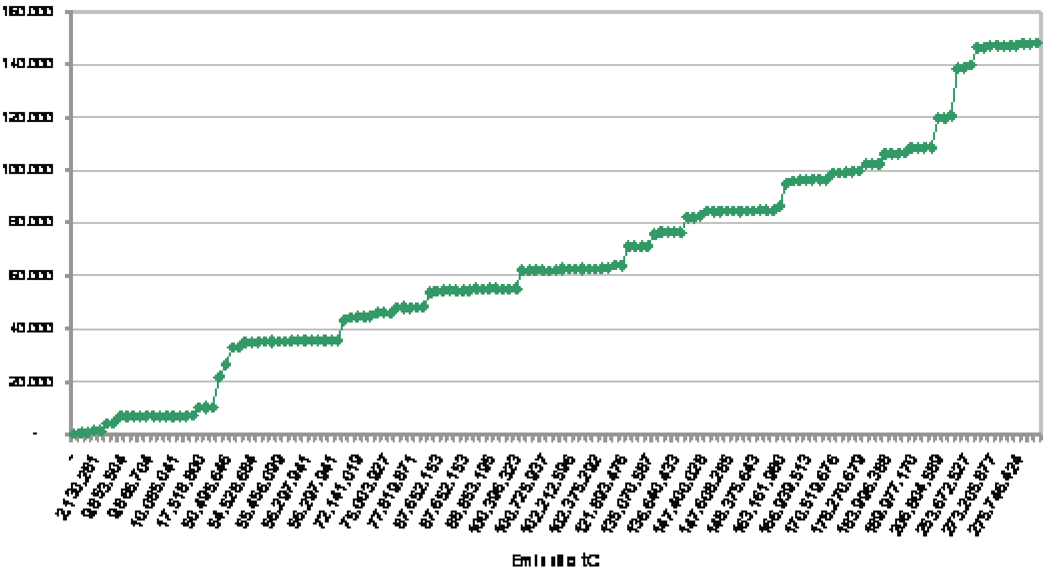

Figure 6 - Accumulated cost of emissions reduction/deforestation 2000-2002 Accumulated cost (milUS%) for 2000-2002

Source: Elaboration by the author.

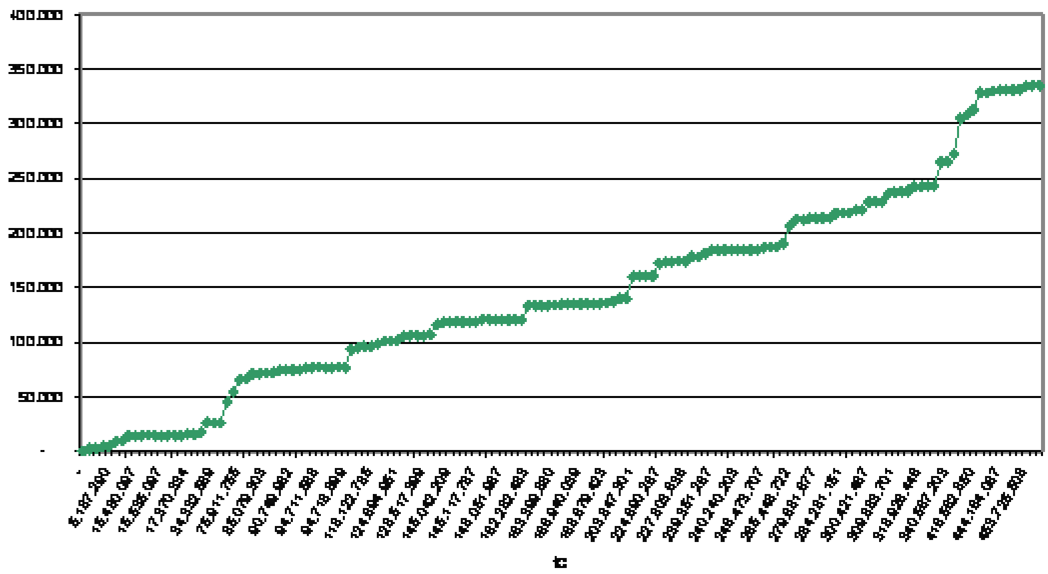

Figure 7 - Accumulated cost or emissions reduction/ deforestation 2003-2005
Accumulated cost (mil US$) for 2003-2005

Source: Elaboration by the author.

The graphics above show how much, hypothetically, it would be necessary to disburse to reduce the emissions of deforestation, considering the profitability of land and the place where the deforestation occurs, either in forest or in cerrado.

It was supposed that a greater value of expenditures would be necessary for the second analyzed period than for the 2000-2002 period, since the profitability of soybean and the deforestation grew between 2000 and 2005.

These information are crucial, since they show that as more time elapses, the more expensive will the cost to halt deforestation be, and that as sooner it will be managed and strategic policies be adopted, the cheaper and more efficient it will be to halt the current consequences of the agricultural frontier advance.

Last, for a more detailed analysis on how much will finally cost the emission associated to soybean cultivation, the accumulated cost was divided by accumulated emission, and the valuation of the annual cost to be paid to the landowners was calculated in US$tC, which would induce the non-deforestation (or else, avoid the emission). For the 2000-2002 period, the carbon ton originated from deforestation in forest areas would cost, in average, US$ 0,33/year, while the carbon ton from non forest areas would stay around US$ 0,70/year. For the 2203-

2005 period these values were US$ 0,49/year and US$ 0,97/year, respectively. The cost for reducing a ton of carbon in the cerrado is always higher because, further than a higher average profitability the carbon density is minor than that obtained in forest areas.

To make a current valuation estimative, these values were perpetuated by a discount rate (10% a.a.a.), reaching the following values for the carbon ton (CO) and carbon dioxide (CO_2):

Table 1 - Medium values for Carbon in US$

	2000-2002		2003-2005	
	Forest	Non Forest	Forest	Non forest
tC	3,38	7.03	4,89	9.81
tCO_2	0,92	1.92	1,33	2,68

OBS: 1 tC= 44/14 tCO_2

These estimated values are today below the negotiated prices in the main carbon markets, showing the financial viability of the proposed strategy. Particularly, the reduction of emissions in forest areas is considerably cheaper than the great majority of the available alternative emissions mitigation.

CONCLUSION

The Amazon reality demands positive incentives to rural landowners, better than the traditional command and control instruments applied in solving the problem of deforestation. In this sense, the payment for environmental services may exert an important role - the benefit that can be generated in terms of avoided carbon emissions corresponds to a significant financial amount, nonetheless it should be added to public resources, at a relatively low cost, if compared to other options for mitigation of emissions.

The elements above show that it is possible to elaborate a strategy to fund actions turned to reduction of deforestation owing to a combination of public and private resources. Private resources, in special from external sources, may be obtained via procedures in environment service markets. The most evident example is the constitution of Carbon Credit Markets, however also procedures for reduction of deforestation may offer a significant contribution for the decrease of carbon emissions at a significantly lower cost than the average of international credit markets, already operating. It is possible to halt deforestation in strategic regions at a cheaper cost, particularly if the less rentable areas are selected.

An issue that still remains to be considered is to know how and for how much time the payment should be available to the landowner. These issues are being detailed in specific studies, but the absence of precise results should not be used as justification for non-action. The false antagonism between the command and control approaches and use of economic instruments should also be avoided: the ideal way is the combination of the two types of instrument, command and control and PES, with the possibility of increasing both the efficiency (cost/hectare relation of kept forest) and efficacy (effectively kept area).

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ADAPTATION

SOCIAL "DOWNSCALING". A FEW REFLECTIONS ON ADAPTATION IN URBAN ENVIRONMENTS

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ABSTRACT

The study and analysis of the needs of prevention, mitigation and adaptation and their international guidelines still need a downscalling regarding the social aspects, especially in those countries where social and institutional vulnerability are elevated. Social downscalling refers to global social, economic, political and cultural processes registered in specific territories, in which the socio-cultural production and development space is constructed, with particular configurations and in situations of uncertainty. The results of numerous international studies, like for example the last summits of the Climate Change Convention and the meetings of the Subsidiary Organisms that deal with scientific-technological and implementation aspects, show that the adaptation problem is taking on an increasingly higher significance. The consolidation of the scientific knowledge on the causal relation between the atmospheric physical factors and their effects on the Metropolitan Area of Buenos Aires (CABA) and, especially, on a city like Buenos Aires, is a line of work that brings judgment elements into vulnerability reduction and its relation to uncertainty diminution. With regard to CABA, the expert knowledge has clearly identified the elements of direct hazardness resulting from the climate dynamics, such as: changes in the wind pattern, increase of the precipitations and severe storms, changes in the average temperature, increase of the sea level and higher intensity and permanence of the climate extremes. The creation of a Climate Protection and Power Efficiency Office within the Department of Environment of the City of Buenos Aires (JULY, 2007) can be read as an adaptive-institutional fact that intends to approach the complexity of the phenomenon focusing on the issue of GHG mitigation and the vulnerability of the power supply sector of the city. There is a combination of several adaptive types of the ones defined by the IPCC in CABA’s case: Autonomous - Public - Reactive. When examining the institutional and technical vulnerability associated to the adaptation forms, it was clear that the low understanding of the issue in terms of complexity was an irremediable and hardly viable obstacle to generate some program of integral and sustainable action. It will be thus necessary to look for other approaches, perhaps more qualitative, that may allow to know how individual

and group subjects make decisions and it will be necessary to foster the opening of political integrated spaces that should “adapt” to the complexity of the phenomenon.

> *“... le présent n'est rien par lui-même ; ce n'est que le prolongement du passé dont il ne peut être séparé sans perdre en grande partie toute sa signification. Le présent est formé d'innombrables éléments, si étroitement enchevêtrés les uns dans les autres qu'il nous est malaisé d'apercevoir où l'un commence, où l'autre finit, ce qu'est chacun d'eux et quels sont leurs rapports; nous n'en avons donc par l'observation immédiate qu'une impression trouble et confuse. Émile Durkheim (1904-1905), L’évolution pédagogique en France, pp 21, 22”*

Keywords: Adaptation to climate change, Vulnerability, Buenos Aires.

INTRODUCTION

When the scientific community, especially its sectors related to exact and natural sciences, refers to the need to adapt to the effects of climate change, it expresses the globalized concern about the western rational human development, from which it sends an international call to face and protect themselves from the negative effects of climate change. The appeal takes place within the framework of conventions and agreements such as the Montreal and Kyoto Protocols so that institutional mitigation measures can be implemented against greenhouse gas emissions (GHG) and so that adaptation measures may be put forward and implemented toward the imminence of a global climate change that is considered to have a 95% probability “to be permanent” (IPCC, 2001; 2007). This suggests a world-wide strong impact on the development conditions and demands the involvement of the different social sectors to face it and diminish its negative results for mankind.

One of the discussions about climate change is focused on the question of the historical responsibilities when the hastening of the changes in the conditions of the climate system began. These historical changes are part of the material base of the social and economic model that, globalized, keeps being the mark of the historical present whose continuity is debated. This way, even though the leading actors are the representatives of the central countries, the global networks involve the rest of the countries in the distribution of the risks derived from the issue. Thus, those countries integrated in the market and the above mentioned issue as partners within the GHG reduction endeavor rise as subsidiary actors and associates in the discussion.

This process began with the early warning given by science, and the commitment of political sectors and environmentalist groups. Nevertheless the consequence of unified criteria on origins and results about causes and effects, presents and futures, submitted to an explanation dominated by exact and natural science as well as by the market economy concerns, exposes not a less intense of a contradiction. The discussion is thus no longer focused on the doubt regarding current and future results (the questionings, if anything, have imposed the adjustment of the forms to communicate these results). A double relation is uncovered: of subordination to expert knowledge, and of opposition or resistance toward the exigency of the very situation (imminence of the effects of climate change) to assume responsibilities, to generate directives and, based on them, to make decisions.

The expert knowledge on the climate change issue has been acquiring a very solid base regarding what will come. But we should be concerned about the emphasis on the adaptive conducts of the society or “man”, (in terms of the studies and specific reports such as IPCC’s) that, by being defined in an abstract way, are so general that they get far from reality and from the possibility of proposing and applying concrete, specific measures, of social change.

If we take into account that it is in local societies where the effects of climate change, the production modes and the repercussions of the market's dynamics are territorialized, the man, as a social subject, is his own reality's maker. In this context it is thus set out the need to do a social downscaling that may allow us to leave behind the idea of a man who is involved but does not really participate, and that may pay attention to the subjects' forms of involvement within and among the diverse sectors exposed to the climate system's unpredictable factors.

In this sense, the implicit conception in the appeal "to adapt" to climate dynamics is insufficient when the problem is supposed to require a frame of total participation. One of the starting points to modify this inertia regarding the human dimension reflected in studies and recommendations that refer to the mentioned problem is to review the adaptation definitions conceptually. Considering "man" as the "trustee of the consequences" of the different kinds of environmental hazards derived from climate change is a partial approach that takes away from the members of the society - each society - their quality of "active subjects" and constructors of their own life conditions and events, as well as of the "hazards" that come from the public policies that are implemented pretending to reduce diverse vulnerabilities. Conversely, we define adaptation as a creative action process where the man-as-subject gets reflexively integrated with reality, which he constructs and transforms[1], thus contributing to a development model that at the same time helps to construct.

"SOCIAL DOWNSCALLING" AND ADAPTATION

The study and analysis of the needs of prevention, mitigation and adaptation - regarding catastrophes due to the impact of a probable climate change - and their international guidelines still need an important itemization work or, paraphrasing the climatologists, a downscalling regarding the social aspects, especially in those countries where social vulnerability, including the institutional one, is elevated.

Social downscalling refers to global social, economic, political and cultural processes registered in specific territories, in which the socio-cultural production and development space is constructed, with particular configurations and in situations of uncertainty. These processes acquire meaning in relation to climate

1 Freire, P. **Pedagogía del Oprimido,** Editorial Siglo Veintiuno, México 1999.

change from a social base theory, used for the analysis of risk situations, the dimensions[2] of which are synthesized as follows: hazardness, vulnerability, exposure and uncertainty. Within this scheme, adaptation –set out as in inverse relation to social vulnerability- can be considered as the specific action carried out within uncertainty frameworks to overcome specific risk levels. The [so called "adaptation"] action or actions are here the core element that may or would allow reducing the present or future vulnerability to viably sustain the dynamics of the social system and that of its relation with the environment.

The results of numerous international studies, like for example the last summits of the Climate Change Convention and the meetings of the Subsidiary Organisms that deal with scientific-technological and implementation aspects, show that the adaptation problem is taking on an increasingly higher significance. Against the inevitability of climate change, the option is to get fit, to adapt to its effects. It is therefore set out the need to act anticipatedly so that the impacts may be the lowest possible, or in order to even take advantage of the resulting conditions, as long as they are not adverse.

Nevertheless the proposal to apply the notion of "adaptation" in the analysis and, particularly, in the decision making, suffers from some vagueness. As an example, let's take a look at the IPCC's definition:

> *Adaptation*
> ***Adjustment** in natural or human systems **in response to** actual or expected climatic **stimuli** or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation (In Glossary; the authors' emphasis. IPCC, 2001; 2007).*

2 Natenzon, C., 1995. "Catástrofes naturales, riesgo e incertidumbre". FLACSO, Buenos Aires. Serie Documentos e Informes de Investigación N° 197. Meconi, Murgida, Natenzon y González 2005. "Participación ciudadana, planes ambientales y desarrollo local. Ejemplo de una comunidad bonaerense". www.filo.uba.ar/contenidos/investigacion/institutos/geografia/pirna/home.htm

It may be observed that this definition takes the natural and anthropic forcing factors as outputs that are part of the total socio-environmental system. Nevertheless, by making a distinction between the different types of adaptation[3], it introduces **aspects inherent** to the dynamics, the characteristics and internal elements of the social system, but only in a biased way: it is either about a generic actor (the society, the human system, the public, the individual) or only some actors of the society are taken into account, that is those related to the decision making process that involves the governments and private agents related to the market economy. Hence, in this definition, the main actor of the adaptation that refers to human systems would seem to be the group of decision makers that actively participate in private spaces and/or that count on economic and legitimate means to impose changes by their authority.

Then if the notion of adaptation, related to the notion of change, is brought into the equation to face future events, it is essential to take into account not only the general dynamics, but also the specific elements of each society along with the keys of the socio-cultural processes that guide the institutional practices at different scales: local, national, regional and global ones.

The socio-cultural processes have the distinguishing characteristic of being under permanent development, with important internal and external qualitative changes. Among the process's components are those referred to the subjectivity that lies in the material and conceptual construction of "space", "time" and "identity"[4], where the individuals act, on their own and grouped, from different (economic, cultural, intellectual, social) positions. The space-time sense of

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- Anticipatory adaptation – Adaptation that takes place before impacts of *climate change* are observed. Also referred to as proactive adaptation.

- Autonomous adaptation – Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or *welfare* changes in *human systems*. Also referred to as spontaneous adaptation.

-Planned adaptation – Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

-Private adaptation - Adaptation that is started out and implemented by individuals, owners or private companies. It is usually achieved in the actors' own rational interests.

-Public adaptation – Adaptation started out and implemented by governments at all levels. It usually addresses public needs.

-Reactive adaptation – Adaptation implemented after the impacts of climate change have already been observed. (IPCC 2001 p. 252, and 2007).

4 Identity is a social construction that is historically generated through facts and processes, within the social frameworks that determine performing agents' position. In this respect, subjects orient their representations and choices through a network of ties created as forms of perception or symbolization of the social experience key aspects (Daniel Mato, 1999; Pierre Bourdieu and Löic Wacquant 1995 ; Claudia Briones, 1988 ; Maura Penna, 1993).

belonging and the particular forms of acting, knowing and perceiving reality are reflected in the different shapes taken by the social organization (adaptation being thus included) which give identity to development.

"Organization, understood as a particular set of interrelations, is the base for the continuity of the social system and its channels of circulation of flows of interchange between social groups, and between these and environment […]" (PIAGET, 1985, p.137) whereas adaptation would be (in biological terms) the condition that enables life in an environment. In this theoretical scheme, societies reach adaptation through the plasticity of their reflective capacity. The search for synthesis-balance is inserted in a constant and dynamic dialectic reality process. Anticipation would be one of the required elements to adapt to a diversity of events that can produce deep changes in the organization, which entails new complexification (PIAGET, 1985).

The forms in which relations are organized generate, as well, forms of adaptation to internal and external changes. These forms have a double quality: they both allow and restrict the possibilities of adaptation according to the characteristic features that are dominant in the development dynamics of the society at issue. In this sense, the inclusion of the issue in political agendas requires taking into account the (past) social experience and its (present) conscious perception of each group's inherent possibilities. Integrating heterogeneous actors and interests with their concrete interrelations fosters (future) possibilities of adaptation and vulnerability reduction.

Hence, social perception is part of social ability: ability to do, ability to adapt, ability to change. This "social ability" does not recognize a single path. It is historically distinguished and crystallized in the forms of daily relationships, in the spaces of communicative interaction to take part in the socio-natural world, and in the ways to understand political-economic experiences and structures (ALTHABE, 1998; HIDALGO, 2006). The very definition of "social ability" refers to the very social relationship that allows individuals to identify and access -or demand access to- resources, as well as to determine those resources qualitatively and quantitatively.

Now, if we focus on behaviors derived from repeated interactions between the elements of a system (the social one) as a whole, in relation to other systems (other totalities) of another kind, in this case mainly the interactions between the climate system and a specific case of an urban system (the City of Buenos Aires – hereinafter called *CABA,* standing for *Ciudad Autónoma de Buenos Aires* in Spanish) we can see that the reading of the definitions that ultimately intend to create political agendas depends on particular elements of specific situations, and taking those into account can help create anticipatory processes that may forecast events related to the climate dynamics.

ADAPTATION AND VULNERABILITY IN AN URBAN CASE: BUENOS AIRES

The consolidation of the scientific knowledge on the causal relation between the atmospheric physical factors and their effects on the Metropolitan Area of Buenos Aires – AMBA, in Spanish- and, especially, on a city like Buenos Aires, is a line of work that brings judgment elements into vulnerability reduction and its relation to uncertainty diminution.

With regard to CABA, the expert knowledge has clearly identified the elements of direct hazardness resulting from the climate dynamics (AIACC, Second National Communications)[5]:

- changes in the wind pattern;
- increase of the precipitations and severe storms;
- changes in the average temperature;
- increase of the sea level;
- higher intensity and permanence of the climate extremes.

There may also be noticed indirect impacts related to the direct ones, and at the same time to the use of the city and its hydric resources:

- changes in the phreatic layer's dynamics;
- changes in the flow rate of rivers and tributary streams;
- changes in the shore line;
- more frequent floods.

The way these direct and indirect impacts relate to CABA's infrastructure implies more precise details that we could consider they are closer to the social downscalling:

5 Barros, V.; Menendez, A.; G. Nagy Eds. El Cambio Climático en el Río de la Plata. 2005. Natenzon, Marlenko, Gonzalez, Ríos, Barrenechea, Murgida, Boudin, Gentile, Ludueña.. "Vulnerabilidad social estructural", "Impactos económicos y sociales por inundaciones"; "Instituciones, cultura y adaptación" in El Cambio Climático en el Río de La Plata. CIMA- CONICET-UBA-AIACC. Second National Communications – Argentina 2006: "Región Costera del Río de La Plata" Coordinator in charge: Ángel Menéndez.

- Increase in the frequency and intensity of the strong southeasterly wind storms, in the southern area;
- Increase in the frequency and intensity of the torrential rain storms, in the central and northern areas of the city;
- Vulnerability/ exposure of the electrical system;
- Vulnerability/ exposure of the power production;
- Vulnerability/ exposure of the urban drainage.

Getting deeper into this increasingly detailed analysis, among the social processes that have to do with the creation of the population and exposed areas' vulnerability, and the increase of hazards, we can point out the following:

- the power stations are located in the coastal area of the city;
- the power generation depends on non renewable sources;
- the programmed and in process technology for the pumping system under conditions of river level rise must be revised in accordance with the results of the studies on climate change which ere apparently not taken into account when this technology was planned[6];
- over time, the population increased in density, even though, in statistical terms, over the past decades this process has shown stability indicators the city as a whole (population national census 1991/ 2001);
- the social groups of lower resources settled in precarious settlements within the urban scenario over the past years have grown, and as a result they reached a high demographic density, which at the same time is mixed with environmental pollution of different kinds;
- there has also been an increase in collective housing complexes (that comprises not only the social ones, but also the construction of "horizontal property" houses for high income economic sectors);
- the city is showing a negative correlation between the construction surface and the green outdoors;

6 (http://www.buenosaires.gov.ar/ Climate Protection And Power Efficiency Office – in spanish, *Oficina De Protección Climática Y Eficiencia Energética*. GCABA, 2007)

- the insufficiency of green outdoors does not allow temperature to decrease and hinders the in situ rain water retention capacity.

These independent variables show a deficient set of adaptive responses. They derive from the vulnerability in the institutional management of the city, where the basic groups of governmental social actors approach specific situations in a political-technocratic way. In such situations, the involvement of other actors such as the non governmental actors, the mixed ones and the civil society, intervenes in the definition of the decision making from a narrower angle of participation. That is done through commissions that have a voice but whose incidence in the decision making is subject to officials' deliberation.

VULNERABILITIES EMERGING FROM THE MARKET

The case of the private intervention on the territory is interesting. Mainly since the 2001 crisis, there has been an intensive construction of buildings in hierarchized and densely populated areas. In the terms defined by the IPCC, it is an autonomous or spontaneous adaptation, mainly caused by changes in the market. As the possibility of urban space consumption rises, real estate supply is generated. This consumption is related to values of middle and middle-high social sectors, which give priority to location factors such as the distance to poverty nuclei, or to the existence of public transportation means that make traffic easier, such as the subway[7]. The strong economic deregulation, combined with the excessive weakening of the State's social functions during the nineties generated dragging processes that have been projected in the use and distribution of the territory both in the city and in its metropolitan area, where the processes of "getaway" towards the periphery were complemented, after the model's crisis, with a return of the middle and middle-high sectors and that accepted the renewal of the real estate supply in the city (cf. M.Svampa)[8]. This way the demographic density of some specific areas of the city has been raised, thus increasing both the vulnerability of the population formerly settled and that of the new inhabitants.[9]

7 Cf. Girola, M. F., M. Lacarrieu y A. M. Murgida 2004 Usos de la naturaleza y experiencias de lo barrial en urbanizaciones cerradas del Gran Buenos Aires. Etnia 46-47: 169-186, Prévôt Schapira, M. F. 2002 *Buenos Aires en los años '90: metropolización y desigualdades*. EURE 28(85): 31-50.

8 M.SVAMPA. **La sociedad excluyente:** Argentina bajo el signo del neoliberalismo. Buenos Aires: Taurus.

9 Center for the Metropolitan Economic Development Studies of the Department of Production, GCABA, City General Audit 2004.2007, GCABA, http://www.buenosaires.gov.ar/, http://www.caballitocolapsa.blogspot.com, http://www.protocomunacaballito.blogspot.com.

The complexity of the situation does not have a single cause when it comes to talking about risk. The issue related to the direct effects of the climate dynamics is enhanced with the private adaptation as an initiative and implementation by individuals and companies guided by market interests.

In that case, the lack of a planned intervention of the government to regulate construction is associated to the issues of the increase in the frequency and intensity of torrential storms, the change in the flow rate of the rivers and tributary streams, the technology applied in situations of river level rise, and the consequent modifications in the dynamics of the phreatic layer. The result is the risk increment for the population exposed to recurrent hazard situations of power supplying due to the tendency to use electrical heating and refrigeration systems (SECOND NATIONAL COMMUNICATIONS ON CLIMATIC CHANGE, 2006), etc. The population's need to get responses from the government has thus been increased.

Finally, the response of the city's authorities, when there is an echo to the complaints, turns into a public, reactive and specific adaptation to observed situations, in some cases recurrent and now related both directly and indirectly to the climate dynamics.

VULNERABILITY EMERGING FROM PUBLIC POLICIES

Another case of public adaptation, started out by the government, refers to *housing plans for underprivileged population*. The location of these works does not take into account neither the flood and waterlogging scenarios related to climate change and variability, nor the flood and waterlogging recurrence maps f the city. These forms of intervention on the territory show the fragmentation within the management policies, which, due to the lack of an integrated vision between the different sectors, may consequently generate maladaptation, as well as a risk increment and new aspects of vulnerability.

VULNERABILITY EMERGING FROM THE INSTITUTIONAL FUNCTIONING

The patterns internalized in the management scopes and the ways of communicating and informing have their starting point and circulation channel in the thematic fragmentation as well as in the different political loyalty groups. When generating concrete actions, all this can add up to an obstacle or an advantage, depending on the technicians' interpretation and the interest produced among the political decision makers. Unfortunately, the rivalry attitudes lead to disinformation and atomization in areas of intervention and specific functions, which should actually articulately work together to attend to issues in which the present context and the past are part of the forecasts.

The magnitude of the effects does not have a linear relation with the causes; rather, the direct and indirect impacts are recombined configuring complex situations that require, in systemic terms, that the measures proposed by a sector be correlated to the impact on the others. In order to reach an intersectorial participation it is necessary that one tool of the process be the reflexivity to detect and control the multiple aspects that are at stake within and between the groups of actors involved.

Thus, for example, the creation of a Climate Protection and Power Efficiency Office within the Department of Environment of the City of Buenos Aires (JULY, 2007), can be read as an adaptive-institutional fact that intends to approach the complexity of the phenomenon focusing on the issue of GHG mitigation and the vulnerability of the power supply sector of the city. This office, which is decentralized and reports directly to the Department of Environment, could have escaped to the political-personal relation logic. Nevertheless, it did not mke it.

A combination of traditional politics and environmentalist NGOs' exercise privileged atomization, and hindered the development of technical contributions that may have generated a work integrated with other institutional sectors.

What follows is a detailed example of the results that this frame had in the institutional practices: the office's management considered that the task of compiling information outside its limits constituted an excess due to the lack of knowledge about the filiation of those who managed other areas of the same department, or of other departments, and they even doubted to contact a few personalities of the civil society who had constituted themselves in an interdisciplinary and inter-sectoral advisory group. The latter was a mixed social actor that enhanced the participation of another actor, the civil society (scientific academy, mass media, consultancy firms, companies, political parties, neighborhood organizations, social and neighborhood movements, etc.), since its members had diverse memberships to the socio-political party space.

The regulations and resolutions issued by this management were rooted in a scheme of perception, evaluation and action within the force field of the traditional politics that made no interpretation of the political needs risen within the department nor of the recommendations contained in the most recent studies on vulnerabilities of the different sectors to the climate dynamics in AMBA and particularly in CABA.

Although the office showed a quite marginal position regarding the distribution of resources, it had the academic media's recongition, which was too much of an outstanding privilege position to generate actions. The final political involvement resulted in a work that was fragmented as well, where the traditional patterns derived in a failed attempt of adaptation for a potentially positive project.

Among the elements that make the institutional dimension vulnerable, are preexisting patterns that did not collaborate with a diagnosis and a praxis in accordance with those required by the complexity of the matter at issue. What prevailed then? A structure of clientelistic political relations that included the traditional policy makers and others that came from ecologist groups. This combination, far from making the application of techniques that combined diagnosis with action-intervention easier, turned out to be a barrier that prioritized fears derived from personal political debts over the possibility to take advantage of the institutional channels in order to integrate the diagnosis interinstitutionally and thus to optimize the necessary actions for “completing adaptation”.

ANALYSIS AND CONTRIBUTIONS FOR THE DEBATE

Urban centers, such as the case shown herein, are an arduous phenomenon to analyze and understand. The people who inhabit them participate in their construction with their practices and representations, through interdependent micro-systems that convey interests structured in particular categories such as, for example: districts, financial networks, basic services, migratory movements, public and private activity centers, at different legal and administrative levels.

Behind the values and explanations of the results obtained in the diagnosis on social vulnerability, are the representations, beliefs, the ideology that legitimize a way of living, producing and perceivinmg the city. Behind the risk definition there is some knowledge on the threats combined with the subjects’ decision making about what it is wanted to be preserved and, if necessary to adapt, who can and must do it, why, how and in how fast.

Thus, the processes related to the issue of a probable climate change that we have pointed out for our case study, can be synthesized in: current floods and increase in their amount and permanence in the future, temperature rise and consequent increase in both diseases and power consumption, increase in the population’s density, part of which starts within the high income sectors with the consequent pressure on services and issuing increase, and within low income sectors in spaces of uncontrolled growth in areas with pollution and insufficiency of basic services issues.

Against all that, and according to what was argued at the beginning of this text, there is not just one sole way to conceive adaptation. Consequently, there is not just one sole way to adapt. If we address these issues considering a "universal man", there will be a series of postulates that all must comply with, without discriminating differential situations of vulnerability (social vulnerability = situation previous to the occurrence of an accident or a catastrophe or a crisis, of each social group, which sets it up to face, more or less successfully, the negative impacts and, after the event, to count on capacities to recover, according to Lavell, Herzer and other authors of La RED).

In this approach, an adaptive proposal may be that of a decrease in the power consumption. Now, how can we reach that reduction?

From a functionalist point of view, which supposes a reactive conduct of the man as species, there are general and economic actions such as penalties, through an increase in fees if the current consumption exceeds the previous one[10]. Another possibility is to hope that, by means of informative bombardment in crisis situations, the immediate answer will be to tend to reduce consumption. None of these two measures has proven to be successful in CABA. So far, there have been factors not taken into account, such as the physical necessity and the economic possibility to own technologies that compensate the uncomfortable temperatures, aspects that do take into account a different vision on adaptation, one that is more realted to the development models and the political and cultural practices of each society.

The adaptation measures that are usually proposed go against the market processes that lead to major consumption, both of power and of urban spaces. For example, against the present floods and their possible future increase there have been considered works such as the Hydraulic Plan, that aspires to operate in the twelve water courses that cross the City of Buenos Aires. But at the same time, there are other processes (for example, of financial and real estate nature) that are a lot faster and more dynamic, that operate against some adaptive measures: the occupation of highly profitable urban ground, the increase in the population's density through the construction of tower buildings and the diminution of the surface dedicated to green areas.

10 *Adaptation* refers here to any measures that protects […] countries against the impacts of climate change. *Mitigation*, by contrast, refers to the reduction of greenhouse gas emissions. World Bank Global Climate Change Team. 2004 A sample of the emerging World Bank work in climate change adaptation. Ajay Mathur, Ian Burton and Maarten van Aalst, eds. Part 1. pp. 23

If we observe the relation between adaptation and institutional management in CABA's case, there is a combination of several adaptive types of the ones defined by the IPCC: Autonomous - Public - Reactive. When examining the institutional and technical vulnerability associated to the adaptation forms, it was clear that the low understanding of the issue in terms of complexity was an irremediable and hardly viable obstacle to generate some program of integral and sustainable action.

Set out like this, the issuet would seem an impasse. It will be thus necessary to look for other approaches, perhaps more qualitative, taht may allow to know how individual and group subjects make decisions. And in that line of work, it will be necessary to foster the opening of political integrated spaces that should "adapt" to the complexity of the phenomenon. The contribution which we were working at intends to reach that, focusing on the relation between the microsocial and macrosocial perspectives.

The elaboration of a cualitative-quantitative social downscalling is the base for a serious reflection about potentially viable lines of political management in terms of being aware of the existing capacities, the sectorial and socioeconomic interests at stake, the needs and perceptions of the elements that constitute the social construction of climate change and the adaptation forms.

An additional basic supposition indicates that the process of creation of interphases between scientific issues and society will allow an effective and significant participation of the civil society in public issues, including sustainable development and planning. This implies not only to open spaces, but also to have those spaces reassure that the processes are inclusive and legitimate in order to promote the interchange and construction of knowledge meant to create policies, within the framework of a political-institutional agenda.

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URBAN CLIMATE IN CLIMATE CHANGE

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ABSTRACT

Climate change currently represents one of the most contradictory approaches into the scientific realm because there are no conclusive decisions on the degree of participation of elements responsible for global changes even with all our present day technological advances. However, such climate changes have already been proven on a local scale as they stem from the urbanization process (human activities), forming the specific micro climates.

The objective of this paper is thus to discuss how the city is responsible for generating an urban climate and to analyze its influences in the context of climate change, inflected as a contribution to some observations that involve such themes.

In areas where cities are built, atmospheric conditions influence the urban environment built by humans, and consequently alters the energy flow by concentrating pollutants and solid particles in suspension. This land area and urbanization delimit the urban climate.

Keywords: Urban climate, Climate change, Micro climates.

THE CITY AND THE CLIMATE

Important studies about the city and climate[1] agree that it acts as an important modifying factor of regional climate and creates specific conditions in the atmosphere defined as urban climate. The constructions, types of materials, street layout, vehicle circulation, industries and human activities are the most responsible for these specificities.

Transformations in the landscape that result from urbanization alter the balance of energy and the urban water balance and these transformations are caused through the removal of original vegetation; by the increase in vehicle and people circulation; by the generalized impermeability of the ground; by the changes in relief through landfills and canalization of rivers and creeks; by the concentration of buildings; by urban vertical; by the installation of urban equipment (parks, squares, buildings, industrial and residential areas, etc.); as well as the emission of particles and pollutant gases into the atmosphere.

These new geo-ecological and urban characteristics modify the climate's elements, responding through the urban climate to climate controls and attributes.

Therefore the city generates its own climate, which stems from the interference of all those factors that are processed over the limiting urban layer and act in the sense of changing the climate on a local scale. Its most direct effects are perceived by the population through manifestations linked to thermal comfort, air quality, pluvial impacts and others that are capable of organizing city life and deteriorating the quality of life of its inhabitants (MONTEIRO, 1976, p. 122).

Natural materials, replaced by urban ones, result in soil impermeability, and furthermore, the closed canalization of streams increase surface runoff. These are the most responsible factors for urban flooding, so common at the bottom of valleys in these environments. Thus, in most cases, one cannot attribute, especially in small and mid-sized cities, the impacts that stem from floods and inundations on the increase or concentration of total precipitation, but rather on impermeability and improper use and occupation of urban soil.

Islands of heat have been another phenomenon detected in urban environments. They result from the formation of pockets of hot air that stem from the different capacities of materials found on the surface to store and reflect solar energy.

1 The studies that stand out include: Bryson & Ross, 1972; Chandler, 1965; Landsberg, 1981; Lowry, 1977; Monteiro, 1976; Oke, 1978.

According to Oke (1978), the most significant characteristic of the heat island is its intensity, understood as the difference between the maximum urban temperature and the minimum rural temperature.

This characteristic is related to the factors that contribute to the formation of the heat island, including the natural ones (the synoptic situation, relief and presence of surfaces with vegetation and/or water) and the urban ones (urban morphology and anthropogenic activities).

Anthropogenic activities like vehicle traffic and, in tropical cities, the use of air conditioning, are great energy consumers, generating heat in the city. This warmth, inflicted over urban materials, which are heated during the day due to solar radiation, and retained between buildings by the multiple reflections between them, reducing the interface with the atmosphere. Reduced green areas and soil impermeability in urban areas also contribute toward the intensification of the heat island since there is a reduction in the vapor-transpiration process and thus not cooling the city by means of evaporation (PINHO, 2000).

Roofs are also responsible for the heat produced inside as well as outside the buildings. This heat is determined by the albedo variables and material emissivity. The albedo represents the fraction of incident solar radiation reflected by the material, whereas emissivity determines the thermal performance, characterized by surface temperature.

Thus, surfaces with high albedo and emissivity tend to remain colder when exposed to solar radiation because they absorb less radiation and emit more thermal radiation to space, transmitting less heat to its environment. On the other hand, the lower the albedo and emissivity, higher will be the heat absorption and its permanence in the surrounding environment (FERREIRA; PRADO, 2003).

In tropical cities, several types of construction materials have been used in buildings, such as ceramic, fibrocement and metallic (aluminum, zinc and galvanized steel) tiles.

As a result of their physical properties (specific heat), roofing materials have very different thermal responses, some of which are responsible for the intensification of surface temperatures, as observed in Table 1.

Table 1 - Surface temperature of materials (ASTM E 1980-98)[2]

Material	Albedo (a)	Emissivity (e)	Surface Temperature (°C)	Temperature difference between air and the material
Red tile	0,53	0,9	36,8	- 0,1
White tile	0,54	0,9	36,2	- 0,6
Fibrocement	0,34	0,9	47,1	10,3
Unpainted aluminum	0,57	0,05	69,4	32,6
Aluminum in light colors	0,40 – 0,47	0,9	40,1 – 43,3	from 3.2 to 6.5
Aluminum in dark colors	0,26 – 0,38	0,9	45,0 – 51,4	from 8.1 to 14.5
Unpainted galvanized steel	0,57	0,25	57,9	21,1

Source: Ferreira; Prado, 2003.

The urbanization process alters the surface radiation balance due to the replacement of natural materials by urban materials. Tables 2 and 3, organized by Oke (1978), show the radiation properties of urban and rural materials that prove the changes in radiation absorption, diffusion and reflection processes, suffered by the atmosphere, which entails in local changes.

Table 2 - Radiative properties of typical urban materials and areas

SURFACE		ALBEDO	EMISSIVITY
1. Roads asphalt		0.05 – 0.20	0.95
2. Walls	Concrete	0.10 – 0.35	0.71 – 0.90
	Brick	0.20 – 0.40	0.90 – 0.92
	Stone	0.20 – 0.35	0.85 – 0.95
	Wood		0.90
3. Roofs	Tar and gravel	0.08 – 0.18	0.92
	Tile	0.10 – 0.35	0.90
	Slate	0.10	0.90
	Thatch	0.15 – 0.20	
	Corrugated iron	0.10 – 0.16	0.13 – 0.28
4. Windows	Angle under 40°	0.8	0.87 – 0.94
(clear glass: zenith)	Angle from 40° to 80°	0.09 – 0.52	0.87 – 0.94
5. Paints	White, Whitewash	0.50 – 0.90	0.85 – 0.95
	Red, Brown, Green	0.20 – 0.35	0.85 – 0.95
	Black	0.02 – 0.15	0.90 – 0.98
6. Urban areas	Range	0.10 – 0.27	0.85 – 0.96
	Averages	0.15	0.95

Source: OKE, 1978, p.247.

[2] ASTM E 1980-98: Standard Practice for Calculating Solar Reflectance Index.

Table 3 - Radiative properties of natural materials

SURFACE	REMARKS	ALBEDO	EMISSIVITY
Soils	Dark, wet	0.05-0.40	0.90-098
	Light- dry		
Desert		0.20 – 0.45	0.84 – 0.91
Grass	Long (1m)	0.16	0.90
	Short(0.02m)	0.26	0.95
Agricultural Crops, tundra		0.18 – 0.25	0.90 – 0.99
Orchards		0.15 – 0.20	
Forests Deciduous	Bare	0.15	0.97
	Leaved	0.20	0.98
Coniferous		0.05 – 0.15	0.97-0.99
Water	Small zenith angle	0.03 – 0.10	0.92 – 0.97
	Large zenith angle	0.10 – 1.00	0.92 – 0.97
Snow	Old Fresh	0.40 0.95	0.82 0.99
Ice	Sea Glacier	0.30-0.45 0.20-0.40	0.92-0.97

Source: OKE, 1978, p.15.

From a market standpoint, the urban climate study has reached a stage of characterization of its fundamental aspects, which can be presented as follows:

a) urban climate is the substantial modification of a local climate, and it is still not possible to decide about the point of population concentration or building density where this observable change begins;

b) urban development admittedly tends to accentuate or eliminate the differences caused by the site's position;

c) the following fundamental facts emerge from the comparison between the city and the surrounding land: 1) the city changes the climate through surface alterations; 2) the city produces an increase in heat, completed by modifications in ventilation, humidity and even rainfall that tend to be more accentuated; 3) the greatest influence is manifested through the change in the atmosphere's composition, reaching adverse conditions in most cases (MONTEIRO, 1976, p. 57).

The formation and mainly the intensity of heat islands are related to the synoptic conditions action that will establish the type of sky coverage, wind speed and direction and rainfall. Thus, for example, the absence of winds or light breezes makes it difficult to disperse urban heat, resulting in an intensification of the heat island; on the other hand, if wind speed is more intense, turbulence pushes the heat out of the city and consequently the urban and rural temperature differences are smaller. Clouds reduce the reception and return of radiation and moderate urban heat island intensity (PINHO, 2000).

The city's climate is produced from an integrated inter-play between the atmospheric air and the urban environment built by humans. Thus, the city structure must go along with its functions in order to understand this complex environment.

The city modifies the energy balance, water balance, relief and chemical structure of the atmosphere. The human life style interferes significantly in the urban system, completely recreating it.

By changing the nature of the surface and the atmosphere, the urbanization process affects the way climatic system's components work, because it "disturbs pre-urban energy, mass and momentum balance and leads to a modification in the state of all atmospheric parameters that together represent the climate" (OKE, 1980, p.339).

The changes that occur in the urban climate, according to Oke (1978), generate urban and local atmospheric layers, called urban canopy layer and urban boundary layer, with various dimensions in time and space. The canopy layer can reach between 1 and 3 times the height of the top of elements that exist on the surface and can have strong, low-scale turbulence depending on the surface's rugosity. Table 4 shows the characteristics of the urban environment that can alter energy balance, causing positive thermal anomalies at the canopy layer level.

Table 4 - Commonly hypothesized ‘causes’ of the canopy layer urban heat islands

1- Increased counter radiation (L) due to absorption of outgoing long-wave radiation, and re-emission by polluted urban atmosphere.
2- Decreased net long-wave radiation loss (L) from canyons due to a reduction in their sky view factor (SVF) by buildings.
3- Greater short-wave radiation absorption (K) due to the effect of canyon geometry on the albedo.
4- Greater daytime heat storage due to the thermal properties of urban materials, and its nocturnal release.
5- Anthropogenic heat from buildings sides.
6- Decreased evaporation due to the removal of vegetation and the surface ‘waterproofing’ of the city.
7- Decreased loss of sensible heat due to the reduction of wind speed in the canopy.

Source: OKE, 1978. p. 259.

Boundary layer is the layer above the canopy layer, where there are good conditions for mixing. Its height is variable and depends on surface capacity to cause air movement. At night, in the city can reach less than 100m, because the surface cools faster than the atmosphere, and during the day it can reach 1 to 2 km, because the convection currents are more intense. Table 5 shows the city characteristics that can change the energy balance, favoring the formation of heat islands at the boundary layer level.

Table 5 - Mechanisms hypothesized to cause the urban heat island in the urban boundary layer

Entrainment of warm air scoured from the canopy layer heat island.
Anthropogenic heat from roofs and stacks.
Downward flux of sensible heat from the overlying stable layer by penetrative convection.
Short-wave radiative flux convergence in the polluted urban air.

Source: OKE, 1978. p. 265.

The energy balance in cities is mainly changed by the complex geometry of constructed surfaces, the materials' thermal properties, building orientation, soil impermeability and the heat released by several human activities.

Oke (1978), Landsberg (1981) and Monteiro (1997) made it clear that the amount of energy available in the urban atmosphere will depend on the total amount of energy released by human beings as a result of their different activities and the total amount of energy from solar radiation, and in reduced amounts, from inside Earth. Besides that, heat storage in the space built by the aforementioned characteristics, associated with slight heat loss by evaporation, does not make the final balance between losses and gains in the urban environment null, creating conditions for the formation of heat islands or fresh islands.

The heat island effect is the result of differences in energy balance between the urban area and the field as well as the existing differences inside the city. A heat island is a thermal anomaly with horizontal, vertical and temporal dimensions that has been observed in almost every city where it has been studied. Its characteristics are related to the nature of the city (size, construction density and land use) and external influences (climate, weather and seasons) (OKE, 1982).

In ideal atmospheric conditions, that is, clear skies and calm winds, there is maximum intensity of a heat island. In relatively level terrain, higher temperatures are observed in more densely constructed areas with little vegetation. Horizontally, the temperature falls as you approach the rural zone, characterized by a milder horizontal gradient. This general layout is interrupted by hot and cold places associated with the density of tall and low buildings. Parks and lakes are cool areas, whereas industrial sites, apartment complexes, commerce or downtown areas represent hotter areas.

Energy balance in the city, contrary to the field and differences in stability, produce different heating or cooling rates near the surface, make different regimes of air temperature appear, and these differences, at a given time, define heat island intensity (OKE, 1982).

In the rural zone, the temperature sequence is standard. At sunset, there is rapid cooling between 2ºC and 3ºC. The surface drains the radiation energy and subtracts the heat from the shallow layer of stable air immediately above it. As the temperature falls and the radiation emission rate decreases, the cooling rate also declines as night continues. The temperature of rural air at night falls until sunrise.

At daybreak, solar heating of the surface generates a turbulent flow of sensitive heat that converges at the surface layer. Its depth is limited by the growing nocturnal inversion. As the mixture layer grows, the heating rate decreases until noon (OKE, 1982).

The urban regime is different because the heating and cooling rates are smaller. Observe the lack of sharp peaks near sunrise and sunset, producing a confined diurnal temperature wave. As a consequence, the intensity of the heat wave suffers a notable diurnal variation. The diverging cooling rates between rural and urban environments produce sharp heating intensity at sunset until at most a few hours later (3 to 5 hours). After that, slightly greater urban cooling reduces intensity until the morning rural heating "erases" the heat island. There are cities where the downtown gets cooler than in the field, forming “fresh islands” (OKE, 1982). The spatial distribution of the heat island is related to maximum intensity time. The diurnal spatial standard tends to be less defined and to adjust well to the distribution of characteristics that cover the surface.

Radiation at daybreak and sunset in urban areas depends on processes that are intrinsic to the city. In the urban fabric there is a heat flow that is stored during the day as a result of the materials’ high thermal conductibility, emitted into the atmosphere at these hours, presenting higher temperatures. As the sunrays hit the surface, their flow is reduced due to urban surface geometry, which provides multiple reflections, reducing incident short waves, which vary according to construction height and sun direction and angle.

The location of a city imposes a broad interval of effects related to bodies of water, the topographic characteristics, and of the land, vegetation and land use in the region. The possible combinations are as numerous as the number of cities. This reality explains the concern with heat island studies. The relationships between heat island intensity, city size and location exist, but the greatest interest is in elucidating critical physical factors implicit in “size” measures, such as population.

The most important meteorological variables that govern heat island intensity are wind speed followed by cloud coverage. Low clouds are more effective than an equal number of high clouds in limiting heat island intensity.

Wind and clouds are the substitute variables related to rules regarding radiation and turbulence transfer in producing temperature changes. These rules are combined in the simple variables of atmospheric stability, which show the production of a good correlation with island intensity, greater frequency of occurrences and greater intensities, recorded during the hottest half of the year (summer and fall). In part, this is related to weather control seasonality (wind, cloud and air mass stability), but it is reflected in surface cover variations such as vegetation and construction density, and in solar influences, such as angle of incidence in relation to urban geometry and attenuation by aerosol. The heat island is best delimited in summer, whereas the heating demand peaks occur in winter. This indicates that anthropogenic heat is not the main cause (OKE, 1982).

Opinions regarding seasonal variations of heat islands are conflicting, since:

> *[...] on one hand there are studies, such as those carried out by Mitchel (1979), Landsberg and Brush (1980), Jaureguy (1984) and Oguntoyinbo (1984), Lombardo (1985), who observed that the greatest urban-rural thermal contrasts (1.3ºC to 5ºC) occur in the winter. [...] On the other hand, Sanderson (1973), Ackerman (1985), Imamura-Bornstein (1991) and Mendonça (1994), reported the greatest magnitude (2ºC, 10ºC, 1.2ºC, 10ºC) respectively, occurs in the summer (PITTON, 1997, p. 20).*

Justification for the heat island's greatest magnitude, in winter, is associated to the greatest frequency of thermal inversions and greatest liberation of anthropogenic heat. In summer, the heat island's greatest magnitude is attributed to a greater amount of energy absorbed during the day as well as its absorption at night, or as a result of the role of rural land mixtures, which presented high thermal inertia in summer.

There are clear differences between the atmospheric environments of tropical cities and those at average latitudes. "The most notable differences are observed in the varied temporal formation of the urban heat island, which in tropical cities has had greater diurnal than nocturnal intensity" (IMAMURA-BORNSTEIN; BORNSTEIN, 1992; apud MENDONÇA, 1994, p.13-4).

Other studies concluded that the heat island can be manifested with greater intensity during the day, namely "Nakamura (1967), Nkendirim et al. (1978), Nishizawa (1983; 1986), Iamashita (1988), Imamura-Bornstein (1991), Sette (1996)" (PITTON, 1997, p. 20).

The fact is the cities have climatic specificities that should be considered and which vary in intensity according to their own characteristics.

Among the climatic specificities the most prominent is the lower amount of water available for evaporation. The city's atmosphere is less humid than the rural zone, but there are variations in this overall view, since during the day there is a greater probability of the air in the rural zone to acquire water vapor due to the presence of vegetation and because the land is more permeable. On the other hand, at night, the rural zone goes through a faster drop in temperature, leaving the air saturated and avoiding evaporation until the water present in the air, near the surface, decreases as it reaches dew point. Thus, in the city, where the temperatures are higher at night, there is a drop in the dew point, with the formation of "humidity islands" (OKE, 1978).

Due to the temperature differences between the city, the outskirts and the rural zone, air circulation is diverse. Wind speed is normally lower in constructed areas, except in densely verticalized areas that can channel the air, and in these cases reach higher speeds than in open points between buildings (OKE, 1978).

In stable atmospheric conditions, without the action of intense regional circulation due to temperature differences, different pressure zones are formed permitting air circulation in the outskirts (less heat - high pressure) towards the center (more heat - low pressure).

City areas with greater concentration of green areas or near water reservoirs goes through declines in temperature.

> *[...] this can be explained by considering that the greater amount of vegetation implies a change in energy balance since the plants absorb solar radiation through photosynthesis transpiration. Likewise, the water masses interfere in the energy balance, as a result of their high calorie capacity as well as the consumption of latent heat by evaporation (LOMBARDO, 1995, p. 53).*

Several studies presented vegetation's influence on the city environment since it is responsible for mitigating higher temperatures that cause thermal discomfort, as well as reducing wind speed and the impacts caused during precipitation. These include: Kopec (1970), who showed vegetation’s influence on wind speed; Gomez and García (1984), who found significant differences within the heat island due to the presence of a park; Oke (1989), who addressed micro-meteorological aspects of an urban forest and its effects on temperature; and Pitton (1997), who emphasized that green areas intercept, absorb, reflect and transmit solar radiation, capturing and transmitting water, and interfering in wind direction and speed, and are responsible for lower temperatures even in the downtown area. This was also observed by Danni (1987) and Cruz (1995).

Habitually, urban planning in Brazil does not consider local climate conditions. The technology is imported from countries at average and high latitudes. Colonial occupation left construction techniques and urban design adopted by European countries as an intrinsic inheritance, as well as the architectural structure in force in the United States as well as Europe.

Besides the quantification of detected changes, the study of urban climate makes it fundamental to make a geographic analysis of the phenomenon, that is, it establishes relationships between measured data and the city’s component elements. These studies contribute towards improvement on environmental quality because the formation of heat islands creates air circulation in the city that favors the concentration of pollutants and can cause disorders in people, such as respiratory and circulation illnesses, and in tropical countries great thermal discomfort, favored by high temperatures, common at these latitudes.

Thus, as observed in literature on this subject, in studies carried out by Amorim (2000; 2005), heat storage and reflection have different behaviors according to the period of the day. At daybreak, when the sunrays fall at a greater angle, densely constructed areas create the “shadow effect”, making it difficult for sunrays to penetrate and resulting in lower temperatures than in the rural environment. On the other hand, in places with sparse buildings or a rural environment, the transformation of shortwave solar energy to long-wave occurs quickly, leading to hotter environments.

As solar radiation intensifies during the morning and afternoon, higher temperatures are observed in areas with greater construction density and less tree vegetation, whether in streets or gardens or rural areas.

At night, the atmosphere near the surface in the city is hotter than in surrounding areas due to the capacity of urban materials to store heat. For example, in the rural environment with vegetal coverage, absorption is approximately 75% of the heat, where in densely constructed areas without vegetation, heat absorption can reach 95% or 98%.

Depending on the characteristics of each urban environment, it is possible to find not only a heat island, but an archipelago, with several places with higher temperatures. The main factors that interfere in intra-urban and rural temperature differences are the high capacity for heat absorption of urban surfaces such as asphalt, brick or concrete walls, clay or amianthus tile; the lack of green areas, reducing albedo because the larger the green area. the greater the reflective power, leading to great heat absorption; surface impermeability by asphalt and deviating water to culverts and galleries, reducing evaporation and increasing sensitive heat; building concentration, which interferes in wind circulation; air pollution, intensifying the greenhouse effect; increased heating of the atmosphere by burning fossil fuels in vehicles and industries.

García (1995) classified the thermal differences in heat islands as of weak heat magnitude when the differences between the hottest and coldest points can vary from 0ºC to 2ºC; average magnitude, when they vary from 2ºC to 4ºC; strong magnitude, when they vary from 4ºC to 6ºC; and very strong when they exceed 6ºC.

Besides the thermal discomfort that areas with high temperatures can provide for its inhabitants, the differences in temperatures cause differences in pressure since higher temperatures result in lower pressures at local climate scales, and consequently, the colder, surrounding air shifts to hotter places. If there are any sources of air pollution along the way, these pollutants will be carried to the hotter places and can result in public health problems.

However, it is important to underscore that heat islands can be detected and their maximum intensity occurs in stable atmospheric conditions, that is, clear skies and calm winds.

Under the action of unstable atmospheric systems, which result in high wind speed and precipitation, heat islands break up and there is temperature homogenization in different points of the city.

CLIMATIC CHANGE: A MATTER OF SCALE

Due to urban growth, and consequently its insertions in the urban grid, meteorological stations have gradually recorded micro climatic effects that are gradually incorporated to the temporal series of climatic elements. With that, the seasons tend to record, for example, higher temperatures due to the sum of heat from anthropic actions.

According to Molion (1995), this fact questions some considerations about global warming, since its speculations are based on these series, recorded in diverse parts of the world (mainly by stations in the northern hemisphere, countries that in the 20^{th} Century underwent great transformations in their landscapes). Besides that, the spatial and temporal heterogeneity of the series, changes in instrumentation and transfers meteorological shelters make certain comparisons and conclusions significantly difficult.

While humans are responsible for local change, it is still not possible to determine the factors that determine the global climate, which results in the great controversy. According to the Intergovernmental Panel on Climate Changes - IPCC (2007), rising temperatures on the planet are due to the increase in atmospheric gases (especially, carbon dioxide, which responds for nearly 60% of detected consequences), from anthropic activities, intensifying the greenhouse effect, and as a result the average temperatures until the end of this century (between 1.5ºC and 6.0ºC).

> *However,*
> *Thus, we should be very reticent regarding IPCC reports being prepared by "hundreds of scientists". The announced number can be illusive and hides the message's monolithism. In reality, a small and dominating team imposes its point of view on a majority without climate competence. The 'I' in IPCC means 'intergovernmental'. That means that before all else the so-called scientists are representatives of the government. The IPCC is absolutely not a research body (LEROUX, 2003, no page, own translation).*

From the dynamicity of the atmosphere, the climate has its own natural variability, contrary to referred to conceptions. Feedback mechanisms, lithospheric plate tectonics, Milankovitch's cycles (earth orbits), El Niño, volcanic activity and variations in sun spot emissions are natural factors that directly influence global change, as does the Pacific Decadal Oscillation (PDO)[3], which, "[...] considering that the earth's atmosphere is heated from below, the oceans are the most important lower contour for the climate, and certainly the Pacific, since it occupies one third of the earth's surface, must play a core role in inter-decadal climate variability" (MOLION, 2005, p. 1).

Discussions about climate change culminate in a central point: scales. On the global scope (generalization), we apparently do not see heating in every part of the world, whereas in the local (specialization), micro climatic changes are confirmed that have a direct relationship to the surrounding environment.

[3] It is in a cold phase (since 1999), still not knowing its cause or its impacts on the climate.

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WATER VULNERABILITY IN RURAL AND URBAN AREAS IN BRAZIL: THE USE OF RAINWATER AS AN ALTERNATIVE FOR WATER SUPPLY ADAPTATION

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ABSTRACT

Global changes in climate may cause a decrease of water resources as well as increase the frequency of extreme events occurrence. Scenarios for 2050 presented in the 4° Report of the IPCC (2007) drew attention to the risk of water shortage getting worse in regions that already present susceptibility to long dry periods and also to water excess in flooding areas. The use of rainwater in a direct system can reduce the impacts of extreme events of dry period and flooding. In this article we analyze the techniques of good use of rainwater in rural and urban areas in Brazil. In a more specific way, we gain knowledge in the analysis of two case studies. The first in the North Eastern Semi-Arid region, which copes with recurrent problems of water stress, where the implantation of more than 200.000 cistern plaques have been changing the water supply for families in the north eastern rural zone. The second case study occurs in an urban area and discusses the potential to develop green roof (naturation) techniques, which can stimulate the use of rainwater in irrigation of gardens and flushing of toilet basins, also diminish the sealing effect of urban soil use and thus collaborating to reduce flooding.

Keywords: Water vulnerability, Use of rainwater, Supply adaptation.

INTRODUCTION

In terms of water availability, Brazil can be considered a privileged country since the annual mean flow of the rivers, in national territory, is of 258.750 m³/s, corresponding to circa 20% of the world availability of water resources (FREITAS, 2003). However, due to its continental dimensions, Brazil envelops a complex geographic configuration, with great physical and climatic diversity. Consequently, the availability of water resources occurs in an inconsistent way in space and time.

The situation of water scarcity and stress has become progressively more evident in most of the countries regions, specially in the basins localized on areas that present a combination of low a ailability and great demand for water resources. According to the PNRH (2006) -“National Plan of Water Resources”- around 83% of the water resources, available in national territory are distributed among the hydrographic regions of minor demographic density, while more densely urbanized regions contain only 12% of the water sources, holding a population of 54% of the country total.

In this sense, the assurance of water access in adequate quantity and quality, to attend social demand, consists one of the great challenges to be confronted by public policies of water resources management that should consider both conventional and decentralized approaches to water management, among which the management of rainwater is outstanding.

The practice of collecting and storing rainwater has been consolidated as an alternative to attend the rising needs of water consumption in Brazil, for most diverse uses both in the semi-arid region, where the scarce and irregular rainfalls limit development, and in other regions of the country that are penalized with long duration rainfall and/or great intensity, frequently provoking environmental, social and economic losses.

In a context of current water vulnerability in rural isolated areas and in urbanized areas, the present work shows the results of two case studies, where practices of rainwater capture are applied, either for human consumption or to control flooding events and reduction of pluvial water overload in urban drainage systems. As a first example, data collected on field at the installation of cisterns are presented in the municipality of Caridade (Charity) in the State of Ceara. The second example refers to an experiment in adaptation of Green Roof (Naturation) Systems to Brazil’s technical and industrial condition, executed in the COPPE/UFRJ.

In rural and semi-arid Brazil, the *cistern* has been the largely used technique to guarantee water of quality for the farming families in areas with pluviometer index varying from 500 to 600 mm/year and a dry period of eight months. In this sense, the Program “One Million Cisterns” – P1MC- is the promoter of a decentralized access to water and emancipation of the rural worker by mobilizing and habilitating the local community for the construction of cisterns, transforming the old practice of public policies of “combating drought” to that of “becoming a member of the semi-arid”. Such example of information is like a landmark in the procedures for a sustainable development of the Brazilian semi-arid.

In the large densely urbanized Brazilian centers, the “System of Naturation” (Green Roof) is an alternative to capturing and filtering of polluted and acid rainwater for non-honorable uses (ROLA, 2008). This results in the economy of energy and sanitized water for public supply. Furthermore, the use of this system results in other benefits, both engaged in constructions, such as the thermal isolation of the roof via absorption of solar incident radiation, and improvements in the surrounding ambiance, enhancing the climate by retention of dust and polluted particle material in the atmosphere, augmenting urban humidity and reducing the island of heat effect (BRIZ, 1999; ROLA et al., 2003).

TECHNIQUES TO COLLECT RAINWATER

The passage from nomad to sedentary society, with control of agricultural and cattle raising techniques, was the result of increased organized settlement of people in fertile areas, next to water sources. With the proliferation of these population nucleuses, other areas began to be occupied, not so near to these water sources, and its supply for human consumption became increasingly arduous, due to distance. This frame was aggravated when these areas were affected by dry periods with consequent decrease of water flow. As an alternative to lack of water, the practice of rainwater collection and storage in small ceramic vases was developed for the survival of the family nucleuses. With the continuous organization of the societies to confront long periods of drought, small receptacles to store water gave way to larger ones such as dams, originating roof or semi roof cisterns to control high evaporation or contamination by animals.

Independently invented in many parts of the world, the collection of rainwater has been practiced for thousands of years (GNASDLINGER, 2000) and the first written register of the practice of rainwater harvesting and its storage in the history of mankind dates from 850 B.C. such register having been made on a rock of black basalt, more known as the Moabite Rock, where, according to Wahlin (1995) and Tomaz (2003), there was an inscription with reference to the braveries in won wars and also a recommendation of the King Mesha of Moabe, in Jordany, for the construction of rainwater storing:... *and I made two reservoirs in the middle* *of Al- Karak. Now there were no cisterns in the city, thus I said to all people, "that all men build a cistern in their houses."*

According to Wahlin (1995), this may perhaps have been the first time the cisterns were mentioned. However, the device was invented much before and in fact, according to Negev and Gibson (2001), the first cisterns were dug from the half toward the final of the Bronze Age (2200-1200 b.C.). The collected rainwater was stored in these cisterns during a short rain period. It was sufficient for, at least, one dry season. In some places in Palestine the cistern was the main source, whether not the only source of water for human consumption, both at times of peace and also in times of war. In the beginning of the Iron Age (1200-1000B.C.), the walls of the cisterns were covered with plaster, which significantly extended the duration of water storage. This technique became an important innovation, increasing the occupied areas in mountainous regions.

According to Wahlin (1995), the dating of the construction of the first cisterns in the middle of the bronze era may be too recent, because in the city of Jawa, in the desert of black lava to the northeast of Jordania there is a sophisticated system of water collecting that was planned and constructed before 3000 b.C. According to Helms (1981) while the craftwork cisterns did not apparently belong to this system, natural caverns were used as recent ancestors of the following structures of constructed or artificial cisterns. The older home cisterns also found in Palestine belong to the calcolitic period (transition between the neolitic and the bronze era), before the year 3000b.C. However, the cisterns could not have been constructed in large quantities before the Iron Age (WAHLIN, 1995). To Evenari et al. (1971) the cisterns of Negev, in the desert of Israel, dated from the second period of the Iron Age and were dug in clay soil and covered with a layer of big rocks to secure the stability of the walls. As well, sculpted cisterns sculpted begin to appear in the nabatean era, in the last two centuries before our era (200 b.C.).

The construction of cisterns varied in time and place, and with the following civilizations like the Greek and the Roman, the harvesting of rainwater became part of the house roofing. In the case of the roman *domus*, in the central part there was an atrium with an opening in the roof, called *compluvium,* and the rainwater while entering through it was stored in an open cistern, almost a swimming pool, called *impluvium* (MALISSARD, 1996). With the management of the construction process of hydraulic concrete, with pozolana and lime, big cisterns were constructed to supply the neighborhood, like the communal cistern of Cosa, a republican colony in North Italy (BROWN, 1980). According to Gnadlinger (2000), in the Province of Ganzu in China, there already existed storage of rainwater, in the Plateau of Loess, 2000 years ago. This solved the problem of water lack and resulted in social and economic development of the region. In India, a research project, developed by the Science and Environment Center, called Dying Wisdom, listed many traditional experiences of rainwater use and storage in Kunds (cisterns) in 15 environmental zones of this country (AGARWAL; NARAIN, 1997). In Iran, it is still possible to find the *abambars*, which are the traditional systems of collecting and storing rainwater for the communities, where an oval roofing allows evaporated water to condense on the internal surface and slide by the walls back to the amount of water stored in liquid state. In Mexico, this practice was also much used and until today vestiges of the Maia and Aztec period are found, where the *Chultuns or* Cenotes used to guarantee the supply of water for irrigation and drink for the population of the city of Oxkutzcab, located at the foot of the Puuc mountain, in the peninsula of Yucatan (GNADLINGER, 2000).

According to Wahlin (1995), old cisterns were considered notable and picturesque, but rarely as efficient and pertinent in a modern context. With the rise of water demand the aqueducts appeared as an alternative for transference by gravity, of great volumes of water from distant sources for the supply of population nucleuses, the cisterns becoming only storing spaces for non rain water.

According to Gnadlinger (2000), with the process of invasion and colonization of these old civilizations that had introduced new agricultural systems, many new species of domestic animals, exotic vegetal species and imported construction methods did not adapt to the environmental and cultural reality of the Yucatan. Besides, the British colonizing process in India went further with the creation of taxes on the use of water, forcing the population to abandon villages based on the practice of rainwater collection, causing the collapse of a millenary system. It is estimated that this is the zero landmark in the long obsolescent process of the cisterns in urban agglomerations. Furthermore, it can be considered that the advent of the Industrial Revolution, at the end of the XVIII century and the technical progress in the XIX and XX centuries were determinant in this process, since it not only made possible the development of modern practices of irrigation that were adequate to temperate zones as well as, with practices of agricultural colonization, forced these colonies into areas of arid climate, also provoking the technical development of electrical motors for bombing water wells, and the construction of big reservoirs with large scale production of tubes and connections, allowing the consolidation of a public system of water supply in human agglomerations, a system that became the model to be obeyed in urban areas.

ALTERNATIVES OF RAINWATER USE IN THE RURAL BRAZILIAN ENVIRONMENT

The Brazilian semi-arid includes the northern region of the State of Minas Gerais and the bushes of Bahia, Paraiba, Sergipe, Alagoas, Pernambuco, Rio Grande do Norte, Ceará and Piaui, totalizing 1.113 municipalities, with an area of 969.584 km² (Figure x). The total population is of 20.858.264 inhabitants, 43,56% living in the rural zone. The region is one of the most vulnerable and poor of Latin America, where millions of families live on cultivation of their own lands, or owned by others, under extreme climatic conditions (BRASIL, 2007).

The region has been characterized mainly by problems related to drought, where the climate is marked by an irregular regimen of rain both in time and place, whose pluvial precipitations are concentrated generally in a period of four months. This situation becomes still more critical due to high rates of vapor transpiration that reach 2.500 mm per year, accompanied by soils of low fertility and a high contingent of dispersed population (ANA, 2006).

The low availability of water is considered a limiting factor to the development of the region, the frame of insufficiency with high rates of pollution being directly associated as restrictive for human occupation and inhibitor of productive activities.

During a lot of time the discourse and government practices of “combating drought” influenced the whole process of official planning activity and reflected the dominant optics on the semi-arid problems, where all converged to water scarcity, not considered the severity of social condition prevailing over climatic and environmental adversities.

The change of focus in policies to confront drought periods, in detriment of debates on the familiarity (friendship) with the semi-arid, where everything converges to water scarcity, not taking into account the gravity of the social situation of the population prevailing over the climatic and environmental adversities. The change in focus of the policies to combat drought, in detriment of the debates on life in an inhospitable climate, gained visibility when the Parallel Forum of Civil Society to the III Conference of the Parts of the Convention to Combat Desertification of the UN (COP3) was held in Recife in l999.

In opposition to the discourse of fighting drought, a new concept emerged, or better said, a new perception of the Brazilian semi-arid. The movement converges to reflection, action and conduction of the debates under an appropriate model for development of the region, based on the principle that drought should not be fought against, but otherwise, means should be created for a living in concert with the environment, in modus to overcome the adversities and explore its potential in a sustainable way (CARVALHO, 2004).

To achieve the goal of promoting means of familiarity of the population with the semi-arid, different strategic procedures have been implemented along the years, either through environmental education or technological solutions. Among these procedures, the practice of rainwater cistern colleting and storing was emphasized, to democratize access to fresh water for human consumption in rural communities. The recent initiative toward implantation of cisterns to harvest rainwater is specially expressed by the Program of Formation and Social Mobilization for a Life in the Semi-Arid: A Million of Rural Cisterns (P1MC) is an achievement of non-governmental organizations supported by the federal government. The program started in the year 2003 and since then around 220 000 cisterns were constructed.

The cisterns have the capacity to store 16000 liters of water that would be attending basic necessities, (drinking, cooking and brushing teeth) of a 5 member family, guaranteeing a consumption of 4 liters/member/day, for a period of approximately eight months, corresponding to the dry season. Considering the reference values adopted by the program, it is evident that a cistern does not have to be considered as the only source of water supply, since the offered volume in conditions of drought attends only to basic domestic consumption and makes up for the lack of immediate necessities.

The cisterns are made of pre molded plaques, with dimensions of 2,40 m of height and 1,5 m of radius that allow the storage of water that can be collected from rainfall, by means of training local masons, working in partnership with the benefited family, which takes the responsibility for the general services of excavation of the site where the cistern will be installed. In the following figures it is possible to observe the main phases of the construction process of the cisterns.

Figure 1 – Excavation of the opening and execution of the concrete flooring of the cistern

Source: CARITAS, 2001.

Figure 2 – Fabrication of the plaques and assembly of cistern walls

Source: CARITAS, 2001.

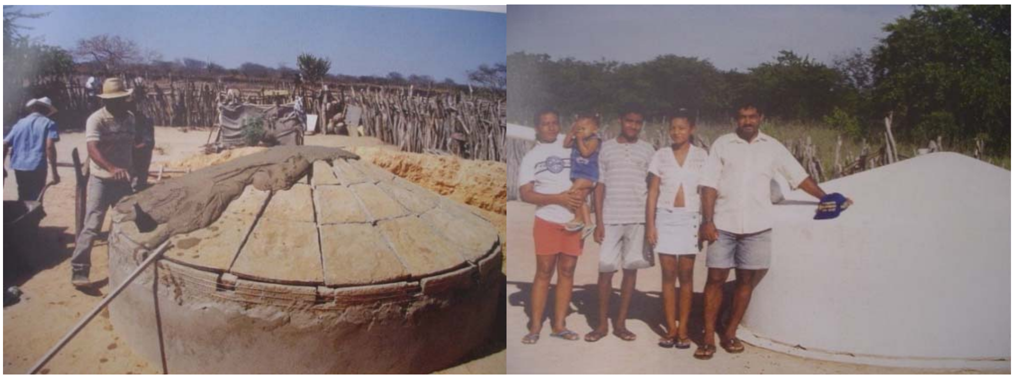

Figure 3 - Covering with mortar and the cistern is built

Source: CARITAS, 2001.

In the visit to the municipality of Caridade, in the State of Ceara, the process of capacitating the families was accompanied. At the occasion they were waiting to receive the cisterns in their homes. In this period, contacts were established with different players of the project, among them the involved NGOs participants, communal leaders, capacitating instructors, families that already had installed their cisterns and families in process of capacitating.

In this manner it was possible to advance in the sense of investigating the social significance of the cistern, the whole process that culminates with the construction, the life of the families and the social relations established in the rural communities of the semi-arid where people live in conditions of water vulnerability due to adverse conditions of the physical local ambiance and absence of water supply facilities.

The municipality of Caridade has a total population of 16.889 inhabitants, 53,71% of them residing in urban areas and 46,29% live in rural areas. The municipality presents low indexes of access to services of basic sanitation, where only 46,07% of the population is attended by the water supply network and 2,8% have access to a collecting drainage network. Normally, the sanitation conditions are worse in the rural zones. The routine of the rural families of Caridade pictures a reality common to thousands of the Brazilian semi-arid, which begins with the morning wake up of the women and the children that go for the coffee water so that the men may have a meal and go to work in the cleared land. During the drought season these itineraries become progressively longer and the task to carry the water buckets over their heads becomes still more arduous, tiring the women and extenuating the children, which usually are not able to continue the school activities.

The prolonged overweight of the task has an impact on physical health and is worse for the children, affecting their growth and leading to backbone problems. Furthermore, other health problems are very frequent in the semi-arid such as hypertension induced by ingestion of brackish water and precarious feeding, supplemented by excess of sugar in daily meals, generating a rising number of individuals with diabetes troubles.

Considering the responses of most interviewed people, in general, the cistern means better quality of life and health conditions for the families, mainly for women that spend less time in search of water and thus have more time to tend to the children. Many have reported the decrease of children sickening, in special cases of diarrhea that were beforehand recurrent. Another aspect observed in relation to families that depend on cisterns, was the possibility of a better orientation in water use in the way they consider as affecting health issues. The cistern water has been predominantly used for drinking and cooking while water from other sources is used to wash clothes, rinse the house and other less noble uses. The experience obtained on the field allows to assert that the cistern, no doubt, significantly contributes to promote a decentralized access to water within the new vision of a sustainable friendly relation with the region, representing a low cost technology and an important instrument to adapt populations that are directly affected by water deficit, specially in isolated rural communities that do not count on network services for water supply.

Alternatives of Rainwater use in the Brazilian Urban Environment - the Case of Green (Naturation) Roofing

To conceive Green Roofing demands that many paths be covered leading to a comprehension of its real significance and, maybe on the etymologic origin of the word naturation. The word naturation, which is a neologism, is based in the Latin terminology *natura,* which means nature, in its more extensive sense. This word contains a vast concept, since it implies the involvement of rural and urban life in an environment where nature recovers its magnitude as vegetal species that meliorate life conditions in a sustainable way (BRIZ, 1999; ROLA et al., 2003)

The urban 'naturation' is about the buildings and urban spaces being transformed in biotypes, in an economic and ecologically optimized way, so that, united by green corridors, atmospheric circulation is the improved as well as the microclimate of the city via the reduction of acoustic, thermal and optic emissions as well as non desired materials (ROLA et al., 2003).

The 'naturation' system is a technology for application of vegetation over constructed surfaces, which, rescuing the principles of *greening* of constructed areas, and combining them with the directives of agenda 21, tries to soften the impacts of urban development, scientifically exploring a response to environmental demands and redirecting the cities toward sustainable development, thus obtaining a greater integration among urban space – citizen- nature (ROLA, et al., 2003).

The 'naturation' technique may be applied in any constructed areas, or else, roofs, façades and accesses, transforming an old system of gardened terraces, typical of the modern architecture amply spread by Le Corbusier, into a system of re -vegetation of the constructed space with indexes of control and benefits for the environment. This system is mainly constituted of four layers of similar importance: (i) vegetation, (ii) substract, (iii) drainage and (iv) sealant (ROLA et al., 2003).

The evaluation of the advantages of 'naturation' applied on constructed surfaces becomes more expressive when there are correlations among economic, social and environmental aspects. Consequently, the benefits converge directly or indirectly to an amelioration of the quality of life for the human being, fixing him in urbanized areas, crowding them. Thus, the use of the 'naturation' techniques in big urban centers makes possible to ponder on the advantages of economic, social and environmental issues, according to Table 1.

Table 1 – Advantages of Naturation

ADVANTAGES		
For the landowner	For the community	For the environment
Increases lifetime of the roof	Reduces the surface flow of Pluvial water	Prevents reflux of drainage
Reduces air conditioned consumption during summer	Reduces the effect of heat islands in cities	Reduces the impact of carbon dioxide
Reduces the consumption of heating during winter	Reduces thermo inversion	Removes nitrogen contained in rainwater
Management tool for pluvial waters	Reduces noise	Neutralizes effect of acid rain
Probability of receiving fiscal incentives	Reduces the demand for energy	Favors consolidation of urban biodiversity with birds and insects
Promotes public relations	Improves quality of air	

Source: Rola (2008).

Being a widely applied technique, much studied abroad, the lack of results in tropical latitudes is a fact and as such becomes a theme for researches developed at COPPE, which, having as reference a similar experiment executed in Mexico[1], now replicated in the Campus of the Federal University of Rio de Janeiro (URFJ), initiate studies in the adaptation of greening in constructed areas (Naturation) to climatic technological and industrial conditions in Brazil, nowadays continuing to focus on observation and further development of the obtained results. Therefore, the naturation process was applied in experimental modules (Figure 4) using native materials and plants (see Table 2).

1 As practical activity in the Specialization Course in NATURACION DE AREAS CONSTRUIDAS Y DESARROLLO SUSTENTABLE DE CIUDADES, promoted by Joint International Project Agribusiness – Environment Protection-3 within the ALFA Program of the European Commission, during the period of 2000 and 2001, and with seat in the Universidad Autonoma Chapingo in Mexico City, Mexico.

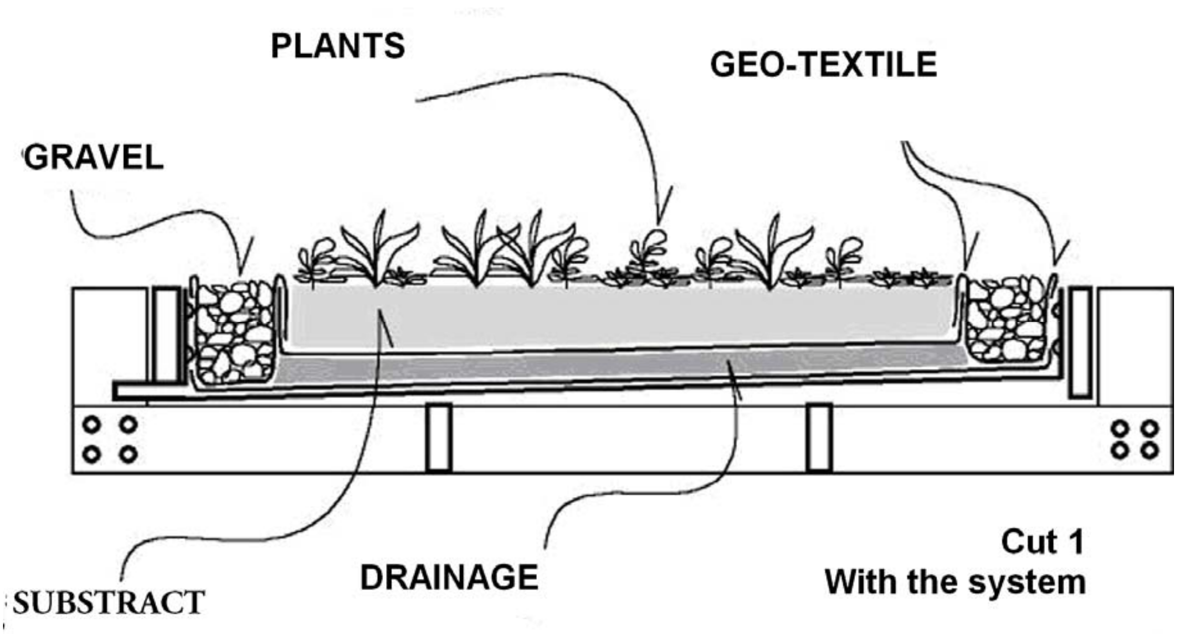

Figure 4 – Schematic drawing of how naturation was primed

Source: Rola, 2008.

Table 2 – A Summary of the experiment set up

A Summary of what was used in the experiment system

Sealing: Vinimanta SANSUY. Produced by SANSUY Industry, this material is a geo- membrane, a laminated flexible film of PVC reinforced with geo-textile support , a propilane tissue of high tenacity
Drainage: Expanded Clay. Produce by Brazilian Industry CINASITA, the expanded clay used presented two dimensions : the larger with a diameter varying from 22 to 23 millimeters and a density of 400/480kg/m³, and the average with a diameter varying between 15 and 22 millimeters and a density of 450/530kg/m³. In each module was used 50 liters0,05m³ of expanded clay
Layer of protection and filtering: Geo-textile. Produce by Brazilian Industry BRAFOR, the geo-textile is a polipropilene material
Substract: The mix used in this experiment was similar in mineral components (35% expanded clay 17,5 sand and 17,5 clay) and organic components (22,5 of humus, 5% o coconut fiber and 2,5% of coconut powder.
Vegetation[2]: The 300 native plants used belong to the family of the crassulaceas , with the following classification in gender and species: *Sedum rubrotinctum* (102 units), *Sedum Prealtum (Balsamo) (*5 units*), Sedum pachyphylium* (2 units), *Kalanchoe tubiflora (*69 units), *Grapto petalum paraguayense* (3a3 units), *Echvera elegans* (12 units) and *Echeveria prolifica* (12 units).

Source: Rola, 2008.

The monitored planning approached aspects both of urban atmospheric pollution which affected the quality of rainwater and the type of response that the naturation system offers to water that goes through it. Thus, to understand the capacity of the naturation system to filter rainwater it was necessary to understand, a priori, the quality of the rainwater that flows in the experiment, and compare it with the resultant water (see Figure 5).

[2] The quantity used per species was determined by the success of the seedling reproduction.

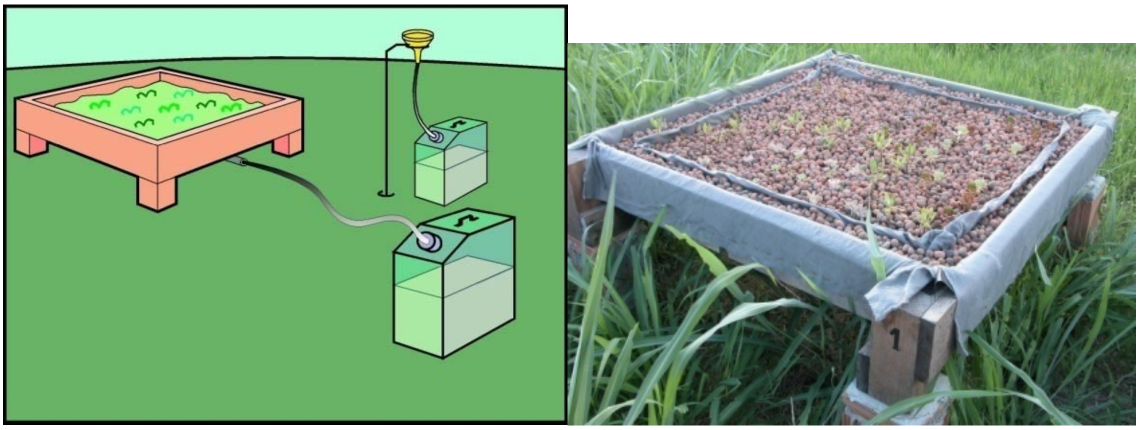

Figure 5 – To the left, a proposal of monitoring of rainwater harvest and of the drained water and, to the right, one of the experimental modules already natured

Originated in different environments, the main inorganic soluble ions, or majority ions present in rainwater are: H (hydrogen), Na (sodium), K (potash), Mg_2 (magnesium), Ca_2 (calcium), NH_4 (ammonia), NO_3 (nitrate), CL (cloret) SO_4 (sulfate). From these premises, samples of rainwater were collected as well as the residual water from the naturation system and the presence of the mentioned ions was analyzed for a subsequent comparative study.

From a statistical analysis it was concluded that a naturation system, in the manner in which is was assembled, was capable of removing a great part of inorganic (NH_4 and $NO_{3)}$ nitrogen, associated to the atmospheric compound, which is of great significance once there is a tendency of augment of nitrogen oxides emissions, precursors of NO_3, al well as of ammonia, precursor of the NH_3, in the next years. The burning of fossil fuels and bio-fuels and the increase of agricultural and cattle raising activities due to increasing demand for foods should be responsible for this rise (GALLOWAY et al., 2008). Furthermore, the captured water can be used for less noble finalities such as: flushing, external areas washing and garden watering, among others.

CONCLUSION

The direct use of rainwater to attend rural and urban necessities may reduce the climatic vulnerability of regions that today are already sensible to water problems. The potential of the available techniques is high and its use should be stimulated as a way to attenuate the stress and water excess problems.

The discussion on the alternatives for water supply in rural environment is less intense than in urban systems. However, in spite of less population concentration this does not mean that the problem is less serious. Problems of conflicts in many rural regions of emerging countries have demonstrated the intensity of the theme.

In Brazil historical dry periods in the Northeastern Emi-Arid were the cause of great migrations that nowadays cause the swelling of cities like São Paulo, Rio de Janeiro, etc. There are today circa 2 million families in the rural environment of the Northeastern Semi-Arid. This population contingent of around 10 million people does not count on alternatives for secure water supply. The use of cisterns, with roof correction for rainwater harvesting, has proved to be a good alternative. In fact, in the last 8 years more than 200 000 cisterns have been implanted, being one for each family, augmenting the water availability of the families for around 200 liters (cacimba) to 16 000 liters (cistern). This simple adaptation technique for extreme dry periods events can be improved for the rest of the families in the region.

In respect to urban areas, the setting of cities along history has presented many periods in which the expansion of population resulted in environmental pressure on natural resources, whose maladjustment in some urban aspects (deficit of sanitation) promoted the appearance of sanitary problems affecting society health, mainly in poorer populations, whose commitment to production systems is showing a diseconomy character. It is worth to highlight that, along history, many public power actions have been confronting these realities with the promulgation of commercial laws to reduce taxes and urban regulations that ordain the use and occupation of the soil, in the sense of solving really important issues for the continuity of life in the cities. More recently, environmental global issues have been incorporated to development policies. The appearance of normative documents, such as the Agenda 21, the Habitat Agenda and the Statute of the City, has mobilized and habilitated the municipality society, as a nuclear entity, with the implantation of public policies that are meant to construe and guarantee the right of all citizens to a progressive access to adequate homing and life in socially inclusive cities, economically productive and environmentally sustainable.

The good use of rainwater, so important for human supply in antiquity, is presented nowadays as an alternative to mitigate problems caused by intensive rainfalls in exhaustively sealed metropolises. The study cases confirmed that this practice should be continued, in the rural environment, for human consumption, where the public system is not all embracing, and for its scope to be enlarged. In urban environment, these practices should become a way to adapt vulnerable areas of cities that undergo flooding problems, additionally providing an cost cut when it is used in buildings.

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GREENHOUSE GAS EMISSIONS AND THEIR IMPLICATIONS ON PUBLIC HEALTH OF MIDDLE SIZE CITIES

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ABSTRACT

Greenhouse gases interact with electromagnetic radiation and thus make it difficult to lose thermal radiation, resulting in the heating of the land surface. It is very probable that the increase in greenhouse gas emissions by man has been cause of most of this elevation in temperature since the middle of the 20th Century (IPCC, 2001). It is worth noting that in Brazil 75% of the greenhouse gases spewed out into the atmosphere come from the burning of biomass. Nevertheless, several crops still use this rudimentary technique during their production process, including sugarcane. According to the WHO (World Health Organization), climate changes affect human health, not only aggravating a series of current illnesses, but also causing new and unexpected ones, changing the distribution of important vector species and thus increasing the proportion of new diseases. The city of Ourinhos, a typical middle city in the tropical climate zone, has low rates of industrialization and automotive flow, but during the sugarcane harvest, which corresponds to the period from April to December, the soot and other gas products like CO, CO_2 and CH_4 impregnate the city, hitting the population most vulnerable to respiratory tract pathologies. The burning of sugarcane fields occurs in the period that coincides with the dry season. This is a potentially aggravating scenario in the genesis of respiratory tract illnesses due to unfavorable meteorological conditions for the respiratory tract (cold and low relative humidity) and an increase in pollutants in the air. Thus, the objective of this study is to understand the influence of the main products obtained by the combustion of biomass on the genesis of respiratory tract morbidity in the region of Ourinhos.

Keywords: Public health, Middle size cities, Climate change and health.

INTRODUCTION

Interaction between the atmosphere and the land surface has been proven in different studies (NOBRE et al., 2002; MENDONÇA, 2007; SANT´ANNA NETO; ZAVATTINI, 2000) on the knowledge of greenhouse gas behavior in relation to the discussion about the transformation of planetary albedo and its possible influences on climate change, as well as its consequences for humanity.

Greenhouse gases interact with electromagnetic radiation and thus make it difficult to lose thermal radiation, resulting in the heating of the land surface.

The reports by the IPCC (Intergovernmental Panel on Climate Change), created by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988, are released on average every five years. In the last report, in 2007, the average global temperature projected by numerical models suggests an increase of between 1.8ºC and 4.0ºC by 2100. This increase may be even greater (6.4ºC) if the current conditions of economic and population growth are maintained, with the burning of fossil fuels, augmented deforestation and other variables.

It is very probable that the increase in greenhouse gas emissions by man has been cause of most of this elevation in temperature since the middle of the 20th Century (IPCC, 2001). In Brazil, the burning of biomass during deforestation for expanding agriculture and implementing pastures is the most responsible for this growth in greenhouse gas emissions.

It is worth noting that in Brazil 75% of the greenhouse gases spewed out into the atmosphere come from the burning of biomass. Nevertheless, several crops still use this rudimentary technique during their production process, including sugarcane.

In large metropolises and even many large cities, the emissions of these gases mainly occur from the burning of fossil fuels by industries and the intense flow of automobiles. If this is a proven fact in these locations, in small and mid-sized cities in the interior of the state of São Paulo, where the economic base is predominantly sugar and alcohol activity, the burning of sugarcane is the main emitter of gases, which despite contributing only modestly to global warming, represents a strong impact on local public health.

According to the WHO (World Health Organization), climate changes affect human health, not only aggravating a series of current illnesses (such as respiratory and circulatory diseases), but also causing new and unexpected ones, changing the distribution of important vector species and thus increasing the proportion of new diseases. The elderly, children and people with cardiac and respiratory diseases are the most vulnerable.

The city of Ourinhos, a typical city in the interior of the state, has low rates of industrialization and automotive flow, but during the sugarcane harvest, which corresponds to the period from April to December, the soot and other gas products like CO, CO_2 and CH_4 impregnate the city, hitting the population most vulnerable to respiratory tract pathologies.

It must be underscored that, in the most part, the burning of sugarcane fields occurs in the period that coincides with the dry season. This is a potentially aggravating scenario in the genesis of respiratory tract illnesses due to unfavorable meteorological conditions for the respiratory tract (cold and low relative humidity) and an increase in pollutants in the air.

Thus, the objective of this study is to understand the influence of the main products obtained by the combustion of biomass on the genesis of respiratory tract morbidity in the region of Ourinhos.

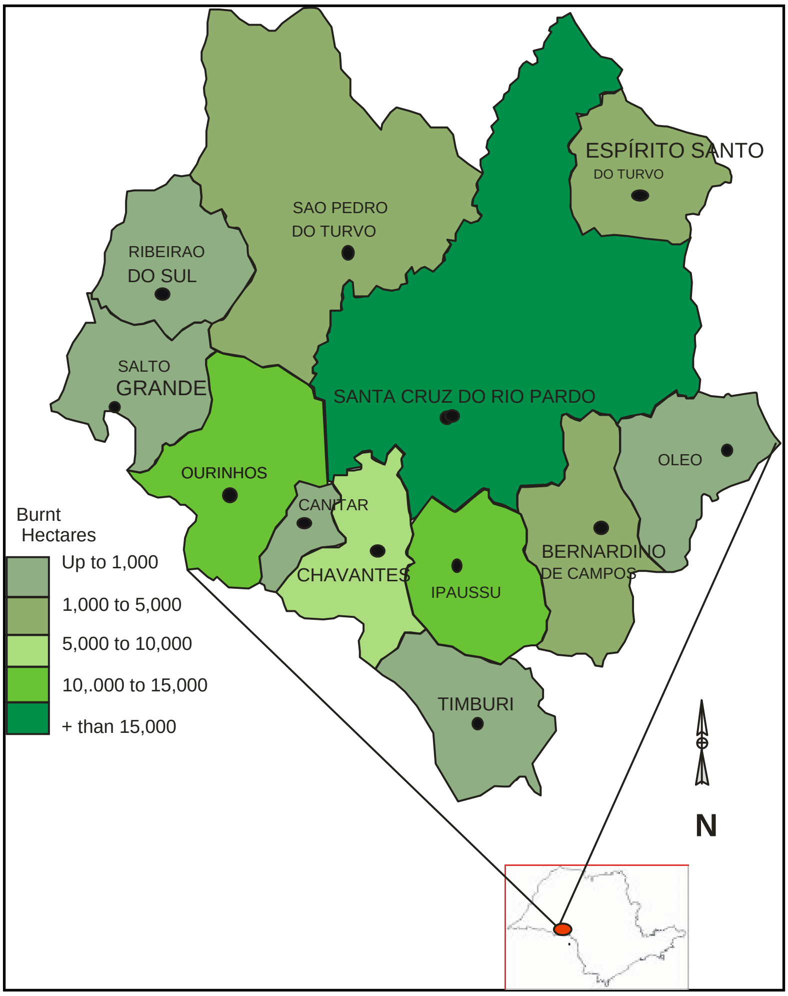

Figure 1 - Total burnt hectares in the region of Ourinhos

Source: Secretary of the Environment. Org.: Aleixo, 2007.

THE SUGARCANE CROP

In Brazil, the sugarcane crop is as old as the occupation of the land, but its development resulted from the installation of mills and plantations with saplings brought by the Portuguese. By the end of the 16th Century, the states of Pernambuco and Bahia had more than one hundred mills, with the crop flourishing in such a manner that by 1650 Brazil was the world's largest sugar producer, with great penetration in the European market.

Almost half of the world production of sugarcane is currently concentrated in four countries of the Americas: Brazil, Cuba, Mexico and the United States. In ranking of harvest importance, Asian countries like India, China and the Philippines follow.

In Brazil, after the 1970s, the oil crisis led to the intense production of ethanol, derived from sugarcane, for direct use in combustion engines (hydrated), or mixed with gasoline (anhydrous). Through incentives provided by the Pro-Alcohol Program, areas that once produced soy bean, beans, corn and oranges, among other crops, have become sugar and alcohol agroindustries. Ever since, the alcohol fuels departing from modern distilleries to many points in the city, have replaced the old mills, and thus began to absorb a considerable part of this raw material once mainly used for sugar extraction.

Among the studies already conducted on the burning of sugarcane, the use of fire in agriculture has been condemned for more than a century by soil conservation manuals and soil science. However, the use of burning to remove forest and fields is a millenary practice aimed at implementing pastures and crops. (FERREIRA, 1991).

Since the 1970s, the environmental issues have been permeating discussion about humanity’s great problems. In the state of São Paulo, pressure about the sugarcane burning problem by non-governmental organizations, environmentalists, civil society and state environmental entities resulted in state law 11.241 of September 19, 2002, on the elimination of field burning.

However, this law was only regulated with decree 47.700. After that the necessary procedures and criteria were implemented for sugarcane burning, respecting the temperature and relative humidity conditions in the region in order to avoid risks to the population, or when air quality reaches provenly harmful indexes for human health, as per the law. Burning was thus authorized until 2031.

In 2007, during the Ethanol Summit-São Paulo, an Agro-Environmental protocol was established between the government of the state of São Paulo and Única, the sugar and alcohol sector representative. The objective is to reduce the burning of sugarcane straw in a shorter period than projected in law 11.241/02, respectively 2014 and 2017, for areas considered mechanizable and non-mechanizable.

Nevertheless, inhabitants of areas neighboring producing regions would still have a long period of exposure to pollutants launched into the atmosphere by the biomass combustion process (table 1).

Table 1 - Main products emitted in the different phases of biomass combustion

Flaming Stage	**Intermediate**	**Smoldering Stage**
Carbon dioxide (CO_2) Nitric oxide (NO) Sulfur dioxide (SO_2) Nitrous oxide (N_2O) Nitrogen (N_2) Particles with high % of elementary carbon	Acetylene (C_2H_2) Cyanogen (NCCN)	Carbon monoxide (CO) Methane (CH_4) Hydrocarbonates (HC, HPA) Ammonia (NH_3) Hydrogen cyanide (HCN) Methyl Cyanide (CH_3CN) Amines, Heterocyclics, Amino acids Methyl chloride (CH_3CL) Sulfurated compounds (H_2S, DMS, DMDS, COS) Particles with low % of elementary carbon

Source: Arbex, 2004.

The sugarcane combustion process occurs in three stages: ignition, is the initial process where there is a small flame; flaming, combustion is more efficient and there are emissions of CO_2, H_20, N_2, No_x and SO_2. In the third stage, smoldering, the low temperature and absence of flame process, incompletely oxidated compounds are emitted (CO, CH_4 and other hydrocarbonates). Such processes involve different chemical reaction and as a consequence produce different products, depending on the proportion of flaming/smoldering. The characteristic of the biomass (arrangement, size, distribution, mixture, chemical composition) affects the duration of each combustion phase.

According to Lobert (apud ARBEX, 2004), the greatest potential of biomass combustion, 80%, occurs in the tropics and it is the largest producer of toxic gases, particulate material (soot, smaller than 0.1 cm), and greenhouse gases on the planet. The exposure of living beings to these pollutants can produce harmful short and long term effects on human health. During harvest, the weather conditions, which are unfavorable to the respiratory tract physiology, allied with the increase in carbon monoxide and particulate material in the regional atmosphere, aggravate the episodes of respiratory pathologies in intra-urban areas.

Thus, this study used collection, tabulation and statistical treatment of climate data (minimum temperature, rainfall, relative humidity, wind speed) from the Unesp Ourinhos weather station, connected to the CPTEC/INPE and IAC (Campinas Agronomy Institute) Sonda project for 2000 to 2006 as methodological procedures.

Inhalation and hospital admittance data for respiratory diseases were collected at DATASUS and Unimed Ourinhos.

Besides that, CO and particulate material data (mp 2.5) were used from CPTEC/INPE's Regional Atmospheric Modeling System (CATT-BRAMS), which were treated with GRADS software.

The CATT-BRAMS model, developed by Freitas et al. (2003), introduces a transport monitoring system of burning emissions in real time, which was operationally implemented generating CO and MP 2.5 projections.

The methodology is based on joining the transport model to the RAMS - Regional Atmospheric Modeling System. The main transport and tracer removal processes in the sub-grade scale are parameterized and transport simulation is conducted together with the evolution of atmospheric state.

According to Hoelzemann et al. (2007), for these emissions to be well-represented in the CATT-BRAMS model, they are calculated daily by 3BEM - Brazilian Biomass Burning Emission Model, CPTEC, (FREITAS et al., 2005, 2006) based on heat focal points identified by remote sensoring.

The model helps in the diagnosis of total CO and M.P 2.5 in the troposphere, and in local scale studies. In this case, it can contribute with an episodic analysis of the relation between air pollution and respiratory morbidity.

The acute air pollution episodes were diagnosed as per the CONAMA 03/90 resolution for April to December 2005. With the exception of November, which received three states of attention, all the other months received states of attention, warning and emergency regarding carbon monoxide (CO). Particulate material 2.5 was not classified as acute concentration, but in July, August, September and October it reached the secondary standard of 60ug/m3 (Figures 2 and 3).

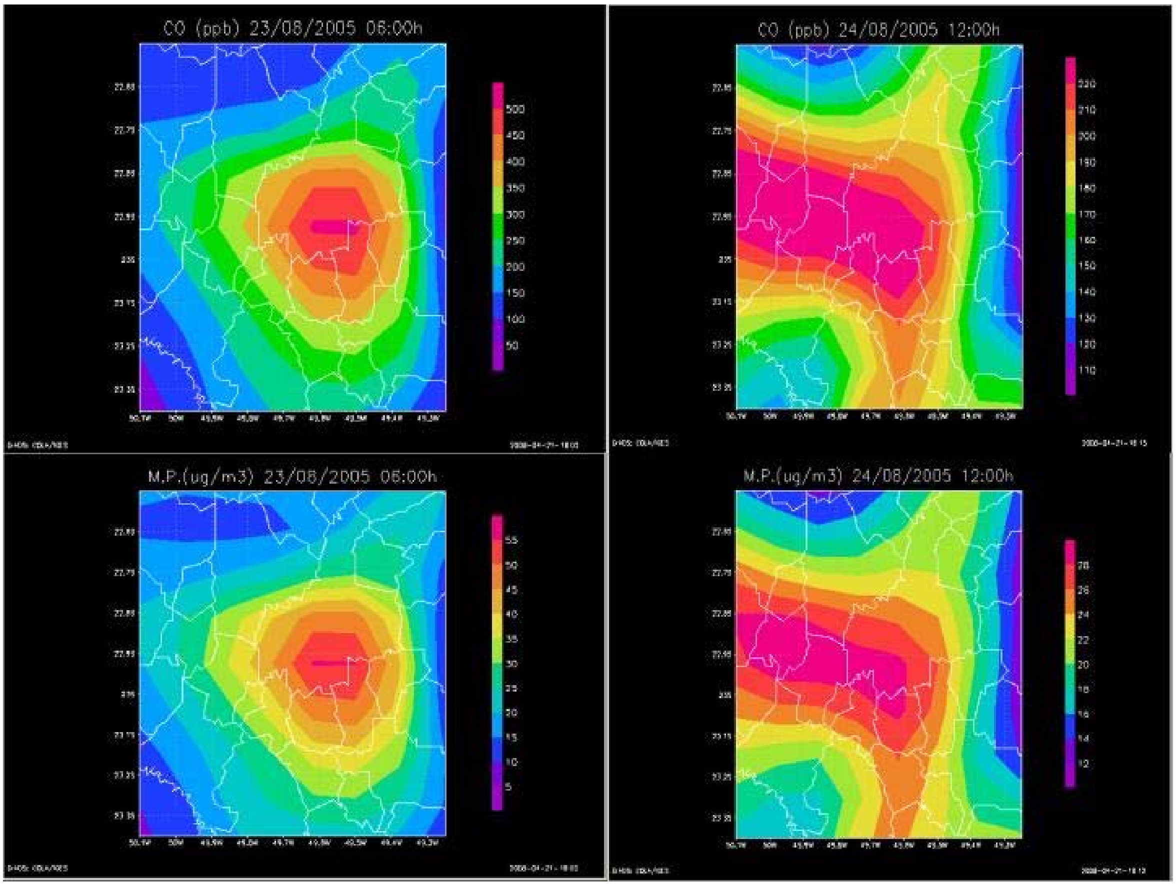

Figure 2 - Emergency episodes of CO (ppb), and concentration of particulate material 2.5 (ug/m3)

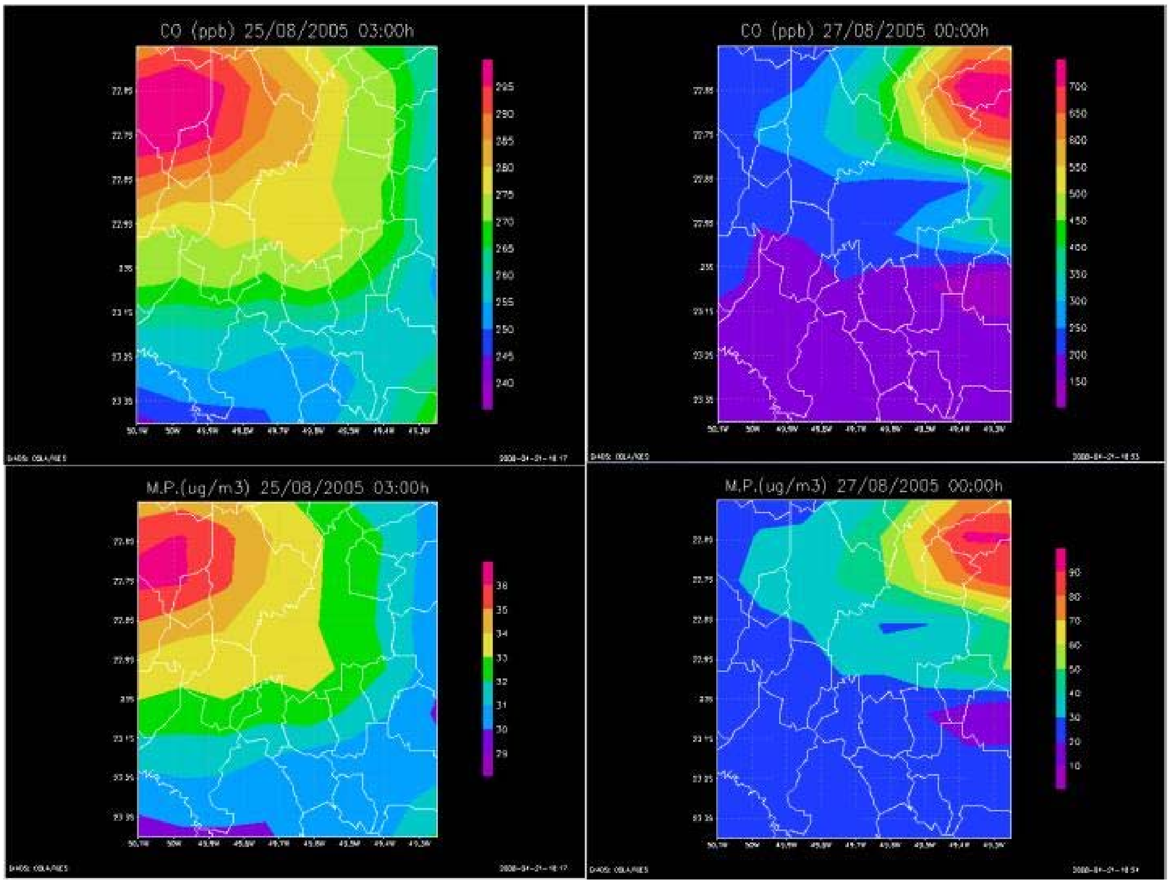

Figure 3 - Emergency and attention episodes of CO (ppb), and concentration of P.M. 2.5 (ug/m3)

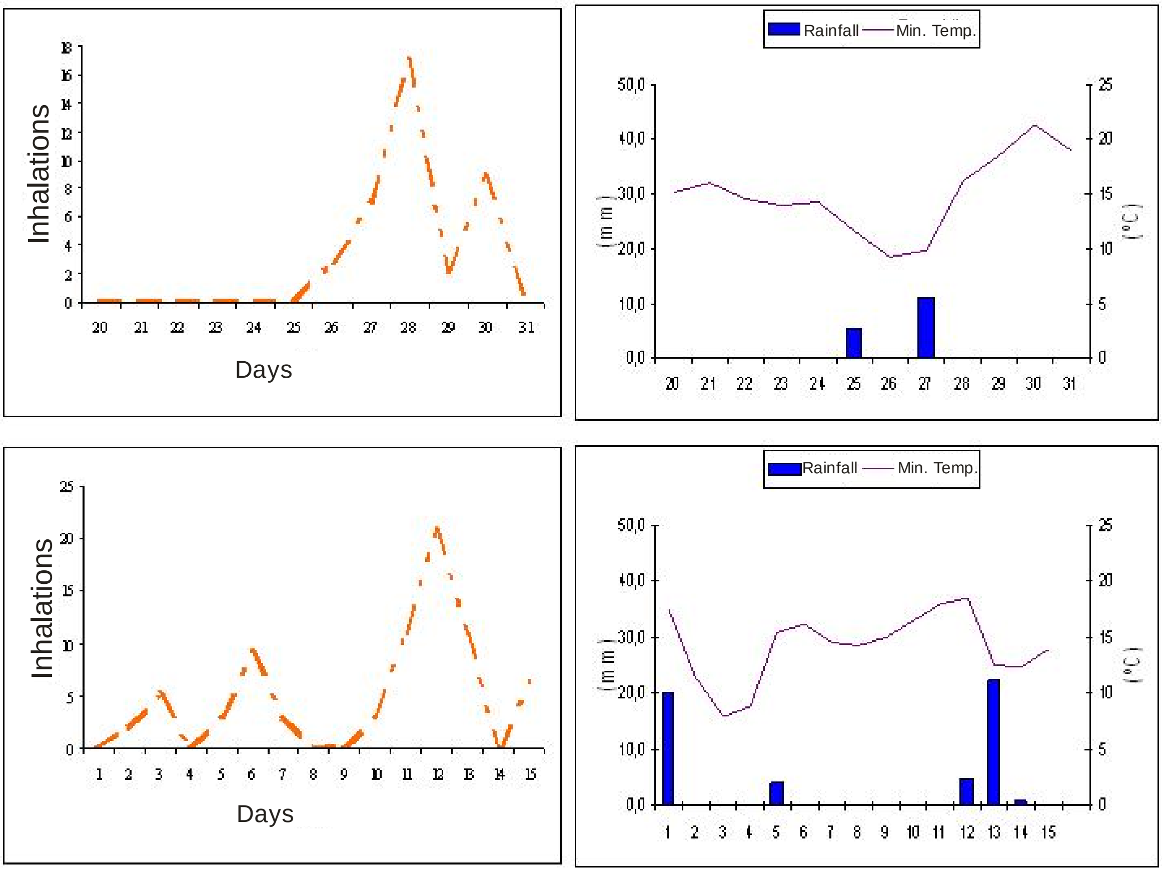

Figure 4 - Climate elements and inhalations from 8/20/2005 to 8/31/2005; Climate elements and inhalations from 9/1/2005 to 9/15/2005

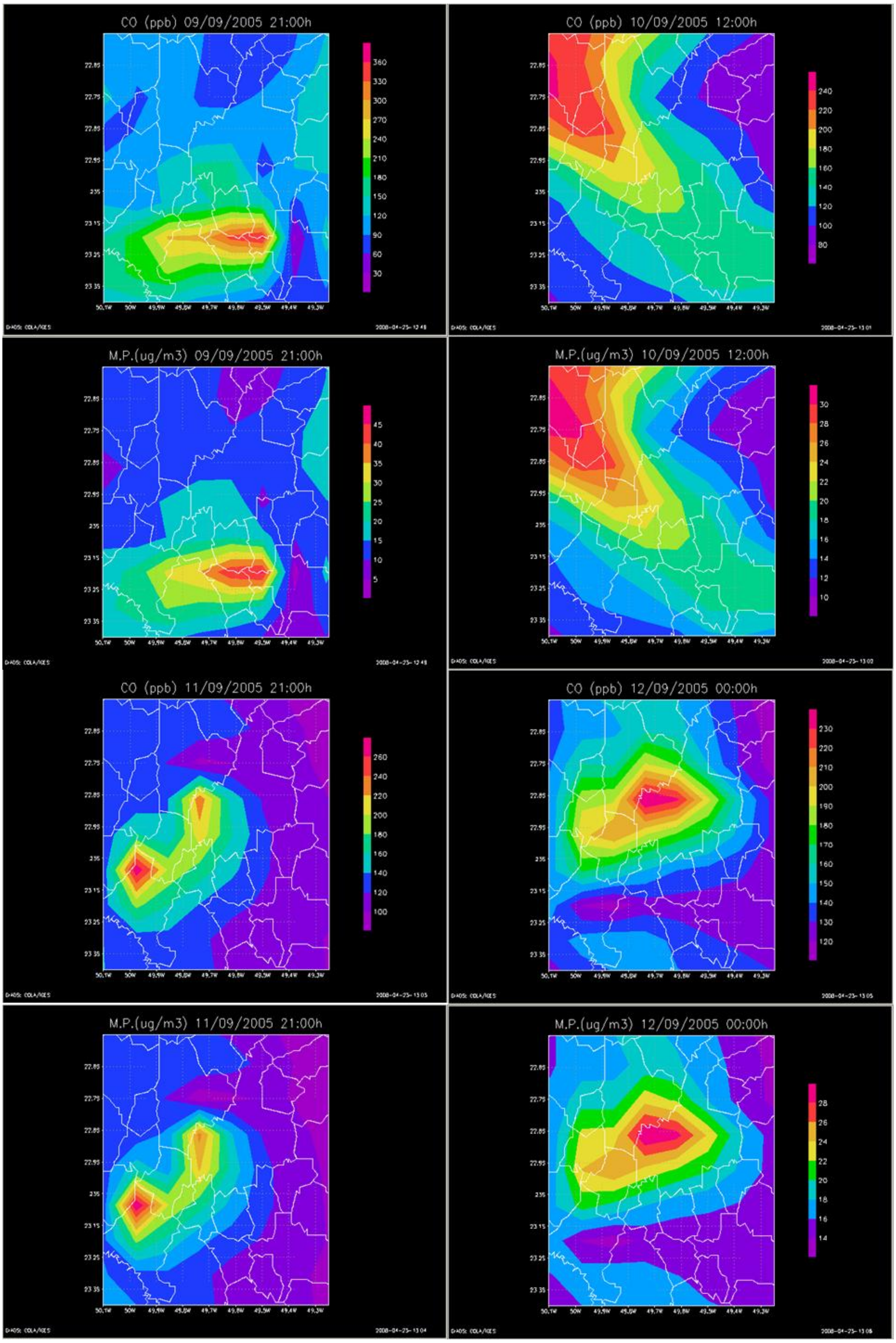

Figure 5 - Emergency and warning episodes of CO (ppb), and concentration of P.M. 2.5 (ug/m3)

In August, it can be observed that after four days of high concentrations of carbon monoxide in the air, there is an increase in the number of inhalations in the city, allied with a drop in temperature during this period.

According to Balbani et al. (2002), the occurrence of obstructive pulmonary disease is related to the high concentration of carbon monoxide in the air being breathed. Carbon monoxide is involved in airway inflammation. Research on the gas should intensify because its physiological role in the respiratory tract is still not fully explained.

In September, the episode after two days of high concentration of carbon monoxide, there is an increase in inhalation care.

Concentrations of the variables in the atmosphere were not very intense in the following days due to the rainfall in the city on September 12 and 13.

The concentration of particulate material did not reach the limits considered to be acute in relation to air pollution. It is worth mentioning that the predisposition of individuals to respiratory pathologies, mainly due to physiological conditions, such as children and the elderly, helps to understand that with the high concentration of carbon monoxide and particulate material 2.5 reaching secondary standards for a few days, they become potentially harmful to the well-being of the physiological system, increasing inhalation care in the city.

> *"increasingly more evident signs show the air quality standards are inappropriate for protecting the population that is more susceptible to air pollution. Several studies demonstrate the occurrence of morbid effects at concentrations below these air quality standards." (BRAGA, 2007).*

The particulate material is a mixture of liquid and solid particles suspended in the air. Their composition and size depend on emission sources. Particle size is expressed in relation to aerodynamic size, defined as the diameter of a dense sphere that has the same velocity of sedimentation as the particle in question (FREITAS apud DOCKERY; POPE, 1994).

The particles occur in several sizes and shapes and are classified as fine particulates, those with diameters under 2.5u and thick particulates, with diameters from 2.5 to 3.0u.

The fine particulates we analyzed in this study are more important because they can be inhaled by humans, causing drying of the nasal mucosa, easily deposit on the lungs and are the most responsible for the inflammatory process. Some physiological defense mechanisms try to expel this material, such as the sneeze, the cough that occurs when there is an invasion by these particles of the lower respiratory tract, as well as the larynx. Besides that, there is the defense mechanism of nasal mucous secretion.

The carbon monoxide, also evaluated in this study, is associated with intoxications. Experiments have focused on its effects, mainly on the heart.

According to Braga et al. (2007), despite the scarce physiopathological substrate, several authors have found an association between the increase in respiratory tract disease and CO levels. This finding probably reflects the high correlation between particulate material and carbon monoxide, which in this study can indicate they directly influence the manifestation of prevalent symptoms related to respiratory pathologies.

ENVIRONMENTAL PERCEPTION

According to data from the Municipal Secretary of Health, the main pathologies responsible for hospital in-patient care are? Pulmonary insufficiency, Chronic obstructive pulmonary disease, Lobar Pneumonia, Bronchial Pneumonia. Besides that, the data for all inhalation treatments at each Basic Health Unit (UBS) in the city of Ourinhos were collected and analyzed. Five areas covered by the UBS treated a wide range of people who needed the inhalation service, thus social-environmental risks this part of the population is exposed to should be analyzed.

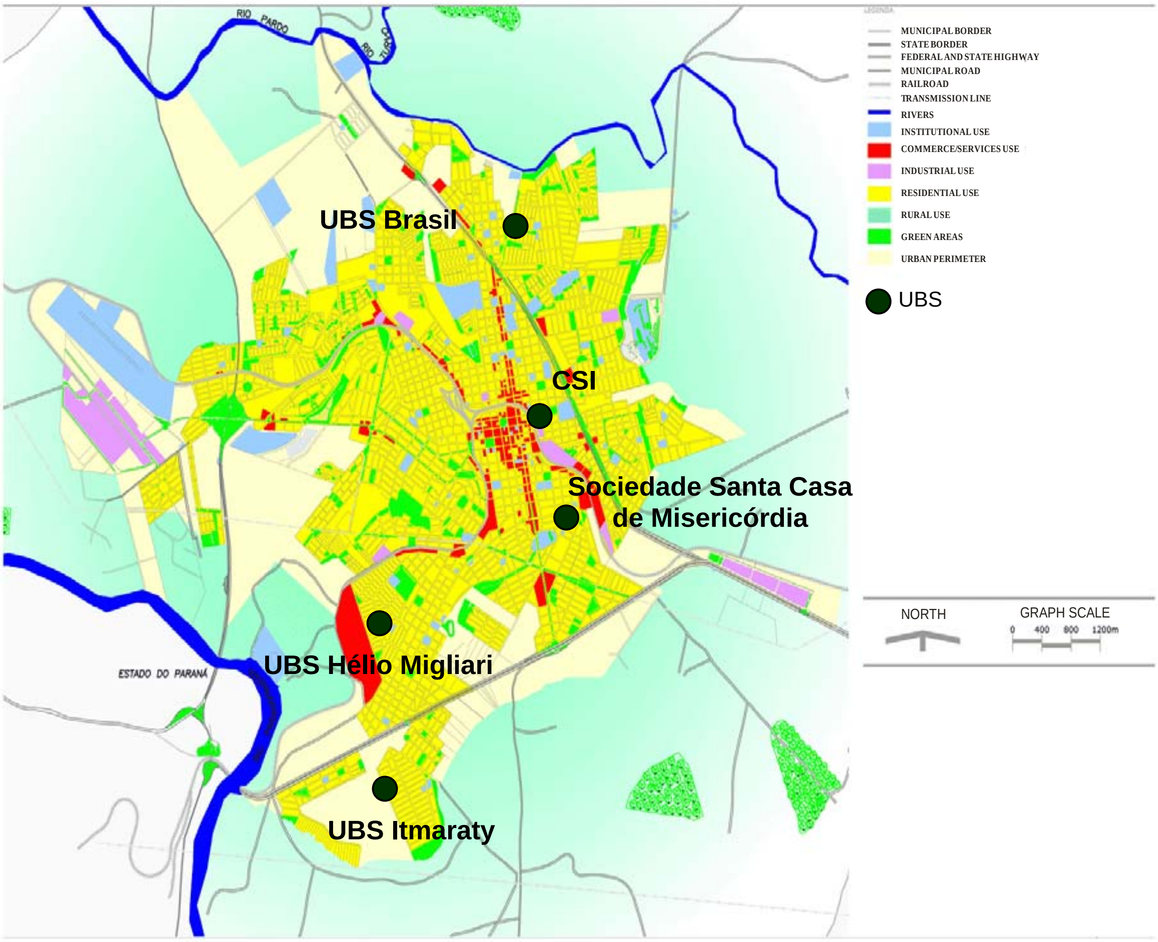

Figure 6 - Location of the five UBS chosen/used and land occupation

Source: Ourinhos City Hall. Org.: Aleixo, N.

The perception of the city residents regarding this problem was conducted through interviews with 400 residents in the respective areas of UBS service in Ourinhos. Of this total, 160 interviews were conducted with students in the 3rd grade of elementary school from municipal schools in these areas since the main age group for in-patient hospital care due to respiratory disease was from 0 to 9.

Burning was the main social-environmental problem ranked by the population, which blames the sugarcane agroindustry for the city's air pollution.

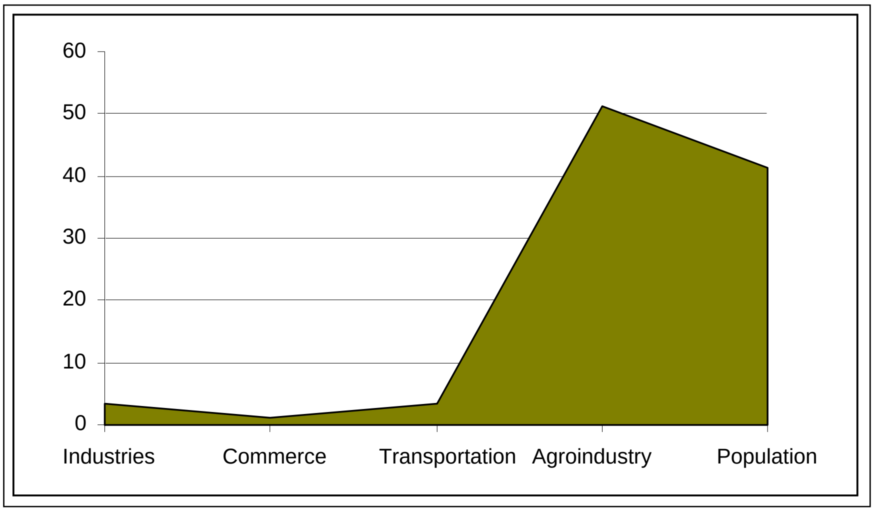

Figure 7 – Main source of pollution in Ourinhos

In the schools, 86.25% of the students interviewed had already contracted some respiratory pathology, mainly bronchitis, whose occurrence is mainly related to air pollution, followed by sinusitis, which is mainly related to the variation in the types of weather.

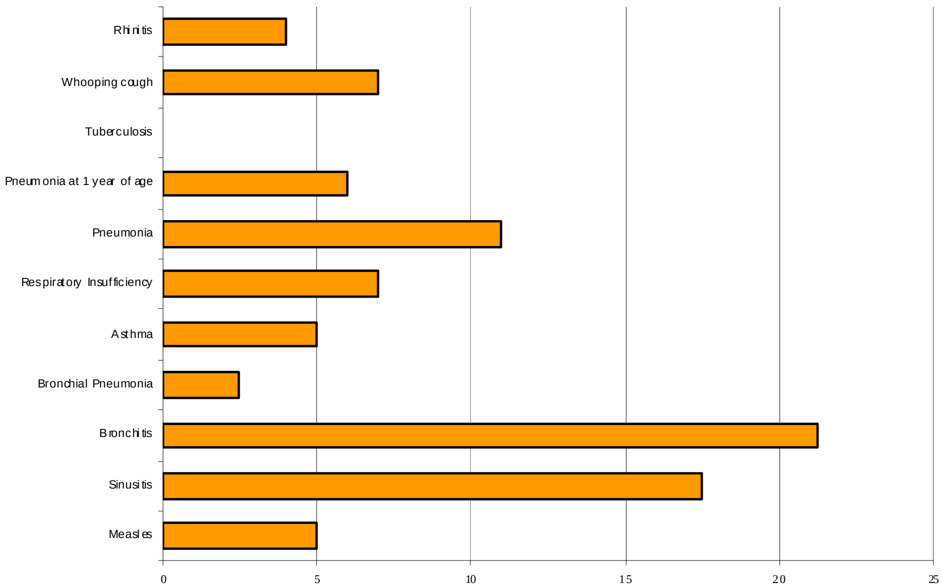

Figure 8 - Respiratory pathologies contracted by interviewed students

CONCLUSION

Three episodes were identified in the city that data analysis demonstrates having a high correlation between prolonged dry season episodes, CO above 500 (ppb) and increase in the number of inhalations in subsequent days. This shows that besides influencing the balance of energy between the surface and the atmosphere, these gases also affect natural landscape and the population vulnerable to the acute effects on health.

The prevalent symptoms in children aged 9 indicate a strong relation of bronchial disease, mainly linked to air pollution, and those prevalent in variations in types of weather like sinusitis. However, most residents notice that the dry season allied with the burning of sugarcane is potentially aggravating to the respiratory tract, thus, they define sugar and alcohol activity as the main agent for pollution in the city.

Thus, it is fundamental to use environmental management as a resource for sustainability of this agriculture activity in order to expand the sugar and alcohol industry.

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CLIMATE CHANGE AND URBAN SUSTAINABILITY OF CHILEAN METROPOLITAN CITIES

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ABSTRACT

Cities are at the same time cause and effect of climate change. Climate Change processes and effects should mainly affect Latin American cities, where most of the population and economic activities are concentrated. Urban climate changes are associated to urban heat island generation and development, and to hydrologic cycle alterations, particularly in terms of Area Total Imperviousness and Runoff Coefficients caused by watershed urbanization. City climate changes are a result of urban sprawl process that affect Chilean Metropolitan Areas (Valparaíso and Santiago). Land use/cover changes related with development of urban heat islands and micro-islands are analyzed in Santiago city on the basis of satellite images and measurement mobile transects. Changes in total imperviousness and runoff coefficients linked to urban sprawl are presented like main outcomes of Valparaiso expansion over hills and streams. Finally, spatial relationships between air temperatures, air pollution and socioeconomic population levels are used to demonstrate that urban climate changes have strong social components and that they are part of the socioenvironmental segregation that characterize Latin American cities.

Keywords: Urban climate changes, Urban sustainability, Chilean metropolitan areas.

INTRODUCTION

Cities are at the same time cause and effect of climate change. Climate Change processes and effects should mainly affect Latin American cities, where most of the population and economic activities are concentrated. Heat waves, natural hazards and a lack of available drinkable water could be predicted everywhere. Simultaneously, Latin American cities concentrate greenhouse gases sources and their industries and vehicles produce large amounts of Carbon Dioxide, hydrocarbons, methane and other warming pollutants to the atmosphere. Additionally, cities are themselves a relevant heat source due to the continuous functioning of motors that move their industries, transports, and domestic heaters, and specially because the generation of urban heat islands.

Urban spaces are a complex mosaic of heat islands as a consequence of large capacity of built up surfaces for storing direct solar radiation, and latterly, to release it to the urban atmosphere. Urban temperatures are generally higher that rural temperatures, and the origin and diffusion of heat islands is one of the most apparent consequences of urban sprawl that gradually and permanently, substitutes natural land uses and covers by paved ground, altering energy balances and hydrologic cycles. Rainfall is no more infiltrated into soils, runoff increases and cities are increasingly affected by floods. Due to imperviousness, cities are each time more affected by flooding with less rainfall and in a shorter time. Land imperviousness and the substitution of vegetal covers (natural and cultivated) strongly reduce evapotranspiration and atmospheric heat shrinking. This, in turn, strengths urban heat islands and eliminates urban cold islands. The resulting thermal homogenization of the urban atmosphere interrupts air cooling and cleaning functions of local brizes and winds. As a consequence, urban atmosphere concentrates air pollution and in turn, heat accumulation, forcing the use of cooling devices that need electricity, that again, produce more greenhouse gases and air pollution.

Urban climates, like urban environments, should be considered a social construction. The city, its climates and its environments represent the existing social structure and then, a welfare uneven distribution. In Latin America, in general, and in Chile in particular, urban spaces are socially extremely unequal, and the prevailing social segregation is also environmental segregation. In Chilean cities there are urban environments, climates and air qualities that vary according to the economic income of the population. Chilean cities are true examples of social injustice because the poorer and more vulnerable areas suffer disproportionally, the negative effects of natural hazards and air pollution.

Then, climate change effects on urban population should also be socially assessed. Warmer neighborhoods, where poorer people live, almost always without green areas, concentrate polluted air plumes and, as a result, higher proportion of respiratory diseases. Natural hazards, on other hand, need to be also understood like social risks. Although natural threatens, like heavy rainfall, could cover the whole city, the occurrence of floods, depend from social vulnerability, and then, from socio-environmental segregation and social lack of justice.

URBAN SPRAWL AND URBAN CLIMATE CHANGE IN SANTIAGO

Since nearly three decades, Santiago, the six million inhabitants Chilean capital city, has experienced an explosive growth of urban land uses, which has increased near thirty thousand hectares, passing from 34.000 in 1975 to 65.000 in year 2005 (ROMERO et al., 2006). Most developed urban land uses correspond to high and low density residential and industrial zones, like could be observed in Figure 1. Lower density urbanizations have substituted mainly natural landscapes covered with dense and sparse vegetation located at the eastern part. On contrast, higher density residential areas have mainly occupied previous agricultural lands located at western sides.

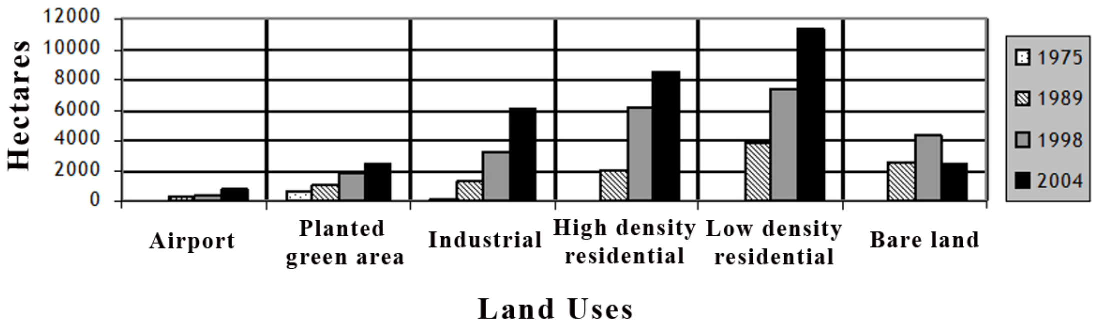


Figure 1 - Santiago city urban land uses changes between 1975 and 2005

Natural covers substitution by urban land uses strongly affect the city environment (PICKETT et al., 2001; WITHFORD et al., 2001). One of the most relevant modifications corresponds to urban climate alterations (PEÑA; ROMERO, 2006; ROMERO; SARRIOCOLEA, 2006), that are a direct result of the disappearance of natural landscapes and vegetation covers that regulate surface and air temperatures in the city, producing a warming process that locate heat islands at the western city border in early morning, which migrate to the historical centre of Santiago during midday and specially, at nights (Figure 2).

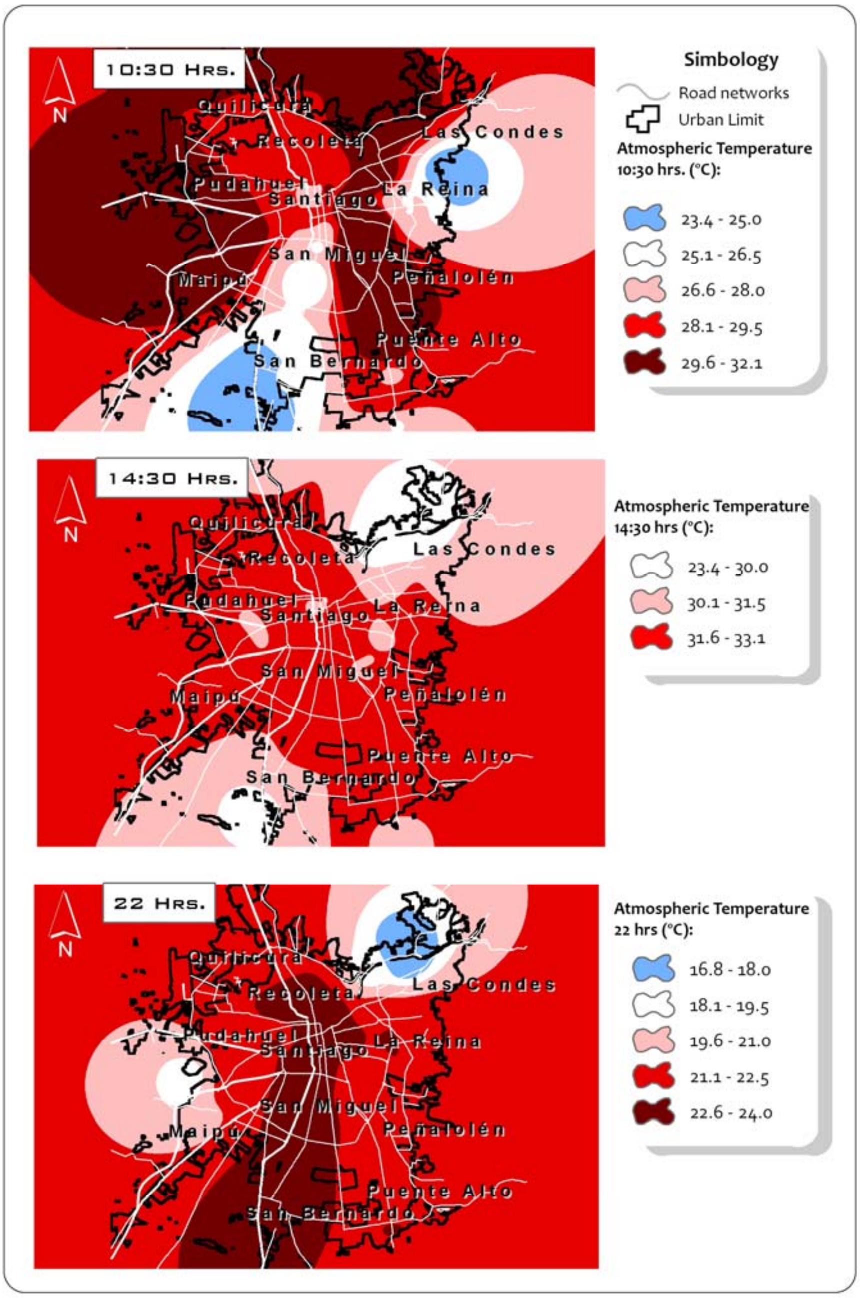


Figure 2 - Air temperatures in Santiago and its daily evolution

Morning warmer temperatures are mainly recorded in the Nonwestern communes (Quilicura, Colina, Pudahuel and Maipú), while in the southern border, San Bernardo and Calera de Tango communes, maintain lower temperatures that are transferred towards the city center trough a climate corridor formed by the Cerrillos airport approaching cone. The rest of the city, and specially the areas near the center, remain cooler during mornings. Figure 2 shows that the urban temperatures distribution begins to change at midday, when they equal and overpass the rural ones. Urban heat islands are located now near the historical center and the surrounding commercial zones. Finally the typical urban heat island centered at historical sites and at the Central Business District could be observed during summer nights.

Spatial relationships between land use, land covers and air temperatures in the city and its daily evolution are presented in Figure 3. Rural areas are warmer than urban areas during early morning (non urban heat islands). However, at midday micro urban heat islands begun to be developed over more built up and impervious areas, such as airports and industrial zones, that reach the hottest temperatures (32,5ºC). At night, these urban heat islands are spatially consolidated at industrial zones, airports and high density urbanizations. A difference of 2ºC is found between residential higher and lower density areas, as a consequence of different percentages of vegetation covers and imperviousness. Cooler or warmer urban neighbors are the result of socioeconomic controls and from urban planning and design, i.e. from human made decisions.

(HONJO et al., 2003; ELIASSON, 1999), have emphasized the role that vegetation and imperviousness play in terms of the climatic performance of the cities. Both factors not only control the spatial distribution of temperatures but also explain micro scale differences between urban zones of similar density or similar land uses (Figure 4). In the case of Santiago, vegetation covers up to 40% explain relevant heat reductions in urban spaces.

Urban planners and managers share important responsibilities on present and future climate changes in the cities. Present situations of poor living quality that suffer most of the urban population –climate discomfort, air pollution, natural hazards, respiratory and environmental diseases- reveal permanent and severe fails in urban planning and management in Latin America, and constitute an urgent plea to solve these accumulative issues.

Imperviousness rates and vegetation covers -both dependent from politic decisions-, must be considered in decision making about land use allocations, urban densities, nature and location of urban parks, green belts and ecologic corridors, thinking in terms of climate control, improving living quality and getting social equity. Like at global scale, urban climate change is not a pure biophysical phenomena but a social, cultural and political issue.

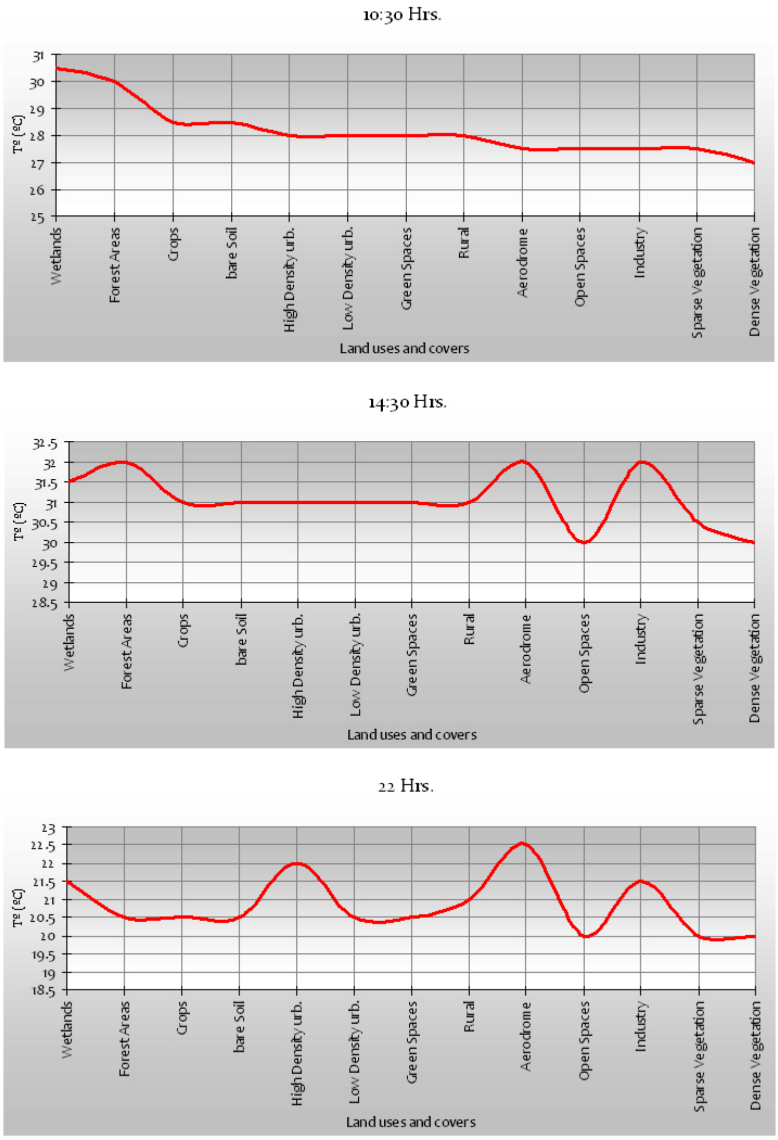


Figure 3 - Spatial relationships between land use, land covers and air temperatures in the city and its daily evolution at Santiago de Chile

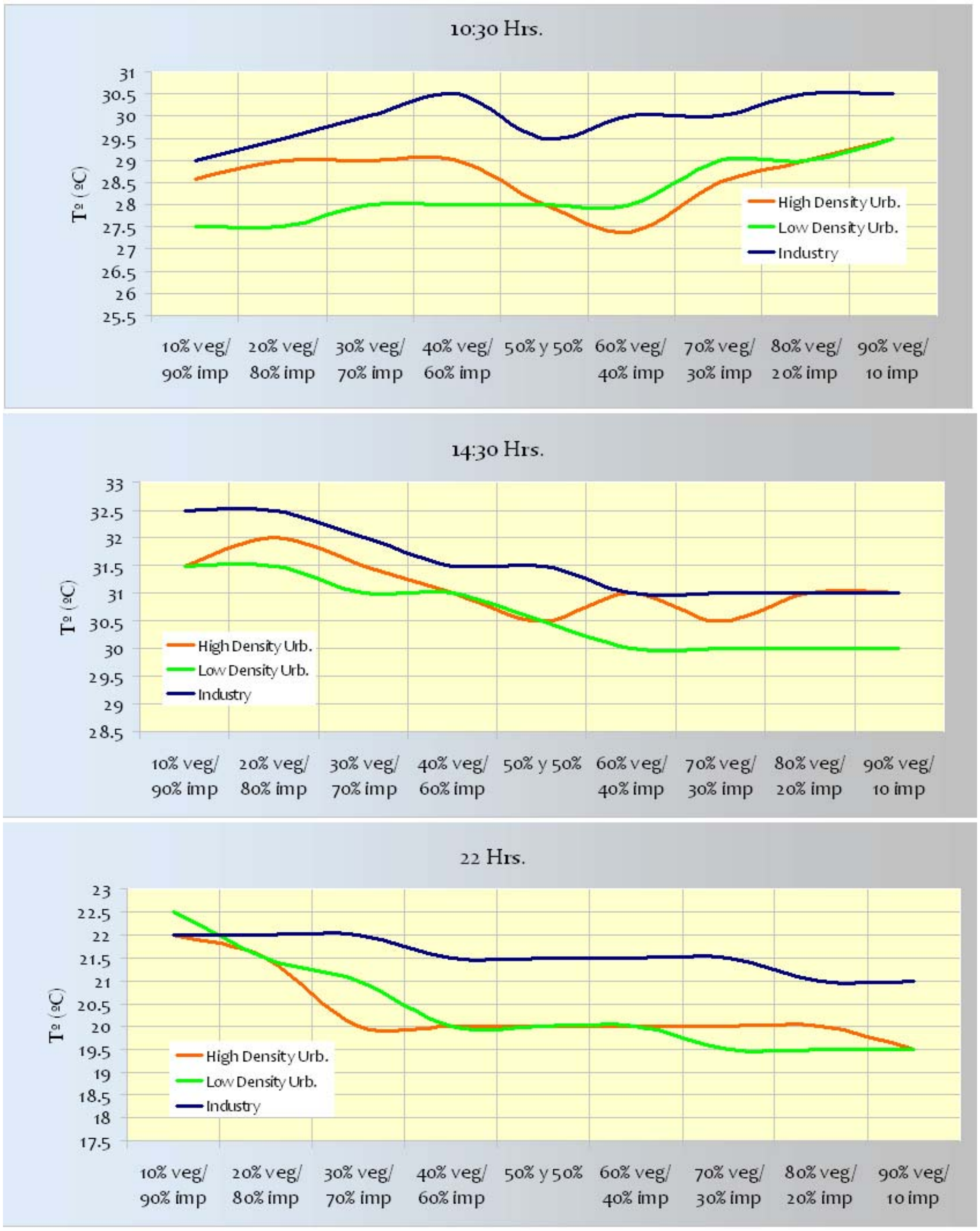


Figure 4 - Air temperatures distribution according to land uses, urban densities, vegetation covers and imperviousness rates at Santiago de Chile

URBAN SPRAWL EFFECTS ON IMPERVIOUSNESS TOTAL AREAS AND RUNOFF COEFFICIENTS AT VALPARAISO

Due to a complex topography, Valparaiso Pacific Ocean port city, reaches extreme levels of urban landscapes heterogeneity. Such complex landscape mosaic is also explained by the continuous human occupation of a series of watershed that are formed by very steep slopes and numerous streams that drain several and successive marine abrasion terraces that could reach up 500 m above sea level, towards a vey narrow flat sedimentation plain.

Watershed urbanization modifies the Total Imperviousness Areas (TIA) or the percentage of watershed surface that has been effectively ceiled by urban land uses, that, finally determines the proportion of rainfall that it is on site infiltrated or runoff down water. Imperviousness rates vary substantially among such lands that are completely covered by vegetation, that infiltrate near 100% of rainfall, and those lands occupied by commercial zones or covered by buildings and high density residential areas where infiltration is almost nothing and water must drain down water.

Imperviousness rates of different land uses and covers determine runoff coefficients, or the amount of water that descend from the slopes. Increasing TIAs and Runoff Coefficients (RC) have depth effects in respect to climate change in the cities. Under most concentrated and seasonally irregular rainfalls, they increase natural hazards in terms of debris flow, floods and landslides, decrease ground water recharges and increase available heat because evaporation reduction. Additionally, because watershed urbanization consist mainly in the substitution of green covers by paved areas, home roofs and walls, disappear several vegetation environmental services that control urban heat island development, filtrate polluted air, and offer wildlife habitats and recreational sites for urban society.

Urban watersheds are a complex mixture of different land covers and land uses. Although their urbanization needs to be carefully planned and managed, most of Valparaiso watershed urbanization has been the result of unplanned and spontaneous occupation, mainly by poorer and more vulnerable social groups. Some quantitative indicators are required to facilitate decision making and to monitor the performance of these urban spaces, particularly under great climate uncertainties. TIAs allow the consideration of different land uses management because they weight the imperviousness rates of housing, roads, parks and other urban lands, according to the surface that they occupy in the watershed. An intensification caused water up by social housing construction could be compensated by infiltration green areas located down water.

In Valparaiso, there are still large natural vegetation covers in the watersheds. However, the continuous urban sprawl process is progressing slope up, increasing TIAs and RCs (DIETZ, CLAUSEN, 2008), like could be observed in Figure 5, which corresponds to the evolution of Subida de Yolanda neighborhood, an urban area overlapping the older natural stream.

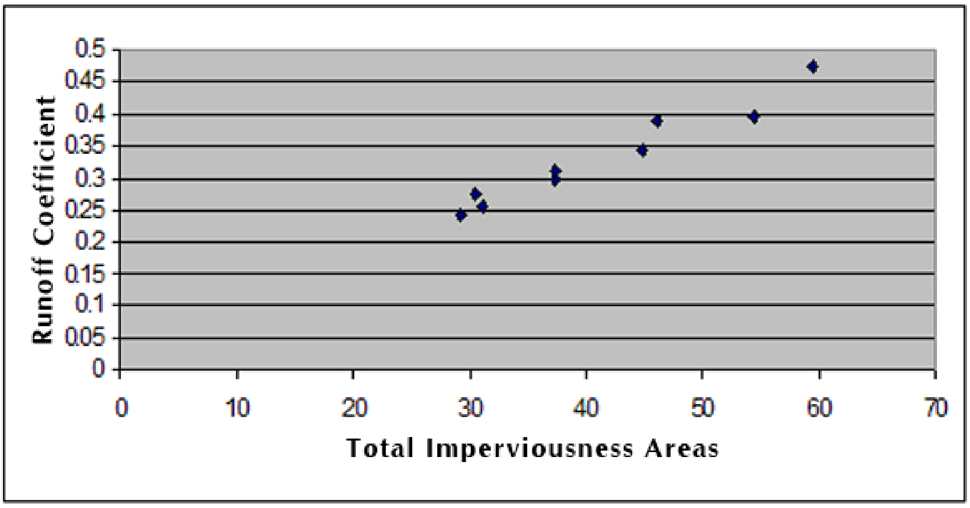
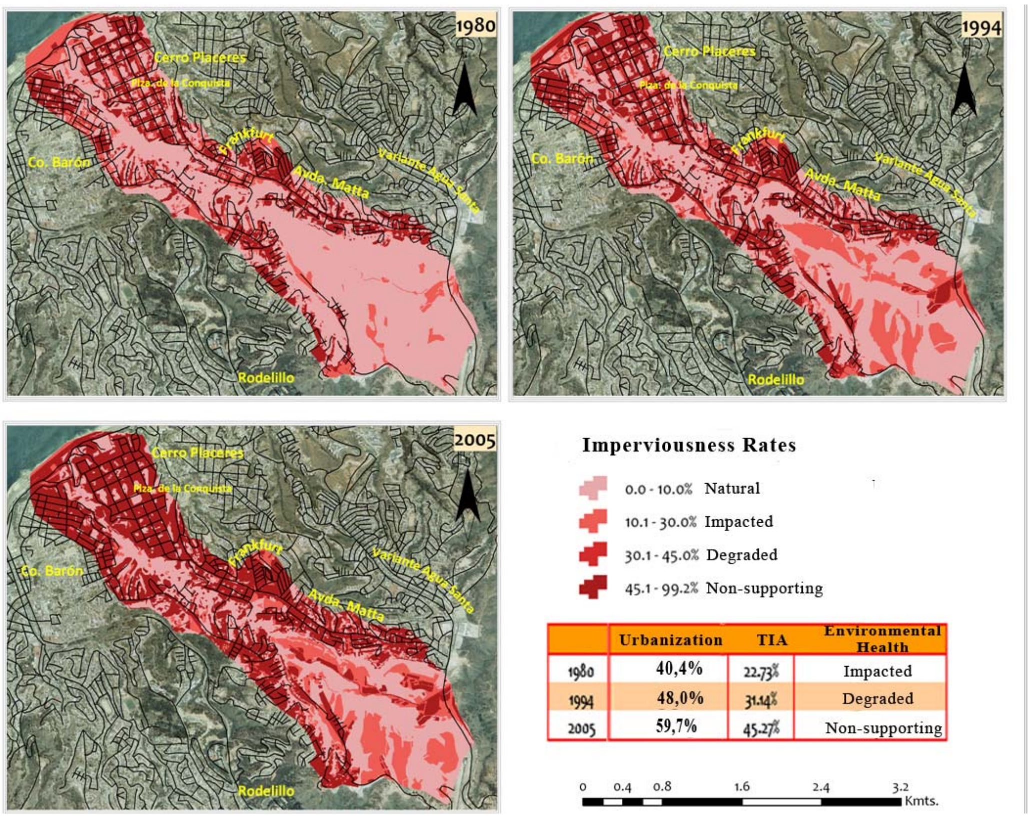


Figure 5 - Correlation between Total Impervious Areas and Runoff Coefficients at Subida de Yolanda neighborhood at Valparaiso in 2005

Table 1 - Imperviousness rates and land uses and covers in Subida de Yolanda neighborhood at Valparaiso

Land Uses and Covers	Imperviousness Rate (%)
Planted green area	4.6
Bare land	19.8
High density residential	89.2
Low density residential	66.4
Commercial	81.1
Industrial	80.8
Primary roads	99.2
Secondary roads	85.6
Dense natural vegetation	0.7
Sparse natural vegetation	4.1
Cleared spaces	17.1
Streams	0.0

Table 1 indicates imperviousness rates for each land use and land cover that occupied at 2005 the Subida de Yolanda neighbor, following the model proposed by Stanuikynas & Van Abs (2000). Figure 6 illustrates about land uses and cover changes that have taken place in this Valparaiso urban watershed between 1980 and 2005, and the State of the Urban Watershed Environmental Health, according to Arnold & Gibson (1996) classification.



	Urbanization	TIA	Environmental Health
1980	40,4%	22,73%	Impacted
1994	48,0%	31,14%	Degraded
2005	59,7%	45,27%	Non-supporting

Figure 6 - Environmental Health of Valparaiso Subida de Yolanda neighbor changes between 1980 and 2005

Subida de Yolanda watershed urbanization has systematically increased impervious total areas. In 1980 they covered 22,73% of the watershed surface. In 1994, urbanization reached 31,14% and in 2005, 45,27% of the watershed the total surface was impervious, demonstrating large difficulties to get a real sustainable urban development along this typical and emblematic urban landscape of Valparaiso and many other coastal cities, either in Chile and Brazil (MENDONÇA; LOMBARDO, 2009; MENDONÇA; ROMERO, 2008). Some urbanizations have been installed at slopes higher than 60º, meaning an important social risk, especially in respect to landslides and avalanches that have always occurred, killing many people and destroying homes and urban infrastructure. It is important to take into consideration that climate change predicts a large rainfall concentration for this part of the country. In Valparaiso, under Mediterranean climate types, annual average rainfall is around 400 mm that precipitate in 30 days, recorded only between May and August.

Extraordinary daily rainfall concentration should be considered for the estimation of runoff coefficients, following the Curve Number Method proposed by Torres (2004). Mean maximum storm precipitation for Valparaiso in 24 hours is estimated in 82.7mm. Table 2 shows the runoff coefficients for each of the main land uses and covers at one representative Valparaiso´s urban watershed.

Table 2 - Runoff coefficients for different land uses and covers in Subida Yolanda neighborhood at Valparaiso in year 2005

Land Use and Cover	RC
Planted green areas	0.143
Bare land	0.249
High density residential	0.738
Low density residential	0.554
Commercial	0.738
Industrial	0.628
Primary roads	0.928
Secondary roads	0.738
Dense natural vegetation	0.082
Sparse natural vegetation	0.110
Cleared spaces	0.206
Streams	1.000

Again, unplanned and mismanaged watershed urbanization has caused a relevant increase in runoff, passing from 0,23% in 1980, to 0,29% in 1994 and 0,38% in 2005 (Figure 7). Reasons to understand why Valparaiso is suffering more frequent and rapid floods could be related with increasing runoff coefficients caused by uncontrolled watershed urbanization.

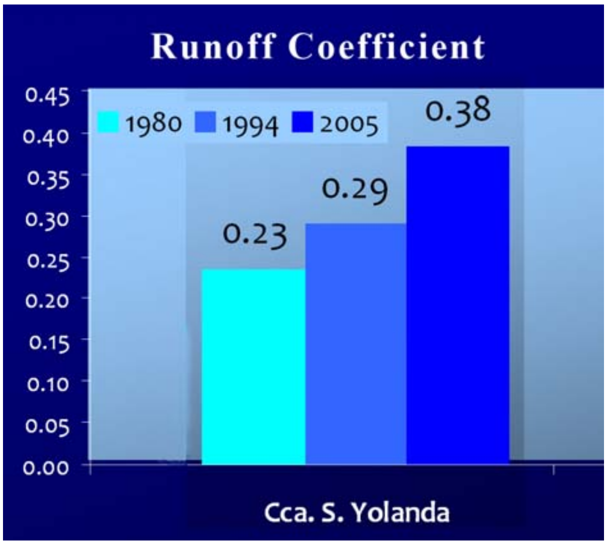


Figure 7 - Runoff coefficient changes between 1980 and 2005 in Valparaiso Subida de Yolanda neighborhood

SPATIAL RELATIONSHIPS BETWEEN URBAN TEMPERATURES, AIR POLLUTION AND SOCIOECONOMIC INDICATORS

It has been already mentioned that urban Santiago´s heat islands and air temperatures demonstrate a daily distribution. Air temperature are higher at the western border of the city during early morning and cooler at night. Conversely, the centre of the city is cooler at the morning and warmer at night time. Comparing both locations, temperatures daily oscillations are higher at the western side of the city. Temperatures spatial distribution is also correlated with air pollution. Figure 8a shows that a logarithmic model explains 86% of their variance. Nigh time concentrations of Micro Particulate Matter (PM10 or particulates >10um), increases with temperature, particularly between 19 and 22ºC. It means that air pollution is concentrated in the centre of the city during night and in the western border during earlier mornings.

Figure 8b relates urban temperatures with the population socioeconomic distribution in the city. A R^2=0,819 indicates that both variables strongly correlate. Higher income population reaches lower urban temperatures because their homes are mainly lower density and have numerous green areas around. The upper class (ABC1) is the only social group that can get moderate temperatures during summer nights as a result of the concentration of urban amenities at their exclusive and segregated neighborhoods. Other social classes (medium C2 and

C3) have intermediate temperatures and do not show large variations. The used logarithmic correlation model has overestimated temperature in areas occupied by lower social classes.

Air quality, represented by micro particulate matter distribution, is also meaningfully related to socioeconomic distribution in Santiago, either in summer and winter season nights (R2=0.842 y 0.791, respectively). In summer night (Figure 8c), when air quality is good in the entire city, micro particulate matter is even lower in areas where richer people (ABC1) live. Such better environmental quality at urban zones where live the most affluent people, is also corroborated on winter season, when air pollution is the most relevant environmental issue in Santiago (Figure 8d). At winter nights, only the urban areas where richer people reside could have a good quality air. The rest of the city presents a fair quality where medium classes live, or definitively, a bad quality where lower middle class and poor people live.

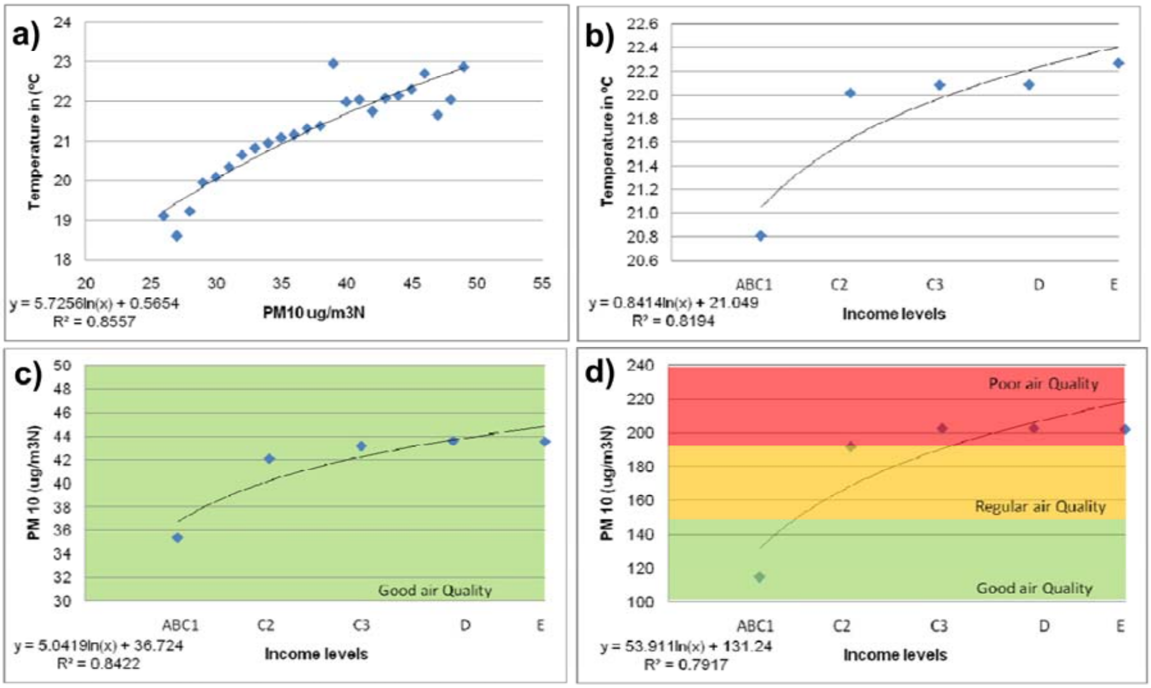


Figure 8 - Relationships between air temperatures, Particulate Matter and Socioeconomic levels at Santiago de Chile

Figure 9a represents the socioeconomic distribution of Santiago's population. Santiago is a very socially segregated city since different social classes tend to occupy very specific urban areas. Richer people (ABC1 groups) are concentrated at eastern and northeastern areas, and the poorest sectors in the nonwestern sectors. Upper middle class groups are extending in axes towards the western and southern sectors, showing a new trend of spatial diffusion since 1990.

Higher land values and scarce available lands in the eastern side, seems to explain this new spatial behavior.

Figure 9b shows that air pollution distribution follows socioeconomic distribution. Concentrations of micro particulate matter are lower at northeastern areas, exactly where richer people live, and higher at the western side of the city, where inhabit most of the poorer people.

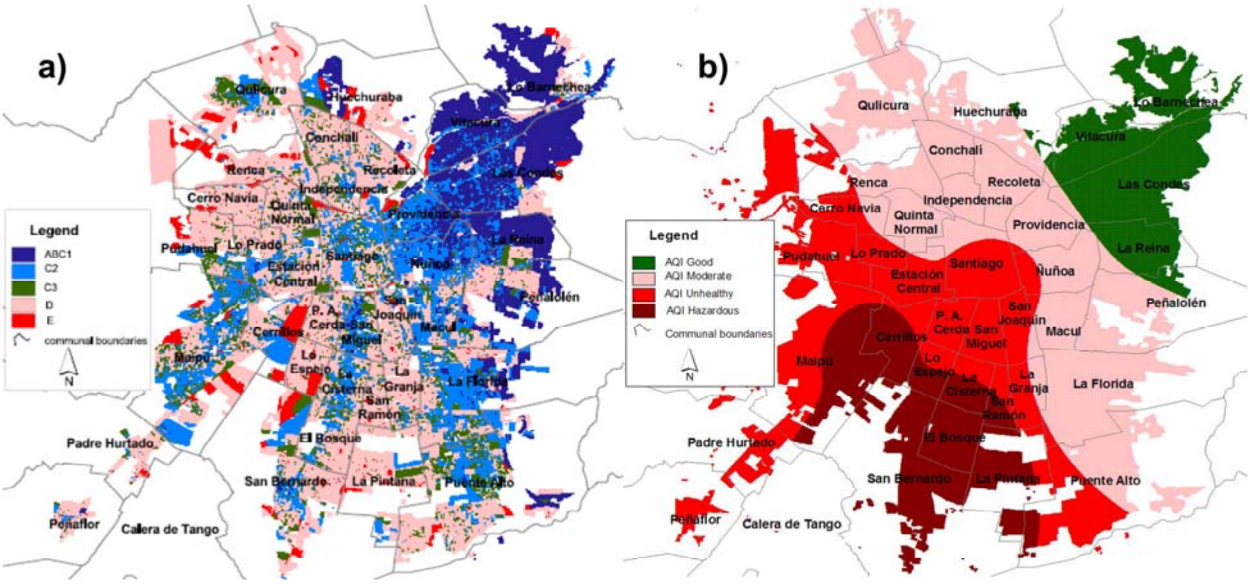


Figure 9 - a) Socioeconomic and b) Particulate Matter distribution at 21 hours in winter at Santiago

CONCLUSIONS

Climate change is evident in the Chilean large cities. Urban sprawl promotes the generation of heat islands and gradually eliminates cool islands, homogenize land surface and reduce local winds and brizes. Urban climate change is caused by heat accumulation on impervious surfaces that are a result of the continuous urbanization of natural and agricultural land uses and covers. Heat islands can cause thermal discomfort, secondary pollutants and heat weaves, and in turn, they promote air pollution because the use of cooling devices to reduce heat in urban spaces. Urban planning and management are not taking into consideration climate change in urban climates programs. On the contrary, lack of urban planning and management are allowing an uncared watershed urbanization on such complex topography of coastal cities, like it is represented by Valparaiso. Uncontrolled urbanization is changing imperviousness rates and runoff coefficients, increasing the occurrence of natural hazards, such as floods, landslides and avalanches. Natural threatens are exacerbated by social vulnerabilities and the lack of institutional commitment with environmental perturbations.

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CONSEQUENCES ON NATURAL SYSTEM

EXTREME PLUVIAL IMPACTS AND THEIR SOCIO-ENVIRONMENTAL REPERCUSSION ON THE NORTHERN SÃO PAULO COAST

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ABSTRACT

The coastline slopes have been the stage of an disorderly occupation and consequently a degradation without precedents, favoring the pluvial impacts that cause the mass movement and flooding processes which go from the natural geomorphologic action to the anthropic. Thus, this paper concentrates on the Northern São Paulo Coast, located between the Serras do Mar and Juqueriquerê and São Sebastião Island to the Serra de Parati, comprehending the municipalities of: Ubatuba, Caraguatatuba, São Sebastião and Ilhabela. They are is characterized by the marking presence of the Serra do Mar near the coastline, presenting steep slopes on its escarpments, favoring the occurrence of orographic rains. In the region extreme, catastrophic events related to flooding and mass movement have taken place, resulting in hundreds of victims and unleashed economic damage, in majority, due to events of intense rains in short periods, associated to the process of inadequate occupation and use of the land. In the search for regional characterization of the pluviometric variations, with emphasis on the extreme events, this paper proposes to assess the impact of rains on the geographic space, based on papers by Monteiro (1971) and Sant'Anna Neto (1990) pertaining to the geographic studies of the climate and Gerardi (1987) and Martín-Vide (2003), based on the techniques in statistic character, highlighting central tendency measures, dispersion and co-relation in several temporal scales. Data was used from 15 pluviometric stations maintained by DAEE – Departamento de Águas e Energia Elétrica do Estado de São Paulo, in the segment of 1943-2000. The statistic procedures and maps were elaborated in the software Excel, Statistica and Surfer, with Ward methods and Kriging interpolation. Among the results reached, the seasonal analysis of the more and less rainy seasons was countersigned, being that summer is the rainier period in all the stations with a concentration of 40% of the annual precipitation at most of them in the period of greater convergence of people in the region due to tourism and with great potential of causing problems and reaching a greater number of victims. A strong inter-annual variability was observed in the annual totals of the station used, especially at the Mato Dentro station. From the daily analysis, of the characterization of the events of maximum rain in 24 hours and its participation in the monthly total, it became evident that this contributed on average with 25% to 45% of the monthly rain volume. In this characterization a linear co-relation was proven over 80% for all the stations between the day with greatest maximum precipitation in 24 hours and the monthly total, evidencing the strong influence of this parameter in the monthly rain rhythm. The characterization of the most recent extreme event of the series studied (February 1996) was carried out through the Rhythmic Analysis, identifying the performing atmospheric systems and the regional circulation dynamic in the study area. It was observed specifically in the extreme event analyzed that the main element to unleash the intense precipitation was the establishment of the South Atlantic Convergence Zone (SACZ), causing significant volumes in the region. Thus, it become evident that the extreme pluvial events on the Northern São Paulo Coast are, undoubtedly, controlled by the tropical systems (Atlantic Tropical Mass) and SACZ, aided by frontal systems and orography, decisive in the distribution of rains in greater quantities in the elevated areas of the Atlantic Serra do Mar hogback, and in smaller quantities in the “rain shadows” located leeward in Ilhabela (west portion) and in São Sebastião and Caraguatatuba.

Keywords: Extreme pluvial impacts, South Atlantic Convergence Zone, Northern São Paulo coast.

INTRODUCTION

The area covered by this paper is comprehended between geographic coordinates 23º23’ and 24º00’ latitude South and 45º04’ and 46º29’ longitude West.

According to the definition by Sant'anna Neto (1990), the Northern São Paulo Coast is the “area comprehended from the Serra de Juqueriquerê and São Sebastião island, in the southeast-northeast direction, to the Serra de Parati at the limits of the states of São Paulo and Rio de Janeiro” (Figure 1):

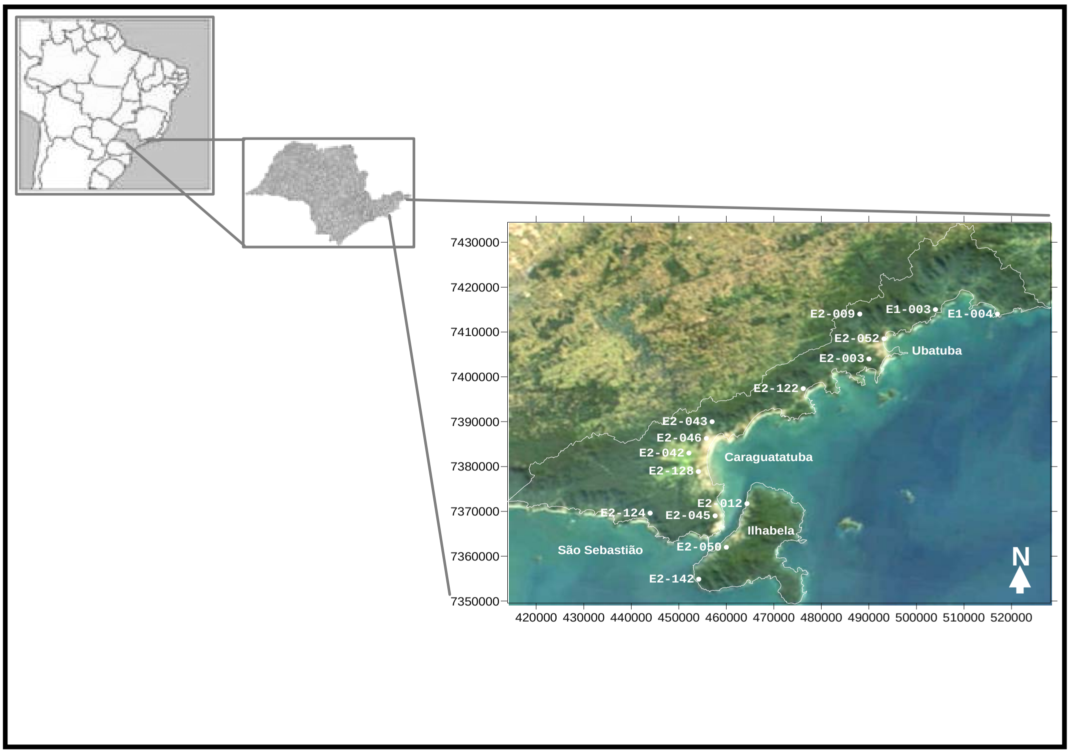

Figure 1 – Study area localization with stations used, respectively (no scale)

Org.: Roseghini, W. F. F. Images source: NASA , IBGE..

The São Paulo coastal line is commanded by the direction of the escarpments and their spores, which unfold into platforms, sometimes into salient residual hills. In this mixed typology of the coastline you can observe in the NE-SW direction a predominance of high, solid coasts, with rocky shorelines, agitated seas and small drop-off beaches. Now in the N-S direction, although with lesser extension, we observe the occurrence of wider coves, with gentle slope beaches and calm waters as, for example, the Caraguatatuba cove.

By the conjunction of the morphological aspects and the regional atmospheric circulation, the Northern Coast is characterized by a great variety of weather types being, therefore, in the meteorological point of view, highly unstable and constantly subject to rain made dynamic by the local geographic conditions (NUNES, 1992).

It the Northern Coast or east-northeast, as suggested by Conti (1975), the participation of extra-tropical systems is lesser allied to the barrier imposed by the serras de Juqueriquerê and São Sebastião, and the general disposition of the Serra do Mar which takes on a more parallel position to the ocean, therefore, less opposed to the entrance of fronts, with an inferior pulviometric total, or in other words, the regional orography works in a manner to form barriers that accentuate the precipitation wayward to the serra, and on the other side, on the leeway slope, diminish any type of precipitation, forming "rain shadows”. In the dry period, the pluvial totals are around 500 mm, and in the spring and summer they rise considerably, presenting total annual rain averages over 2000 mm. Therefore, the coast does not present a winter dry season, but a decrease in pluviosity (SANT’ANNA NETO, 1990).

The constantly high relative humidity, allied to abundant pluviosity and elevated, uniform temperatures, favors the existence of extensive, very dense and rich in species forest formations. In this region, we find tropical pluvial forest formations or Atlantic Forest, in the mountain range areas; beach vegetation and dunes on the coastal plains, and small swamp areas near the river mouths.

Notably, the coast is one of the areas most threatened by the urban demand of soil occupation and generalized use of the natural resources, most of the time in a predatory manner.

Faced by these aspects the public power created a series of legal mechanisms for environmental protection of these areas, through the creation of Environmental Preservation Units (parks, ecological stations, environmental protection areas, permanent preservation areas, among others), where each unit has specific functions for the conservation and preservation of natural heritage, with diversified objectives and differentiated restriction degrees.

In the scope of Climatology and in the other techniques used in this paper, we highlight the geographic climate view developed by Sorre (1951) who introduces the concept of “genesis” and “rhythm” as an expression of habitual succession of the atmospheric states, in a dynamic approach.

Sant’anna Neto (1990), in his master’s dissertation “Ritmo Climático e a Gênese das Chuvas na Zona Costeira Paulista”, does a climatologic analysis of the succession rhythm of the types of weather in a manner to characterize the pluvial phenomenon, quantitatively and qualitatively, in search for a new pluvial typology articulated to the morphological features of the projection and individualized in the regional cells of the climate in the São Paulo Coastal Zone. In this paper, the author suggests a classification of four climatic sub-zones: The Northern Coast, controlled my tropical air masses; the Central, Southern Cooast and Vale do Ribeira controlled by masses of tropical and polar air.

According to Sant’anna Neto (2003) the climate is the result of a complex process which involves several factors such as: atmosphere, projection, vegetation, ocean, etc. Therefore, the climate behavior study is of essential importance for the comprehension of the natural dynamic of sceneries, for economic planning and environmental and life quality of the populations.

Thus, one of the most important aspects of this paper is to identify and analyze the extreme climatic events, especially precipitation on a daily scale, to comprehend its dynamic and its influence and co-relation level in the unleashing of flooding and mass movements already notified by the Civil Defense. The identification of the origin and behavior of these events seeks a perfection of the already done papers for the study area and the search to encourage socio-environmental solutions, or in other words, ecologically and economically viable means to solve the problem.

The disorderly use and occupation of hillsides has taken these areas to rapid environmental degradation. The pluvial impacts resulting from successive mass movement process and floods result both from natural dynamic as well as human actions.

According to Cunha (apud NUNES et al., 1992), “the gravitational mass movements (mass creeps, slides, breaks, inclines and runs) are marking processes in the evolution of the slopes, being pluvial water the main detonating agent”.

Depending on the mineralogical composition and the quantity of fractures, larger, more resistant rock blocks will detach from the decomposed formations. Under these circumstances and due to gravity, natural hogback instabilities will be observed. These instabilities in the escarpment area (mainly the Serra do Mar) translate into slides, mud runs and falling of rock blocks of several diameters.

According to Brunsden (1979), “the general term of mass movements is applied to all processes that involve the transferring of material for the high hogback to the low hogback, under the influence of gravity, without the primary assistance of fluid transportation agents”. If on one side the definition of such movements is quite clear, the different manners of analysis have made it possible to elaborate the numerous classification systems (our translation).

In a general manner, the stability of the hogbacks is conditioned by agents that perform externally and internally, modifying the strength and resistance systems. Among the main internal conditioners are the progressive shearing and weathering, always connected to the characteristics of local mineralogical composition. Now among the external factors the geometric changes on the hogback (natural or induced) and the increase or decrease of its overload and pluvial action stand out. Above all in the tropical regions, the effects due to the rains' performance are responsible for almost the totality of the phenomena observed, through the increment in the strengthen system and in the weakening of the resistance system of the superficial mantle.

The slides are the geological accidents responsible for the largest number of victims in Brazil. These occurrences are concentrated mainly in the urban areas located far from the coast, where the climatic conditions associated to the projection characteristics favor the development of the sliding processes.

In turn, the impact caused by these processes presuppose severe consequences, manifested by financial, and above all, human harm. According to Christofoletti (1995), “in virtue of the occupational density of the urbanized areas, the topography arises as one of the main elements to guide the occupation process”. In fact, steep slopes have been incorporated frequently to the urban mesh of the cities, through, most of the time, irregular occupations.

Conditioned by topographic, geomorphologic and climatic aspects, these areas of fragility should be detected, so that effective measures be implemented for their planning and control.

According to Fernandes (1996), the rains are understood as the energetic atmospheric entrance in the urban system, and many times, exercise a significant impact, unleashing the processes previously described.

This way, comments Monteiro (1976), inspired by Sorre's conceptions, “by their nature, they are events that reflect extreme variations and violent rhythm forms. seclusions or detours of the customary standards, disrhythms”. Thus we observe, in climatologic science, in its dynamic approach, a great potential of contribution for the understanding of natural risks in the urban means.

In fact, of the 15 agents responsible for the destabilization of the slopes listed by Castello et al. (1986), 11 are related to the presence of water. In that concerning the rain's role in the breaking out of movements, it becomes important to consider that different processes many times are induced by distinct conditions of pluviosity, especially as to its temporal distribution.

According to Augusto Filho et al. (1998), “the rocks slides tend to be more susceptible to concentrated rains, while the processes on soli, depend also on the pluviometric indexes accumulated over the previous days. Run type processes are associated to very intense pluviometric indexes, while ruptures in areas modified by man with deforesting, cuts, landfills, etc, may occur with precipitation values considered normal”. This way, for understanding the phenomenon in its totality, it become vital to identify the material moved (rock, soil or both) and their relations with concentrated and accumulated precipitations.

For Tatizana et al. (1987), “the rain distribution is an important variable in the hydrologic cycle, with influences in the soil saturation rate and the development of instant phenomena, with the development of flow lines, sub-pressure and erosion”. Within the perspective of co-relation between rains and slides, in a project done in the municipality of Cubatão - SP, Tatizana et al (1987) also comment that “the increase of soil saturation provokes a decrease in the intensity of precipitation sufficient for the deflagration of slides, in a non-linear, but geometric, reason".

The period of 4 days was pointed out as ideal for the study of the total accumulated from rains in the Serra do Mar region, the same number found by Almeida et al (1993) in a study done in the municipality of Petrópolis – RJ.

Although the 4 day result has been presented in both studies, it is important to emphasize that for each region the occurrence of mass movements takes on greater co-relation with a specific period of accumulated rains, depending on the characteristics of the pluvial regime and of the geotechnical conformations. In the regions investigated, the period found relates to the performance of stationary fronts that remain active for 3 to 4 days, almost always producing rain in excess.

Faced by the relations previously pointed out, it is observed that the atmospheric dynamic and the pluvial character take on the main role in the scenario of gravitational mass movement. In this context, the frequency of accidents reflects the alterations of the climatic rhythm, above all pluvial, represented by the abnormalities already pointed out by Monteiro (1976). The acknowledgement of a rhythmic standard, or in other words, of the performance sequence of the different atmospheric systems and their pluviometric consequences, supplies the possibility of a better understanding of such abnormalities.

Faced by the process of searching for solutions for the problems of natural risks in urban areas, the employment of the dynamic approach in Climatology, allied to the research techniques elaborated by geologists, seems to represent an important advance.

According to Silva et al (2005), the climatic rhythm notion spread in the Brazilian Geography scope by Monteiro (1971, 1976), fundaments a comprehension of genesis and of quality of climatic factors due to the atmospheric layer which most suffers with the transformations of geographic space, the troposphere.

To Monteiro (1971) apud Silva (2005) the technique performed by the rhythmic analysis is capable of detailing, in relation to time, the genesis of the climatic phenomena by the interaction of elements and factors within a regional reality, which aids in the comprehension of the most varied and existing "geographic problems".

Another important factor highlighted in this research is the South Atlantic Convergence Zone (SACZ).

According to Carvalho (2002), the SACZ is the main phenomenon responsible for the occurrence of rain in the spring-summer in São Paulo and other States in the Southeast region of Brazil. It varies temporally and spatially and its special variations regionally affect the occurrence of the extremes of precipitation about the area in study.

The main spatial variations of the SACZ can be oceanic or continental, being influenced by the Pacific and Atlantic TSM.

One of the great characteristics associated to the ZCAS is in the formation of an extensive band of nebulosity which goes from the Amazon and extends all down Brazil in the northwest-southeast direction to the Atlantic Ocean, being easily identified in synoptic maps and satellite images as a connective area of low pressure that persists for several days stationary over the same region, being more frequent in the summer when the Continental Equatorial Mass is more performing and feeding humidity to the entire extension of the instability zone.

In this context and considering the regional climatic typology, we part to an attempt to identify the events occurring on the Northern São Paulo Coast, region located in a transitional position in which the atmospheric systems tend to present greater perturbation. They also seek to identify the rains' characteristics in that which has to do with its genesis, rhythm and space-time distribution, as well as the association of this phenomenon of nature to the soil's use and occupation.

MATERIAL AND TECHNIQUE

In the search for regional characterization of the pluviometric variations, with emphasis on the extreme events, this paper proposes to assess the impact of rains on the geographic space, based on papers by Monteiro (1971) and Sant'Anna Neto (1990) pertaining to the geographic studies of the climate and Gerardi (1987) and Martín-Vide (2003), based on the techniques in statistic character, highlighting central tendency measures, dispersion and co-relation in several temporal scales.

Data was used from 15 pluviometric stations maintained by DAEE – Departamento de Águas e Energia Elétrica do Estado de São Paulo, in the segment of 1943-2000 (Table 1). The statistic procedures and maps were elaborated in the software Excel, Statistica and Surfer, with Ward methods and Kriging interpolation.

TABLE 1 – Relation of pluviometric stations of DAEE on the Northern São Paulo Coast

Minicipality	Prefix	Post Name	Altitude	Latitude	MTU	Longitude	MTU	Period	Summer	Autumn	Winter	Spring	annual mean
Ubatuba	E1-004	Picinguaba	3 m	23º 23'	7414,000	44º 50'	517,032	44/00	817,4	467,4	403,3	674,8	2362,9
	E2-052	Ubatuba	1 m	23º 26'	7408,473	45º 04'	493,189	45/00	786,8	414,5	340,7	626,8	2168,8
	E2-009	Mato Dentro	220 m	23º 23'	7414,005	45º 07'	488,077	56/99	1089,8	524,7	507,5	947,1	3069,1
	E2-122	Maranduba	4 m	23º 32'	7397,384	45º 14'	476,181	70/99	765,3	393,4	335,8	611,7	2106,1
Caraguatatuba	E2-046	Caraguatatuba	20 m	23º 38'	7386,266	45º 26'	455,799	43/00	678,4	300,8	254,1	486,4	1719,6
	E2-128	Porto Novo	10 m	23º 42'	7378,879	45º 27'	454,122	70/97	678,0	357,1	253,4	465,1	1753,6
São Sebastião	E2-045	São Francisco	20 m	23º 46'	7371,509	45º 25'	457,542	43/00	541,3	311,3	168,5	329,4	1350,5
	E2-124	Maresias	5 m	23º 47'	7369,617	45º 33'	443,962	70/99	787,1	552,9	420,2	570,3	2330,6
Ilhabela	E2-012	Ilhabela	10 m	23º 47'	7371,527	45º 21'	464,335	43/00	626,4	333,0	217,6	393,0	1570,0
	E2-142	Burrifas	90 m	23º 55'	7354,891	45º 27'	454,198	75/98	631,7	357,1	307,0	409,6	1705,5

RESULTS

Among the results reached, the seasonal analysis of the more and less rainy seasons was countersigned, being that summer is the rainier period in all the stations with a concentration of 40% of the annual precipitation at most of them in the period of greater convergence of people in the region due to tourism and with great potential of causing problems and reaching a greater number of victims.

A strong inter-annual variability was also observed in the annual totals of the stations used, especially at station E2-009 in Mato Dentro (Figure 2), when some years the difference reached over 1000 mm, as happened between 1967 (4373.8 mm) and 1968 (2355.7 mm), 1973 (4285.3 mm) and 1974 (2340.4 mm), and recently 1996 (3847.0 mm) and 1997 (2554.9 mm).

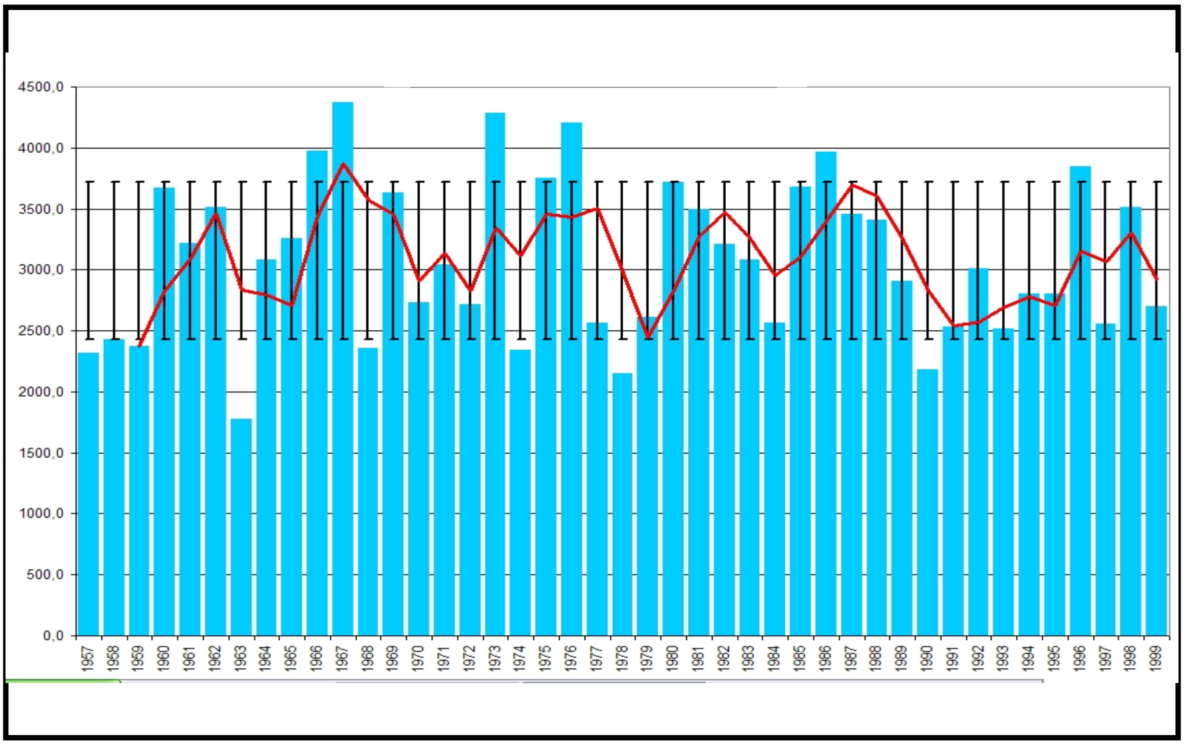

Figure 2 – Annual totals for Ubatuba (Mato Dentro)

Org.: Roseghini, W. F. F. Source: DAEE.

From the daily analysis, of the characterization of the events of maximum rain in 24 hours and its participation in the monthly total, it became evident that this contributed on average with 25% to 45% of the monthly rain volume (Figures 3 and 4).

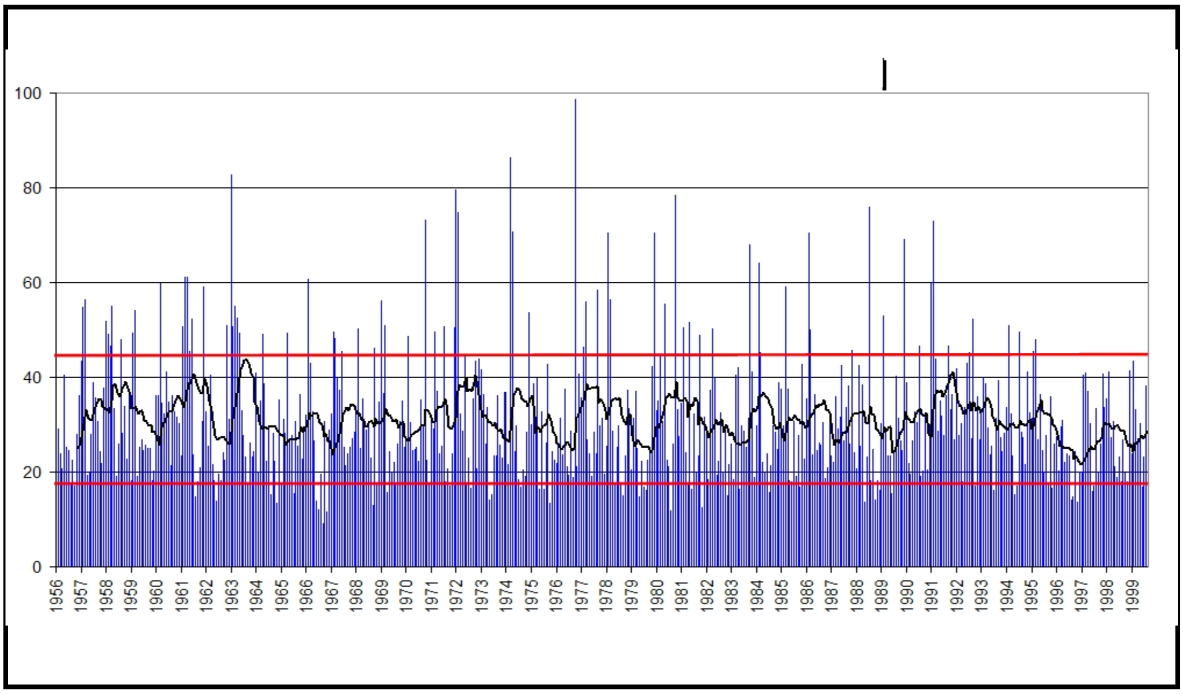

Figure 3 – Percentage participation of maximum rain in 24 hours in the monthly totals in Ubatuba (detour from standard in red)

Org.: Roseghini, W. F. F Source: DAEE.

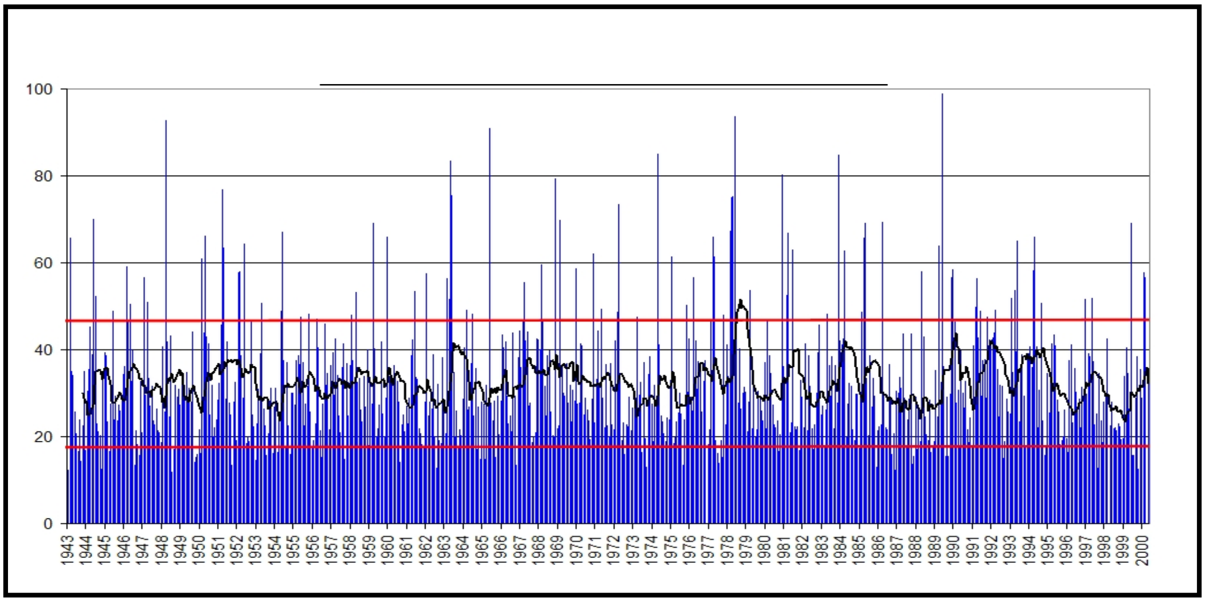

Figure 4 – Percentage participation of maximum rain in 24 hours in the monthly totals in Caraguatatuba (detour from standard in red)

Org.: Roseghini, W. F. F. Source: DAEE.

In this characterization a linear co-relation was proven over 80% for all the stations between the day with greatest maximum precipitation in 24 hours and the monthly total, evidencing the strong influence of this parameter in the monthly rain rhythm.

The characterization of the most recent extreme event of the series studied (February 1996) was carried out through the Rhythmic Analysis, identifying the performing atmospheric systems and the regional circulation dynamic in the study area (Figure 5).

It was observed that specifically in the extreme event analyzed the main element to unleash the intense precipitation was the establishment of the South Atlantic Convergence Zone (SACZ), formed from a semi-stationary frontal system over the region (Figure 6), which strengthened by cyclogenesis which accompanied the cold front and humid winds that blew in the ocean-continent direction, caused significant volumes both in Ubatuba which presented between February 10 and 16, 1996 was 889.8 mm, as in Caraguatatuba where in the same period the volume of 415,3 mm was registered, a significant value, for this took place in a densely occupied area, the opposite of the previous case. It is worth pointing out that in Ubatuba, on February 13, 1996, the most significant volume of precipitation took place in the period registering the precipitation of 442.6 mm in just 24 hours, corresponding to 15% of the annual precipitation of the mentioned location.

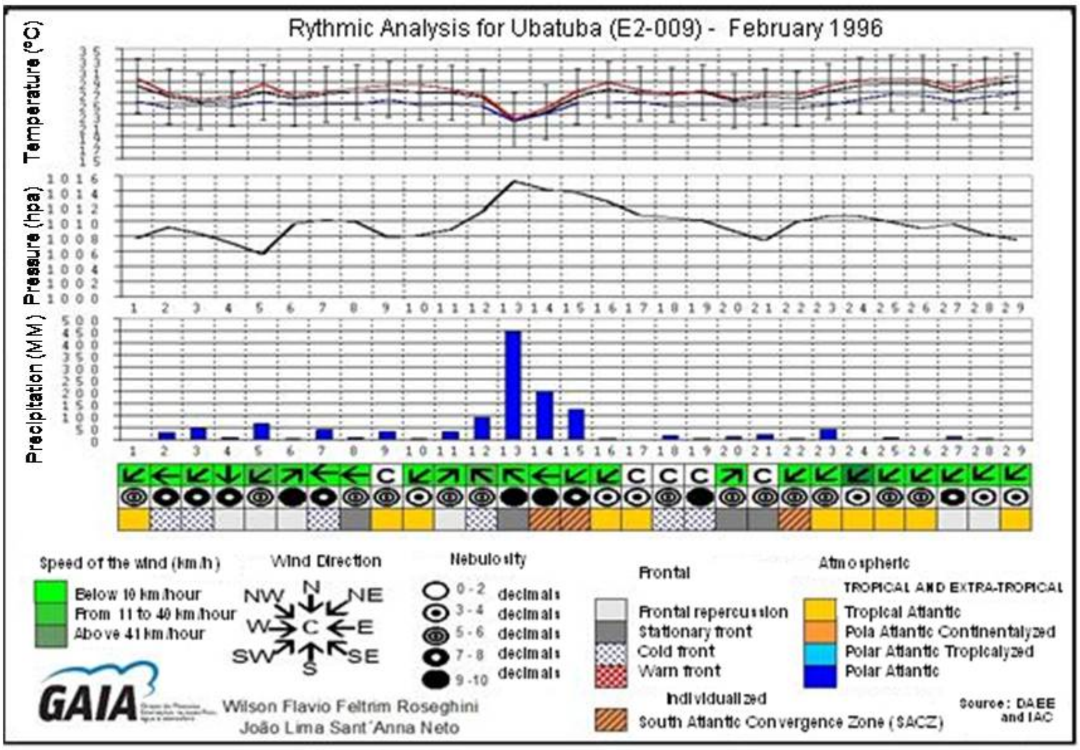

Figure 5 – Rhythmic analysis for the month of February 1996

Org.: Roseghini, W. F. F.

Both on the satellite image as well as on the synoptic map (Figure 6) the performance of the frontal stationary branch is evident over the continent, at the height of the northern coast of São Paulo, corroborating with the force of the South Atlantic Convergence Zone.

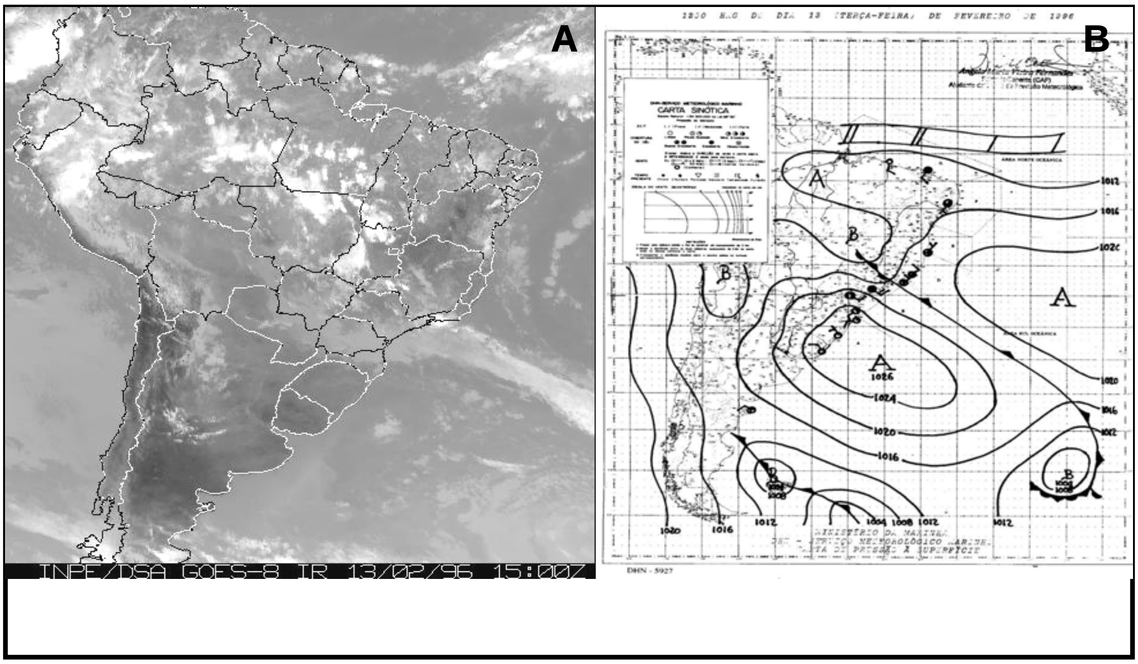

Figure 6 – Satellite image (A) and synoptic map (B) from February 13, 1996

Org: Roseghini, W. F. F. Sources: INPE and Marinha, 1996.

Thus, the extreme event analyzed in February 1996 caused numerous perturbations and it is configured as one of the events of greatest socio-environmental repercussion in the analyzed period, as shown in Figure 7 in terms of the number of occurrences registered.

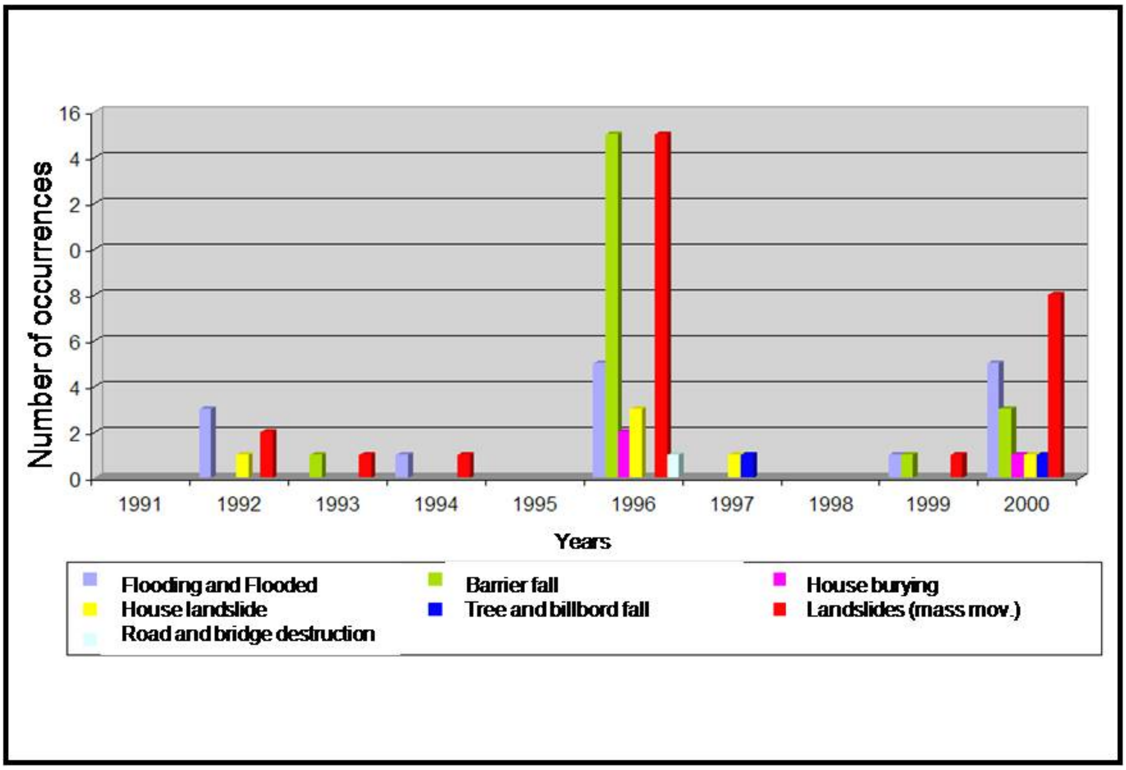

Figure 7 – Types of occurrences notified by the media on the North Coast, between 1991 and 2000

Org: Roseghini, W. F. F. Source: Sant´anna Neto, 2003.

CONCLUSION

Within the proposal elaborated for this research, it can be deduced that the results reached corroborate with previous studies, among them the ones by Conti (1975) and Sant'Anna Neto (1990), reaching the purpose of advancing in the previously described studies in a qualitative and quantitative manner, especially through new computer and statistic analysis resources.

Among these results, the seasonal analysis of the most rainy and least rainy periods proved, with summer being the most rainy at all the stations and holder of >40% of the annual precipitation at most of them.

Thus, it was proven the importance of this seasonal variable of rainfalls, because, concentrated during the period of greater convergence of people in the region due to tourism, presents a great potential to cause perturbations and reach a greater number of victims.

In the daily analysis the increase in the concentration of rains in a lesser time period for the Caraguatatuba and Ilhabela stations was observed, being one more aggravation for the occurrence of extreme events, because it makes possible for these events to happen with greater intensity.

On the counterpart the inverse took place at the Ubatuba and São Sebastião, stations registering an increase in the number of days with rain and consequently better distribution.

A strong inter-annual variability was observed in the annual totals of the station used, especially at the E2-009 station in Mato Dentro.

Extreme precipitation events were identified in the entire series, with two specific cases being analyzed which had greater repercussion in the study area, respectively the summers of 1966-67 and 1995-96, comprehending in this analysis the months of December to March, which showed a very similar dynamic in the precipitation's behavior, evidencing that the motor of this process is the SACZ.

From the daily analysis of the characterization of the events of maximum rain in 24 hours and its participation in the monthly total, it became evident that this contributed on average with 25% to 45% of the monthly rain volume. In this characterization a linear co-relation was proven over 80% for all the stations between the day with greatest maximum precipitation in 24 hours and the monthly total, evidencing the strong influence of this parameter in the monthly rain rhythm.

The characterization of the most recent extreme event of the series studied (February 1996) was carried out through the Rhythmic Analysis, identifying the performing atmospheric systems and the regional circulation dynamics of the study area.

It was observed that specifically in the extreme event analyzed the main element to unleash the intense precipitation was the establishment of the South Atlantic Convergence Zone (SACZ), formed from a semi-stationary frontal system over the region, which strengthened by the low pressure that accompanied the cold front and humid winds that blew in the ocean-continent direction, causing the significant volumes observed.

Thus, it become evident both in this research as well as the previous ones that the extreme pluvial events on the Northern São Paulo Coast are, undoubtedly, controlled by the tropical systems (Atlantic Tropical Mass) and SACZ, aided by frontal systems and orography, decisive in the distribution of rains in greater quantities in the elevated areas of the Atlantic Serra do Mar hogback, and in smaller quantities in the "rain shadows" located leeward in Ilhabela (west portion) and in São Sebastião and Caraguatatuba.

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LOGARITHMIC DISTRIBUTION OF PLANETARY ALBEDO ON SOUTH AMERICA: A NEW TOOL FOR MONITORING CLIMATE CHANGING

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ABSTRACT

The second satellite of the Brazilian Complete Space Mission (SCD2/MECB) was launched at October 23rd, 1998 and it hosts a solar cell experiment (SCE). The solar cell senses visible radiation (400-1100 nm) and allows simultaneous inference of direct sunstroke and the sunstroke that is reflected outside of the Earth. The global albedo is obtained using the ratio between these two values after spherical angular corrections. The SCD2 has a circular orbit of 750 km high and its spin is 35 rpm. The SCE data are transmitted in real time and received by the ground station of Cuiabá, MT-Brazil (16 S, 56 W), which limits its spatial coverage on South America. The albedo data can be grouped in periods of time (annual, seasonal or monthly) or studied for several regions (latitude and longitude) during the orbit time. The albedo data collected through the years 1999 to 2003 in several regions form a basic group of the albedo values. This group has a distribution around a mean value as a function of time, considered here in periods of months, and for each region. A study was done for the albedo data and we concluded that only the logarithm of albedo values shows the normal or Gaussian distribution. Therefore, a pattern of the distribution of logarithm albedo was defined as a function of time based in the 1999 to 2003 period. The following years (2004, 2005 and 2006) may obey or not this pattern. In the negative case, we can say that a climate change occurred in that period in that region. Several regions in South America were studied and we found that a region called South Atlantic Ocean had a climate change in 2004 because a certainty level of 95% was expected, corresponding to the range between the mean value of more or less two standard deviations, and the certainty for this year was only 87%. This difference (95%-87%) can not be explained by the random variation of the albedo values but it is explained only when a climate change occurs. The following years (2005 and 2006) had better assurance levels (90% and 92%, respectively) for this region.

Keywords: Monitoring climate change, Albedo, South America.

INTRODUCTION

The incoming solar radiation that is reflected from the Earth's surface and its atmosphere is generally called albedo. The albedo value depends on the nature, or quality, of the atmosphere and of the land surface, solar position and time. For instance, several phenomena (greenhouse effect, atmospheric temperature, inversion, aerosols, deforestation, volcanic eruption and others) alter the albedo value.

Aerial albedo measurements were apparently first made by Fritz (1948) with two pyrheliometers installed in a B-29 airplane. One was mounted in the top of the airplane to measure the downswelling solar radiation within the atmosphere. The other was mounted in the bottom to measure the upswelling component of solar radiation, which is the radiation reflected by earth-atmosphere system. The albedos values along the flight path were determined by the quotient between these measurements after some corrections (FRITZ, 1948). Fritz (1948) found that the ground (soil) albedo varied from 7% to 12%, and was occasionally higher than 29% when the ground was partially snow covered. Fritz (1950) also found that stratocumulus clouds had albedos higher than 80%.

Planetary albedo is the albedo measured outside of the earth-atmosphere system. It is the main parameter to calculate the solar energy radiation budget (ERB) in the Earth. For example, House et al. (1986) reported notes about several ERB satellite experiments until 1984 and concluded that measurements using non-scanning radio meters are better for measuring the planetary albedo. The solar cell experiment (SCE) of the SCD2 satellite is a non scanning wide field of view (WFOV) sensor. At the moment, a new NASA satellite, called Terra, is monitoring the Earth with passive sensors (KING, 2000). The evaluation of the albedo through this satellite involves the integration of several channels with different spectral windows and they are reliable only when compared with other data. The calibration process is a very complex task and is as expensive as the satellite digital cameras and needs to be done frequently.

Albedo measurements require establishment of space geometry and the angular characteristics of solar radiation (incident and reflected). King and Curran (1980), in a simulation experiment of the effect of a non uniform planetary albedo on the interpretation of the radiometer signal onboard a satellite, have adopted a very useful geometrical model. This model is used by the author of this text to simulate the albedo data obtained by the solar cell experiment (see VEISSID, 2003). Figure 1 shows the views angle of the SCE which is around 50° because the satellite has an altitude of 750km and Earth diameter is 12750km. The circle below the SCE is divided in nine parts with the same area but the zero region (central circle) is responsible for a fraction higher than 70% at the measured albedo. So, we can say, that the SCE resolution is around 5° in latitude and longitude or less.

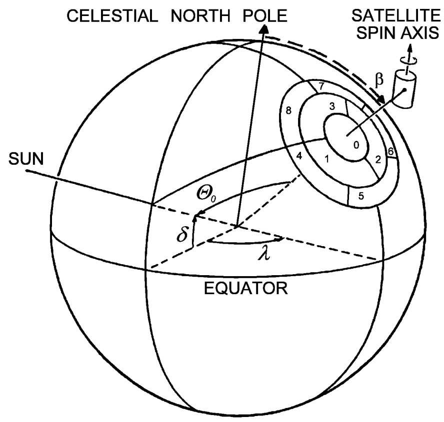

Figure 1 – Schematic illustration of the coordinate system used to simulate the Earth reflectance seen by the SCD2/INPE satellite solar cell experiment (Veissid, 2003)

Photovoltaic sensors are very used in the field of solar radiation measurement (IQBAL, 1983). Solar cell is a large area photovoltaic device and mono crystaline silicon homo junction solar cell has good spectral response between 400 nm and 1100 nm (VIS and NIR). The photo generated current of this kind of sensor is proportional to the power of the solar radiation (RAUSCHENBACH, 1980). Solar cell’s experiments have been used on some satellites (HUANG et al., 1985; VEISSID et al., 1997) to do space qualification of fabrication processes and devices. These kinds of experiments can be separated in two classes. The first corresponds to those with three axes orientation, where the solar panels are guided always to the Sun. Unfortunately this class is not usable as an albedo meter because the Sun and the Earth are not simultaneously viewed. The second class is related with satellites that have spin attitude control. Since spin attitude control allows simultaneous viewing of the Sun and Earth, this second class of experiment is very useful for determining accurate albedo values. This fact avoids problems with temperature sensor and calibration in the measurement of albedo. The solar cell experiment (SCE) in the satellite SCD2 of INPE has a signal conditioning circuit that reads the tension in the terminals of the cell and transmits this value by telemetry.

SOLAR CELL EXPERIMENT DESCRIPTION

The SCD2 is a satellite that collects and transmits meteorological data. The data are received from the terrestrial platforms distributed along the Brazilian territory and they work in a remote way. The orbit of SCD2 is 750 km height and inclined around 25° in relation to the plan of the equator. The satellite spin is around 34 rpm. Its spin axis is maintained normal to the plane of the celestial equator. The satellite is illuminated by the Sun during 65 minutes of each 100 minutes long orbit. It is otherwise eclipsed by the shadow of the Earth.

The SCE is located at the lateral panel of the satellite and has an angle view of 180° because it has no collimation optical system. Figure 2 left side shows the author of this text doing a visual inspection on the solar cell experiment. The SCE is composed by an arrangement of six connected solar cells of two by two in series; see Figure 2 right side. The solar cell is a semiconductor structure n+/p/p+ type manufactured in silicon substract with resistivity of 1 Ωcm. The description of this device is in the reference of Veissid and Pereira (2000). The array of solar cells is laid down on an aluminum mechanical structure. The printed circuit board has the electronics components for signal conditioning l. The array is composed of three pairs of cells and used to operate in three different conditions. The first one simulates the condition of short circuit current. That is, the terminals of the solar cell are connected to a load resistance of 1 Ω and this resistance supplies a tension that is amplified to a maximum value of 5V. The value of this tension has the same magnitude of the short circuit current. The second pair has a load resistance of 8 Ω and the third is the open circuit condition. This work only considers the short circuit current of the solar cell’s array pair, because this value is proportional to the light intensity, whether it is directly from the Sun or reflected by the Earth. The SCE telemetry module reads the value of the solar cells tension/current at each half-second and due to the spin of the satellite the values are distributed like in Figure 3 left side. Figure 3 right side shows these same points after variable changed from time to satellite spin phase where it is possible to see the solar radiation peak and the Earth reflected radiation peak. The peaks have a difference in phases of aproximately 180° because SCD2 satellite was positioned between the Sun and the Earth.

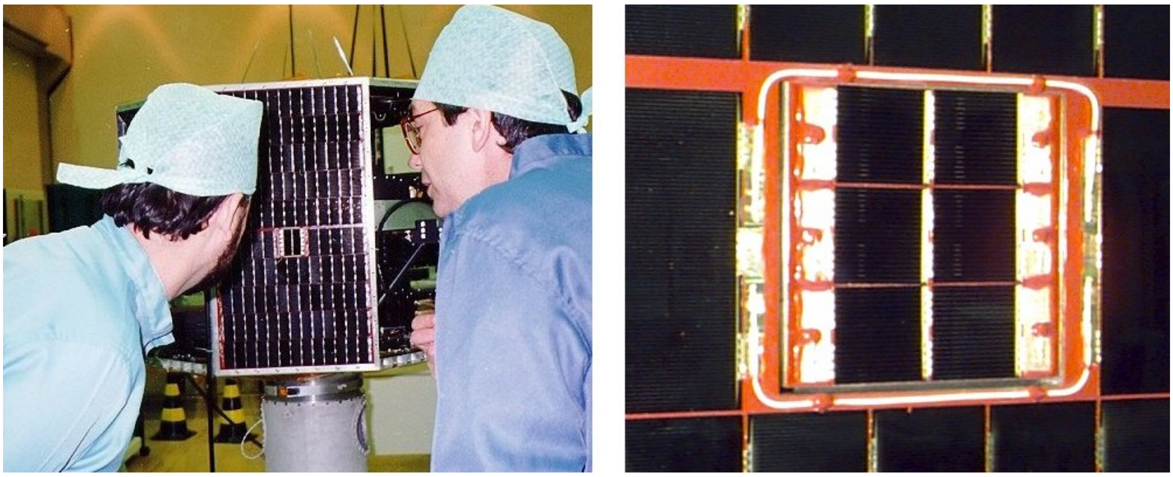

Figure 2 – Author doing visual inspection in the Solar Cell Experiment (SCE) on board of Brazilian SCD2/INPE Satellite and a view of SCE with three pairs of Brazilian solar cells

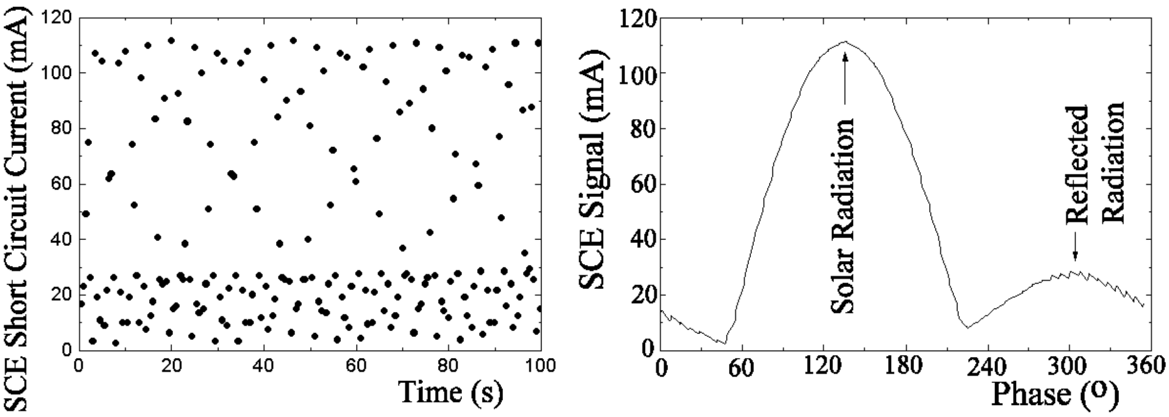

Figure 3 – Left side is a sample of SCE data received by satellite telemetry on November 21, 1998 at the 16:02 h GMT. The points are shown at intervals of half- second. The curve of right side has the same points obtained after variable changed from time to satellite spin phase

Data of SCE are received at real-time only when the satellite is in the ground station field of view located at Cuiabá (16°S, 56°W), MT-Brazil. Unfortunately, this limits the SCE's observation range on the South American continent (i.e., latitude between 10°N and 30°S and longitude between 30°W and

80°W). Figure 4 shows some SCD2 satellite orbits seen by ground station during November 1998.

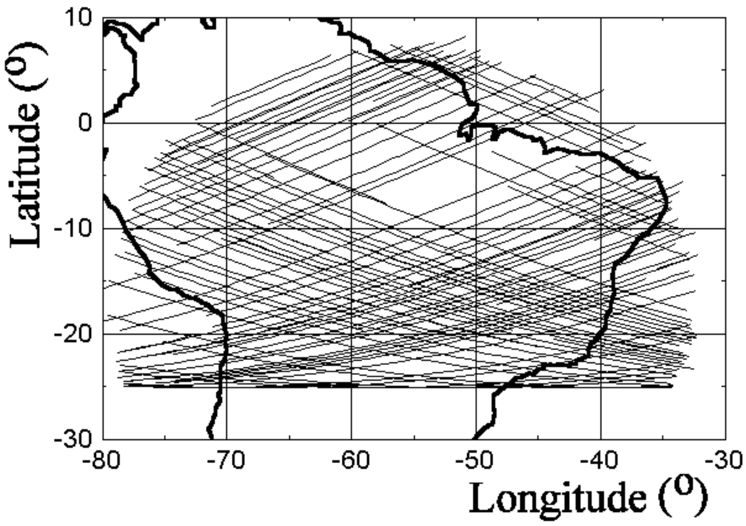

Figure 4 – SCD2 satellite orbits during November 1998 within the visibility range of Cuiabá ground station (16° S, 56° W)

PLANETARY ALBEDO OF SCE VERSUS GOES IMAGE

The Fig. 3 right side permits to calculate the planetary albedo as a function of nadir satellite position (latitude and longitude). The author has published several works about this algorithm; see Veissid and Pereira (2000) and Veissid (2003). GOES images are very useful for meteorologists to make weather studies and it can be used to test the albedo value of the SCE. For example, Figures 5 and 6 show these values during two orbits of the Brazilian SCD2 satellite and the GOES image is at the left side for each figure.

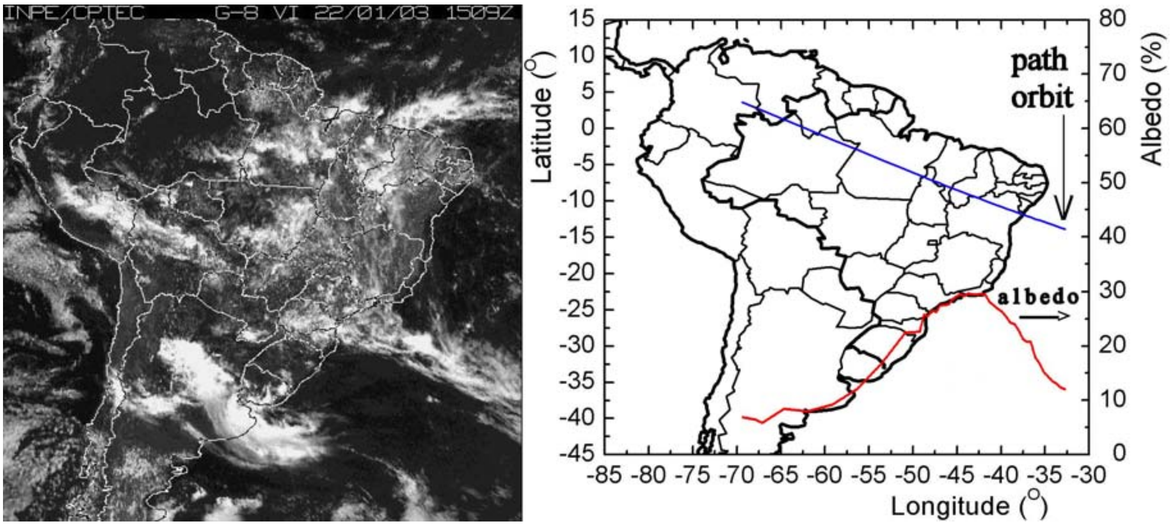

Figure 5 – SCD2 satellite orbit in January 22nd, 2003 with the GOES image. This orbit had an astonishing low value of albedo (6%) when the satellite was passing over Amazonas State (2.5°N;67.2°W)

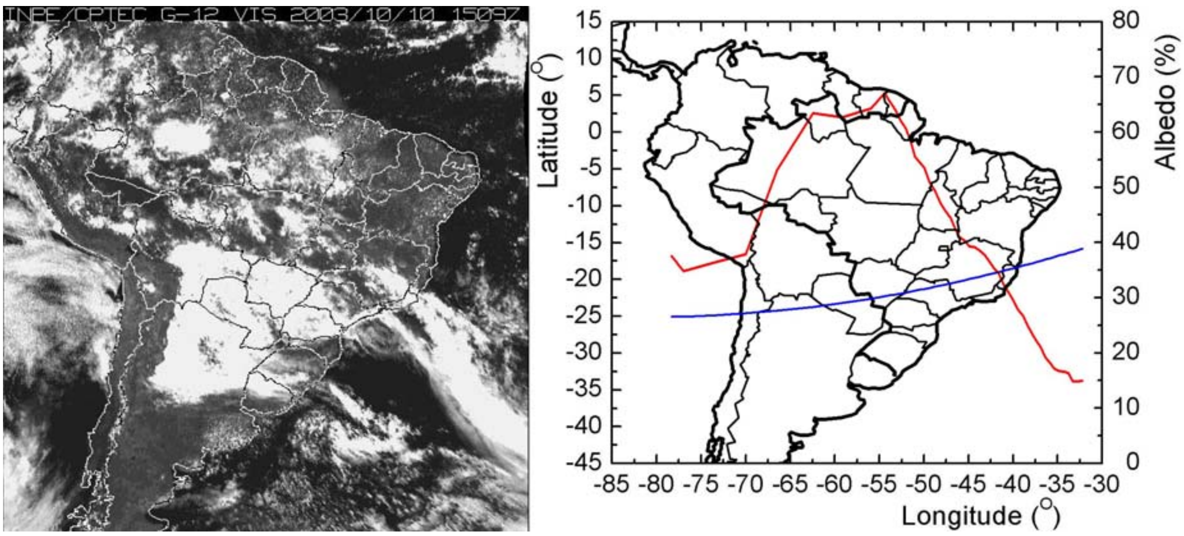

Figure 6 – SCD2 satellite orbit in October 10th, 2003 with the GOES image. This orbit had high value of albedo (67%) when the satellite was passing over Mato Grosso do Sul State

METHODOLOGY

The SCD2 satellite was launched in November 1998 and has provided several daily SCE data files. The SCD2, which is 750 km above the Earth, takes 100 minutes to orbit the planet. We calculated the true albedo only when the solar zenith angle at the sub satellite point is lower than 70° and, normally, this corresponds in the local time between 9:00 h and 15:00 h. This provided six hours of usable data to calculate the albedo. All data were analyzed and they resulted in the temporal record of the albedo as a function of position (latitude and longitude). These data can be analyzed as a function of time (monthly, seasonal and annual) during years. For example, Figure 7 shows the albedo for the city of São Paulo. This figure presents a pattern of albedo variation; the regions without data are associated to the satellite windows when the SCE does not see this region during the day light. During autumn (April, May, June and July) the albedo values are lower than during spring (September, October and December).

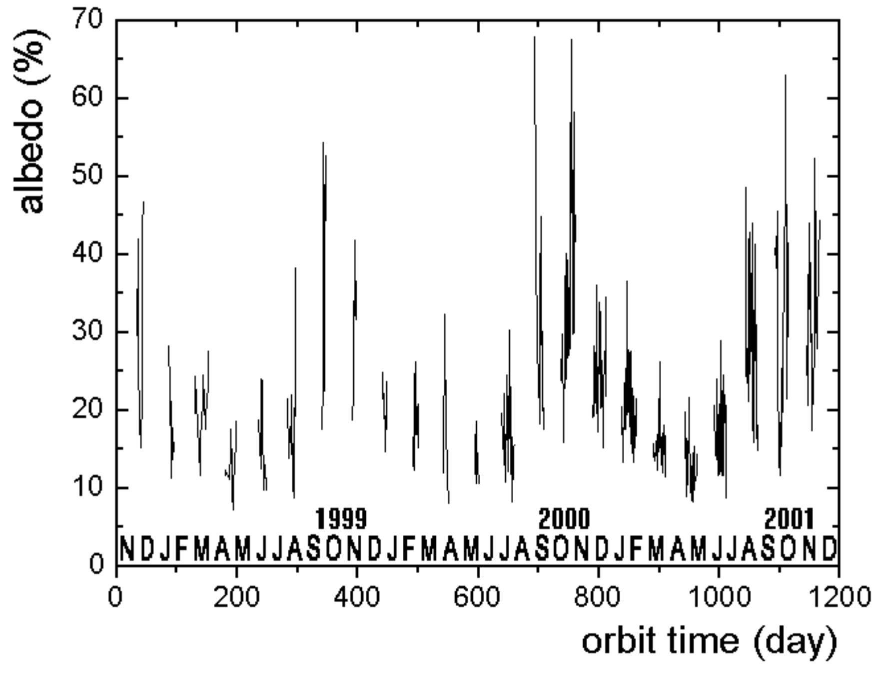

Figure 7 – Planetary albedo for São Paulo (24°S±2°, 47°W±2°) during 1999, 2000 and 2001

The albedo data obeys a statistical distribution and several kinds of distributions were tried (Gaussian or Normal, Lorentzian, Binomial, Poisson and others) without success. Finally, it was discovered that with the albedo value in the logarithm form we have Normal distribution. The Figure 8 shows a histogram of the albedo logarithm taken on city of São Paulo during the last hundred days of the 1999, 2000 and 2001 years. Figure 10, left side, shows that the albedo during this period (last hundred days of the year) is almost constant around 30%.

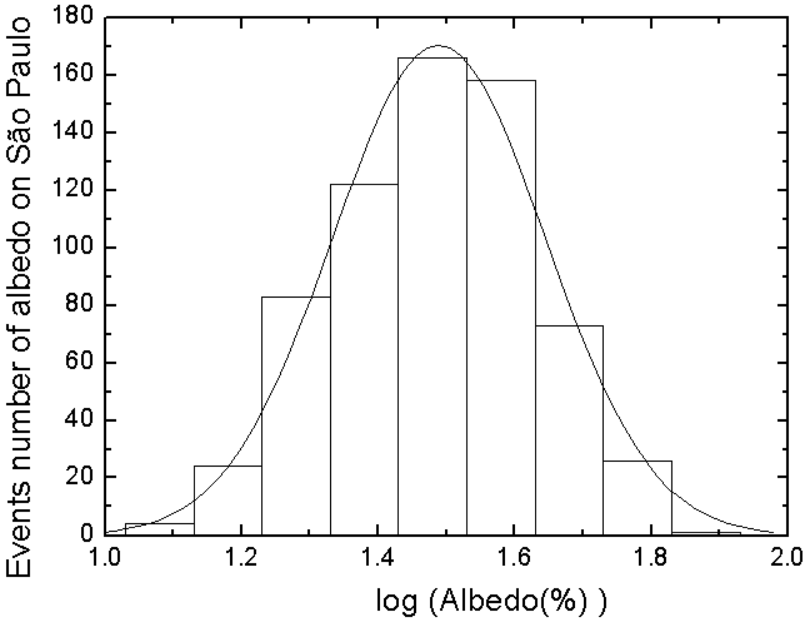

Figure 8 – Normal distribution of logarithm albedo on São Paulo (24°S±2°, 47°W±2°) during the period between days 265 and 365 to the 1999, 2000 and 2001 years

Now, considering a well known statistical distribution, it is possible to study and to monitor climate change. How is this done? The satellite was launched in October of 1998, so, the albedo data are considered in 1999, 2000, 2001, 2002 and 2003 like a base to determine the monthly mean albedo values and standard deviation. This period of five years is a good study base and the region around mean value, with more or less two standard deviations gives a reliable level of 95%. This value (95%) is called a WAITED value and the analysis done in the successive years is able to calculate the number of events inside this region (mean value of more or less two standard deviations). In the case of around 95% of obtained reliability, there was no climate change.

RESULTS

Several regions were studied and Figure 9 shows some of them. The regions of Figure 10-13 were selected because they have interesting details. The right side of these figures show the base of the statistical study (mean value and a region of more or less two standard deviations), which contains 95% of albedo data for the years 1999-2003. The left side graphics have the albedo data for the years 2004-2006, where we can compare the distributions to see if global change has occurred in this region.

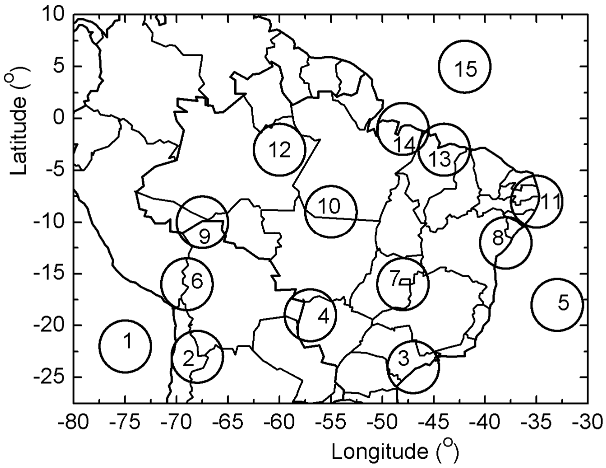

Figure 9 – Regions selected on South America to study the variation of logarithm albedo

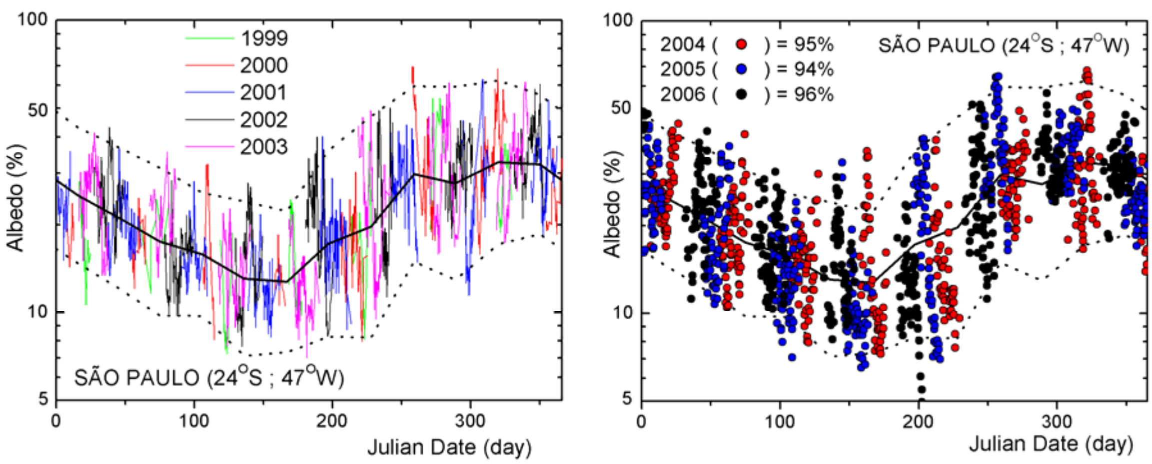

Figure 10 – Planetary albedo distribution seen by SCE on São Paulo City, region 3 of Figure 9

The São Paulo city region has the higher monthly standard deviation of all studied regions. This fact is caused by heavy weather instability with atmospheric conditions governed by cold fronts that come suddenly from the south. A singular event has occurred in the days 21st and 22nd July, 2006, when the albedo was only 5% and this value is typical of the Ocean and not of the land. Probably, in these two days there was a strong thermal inversion.

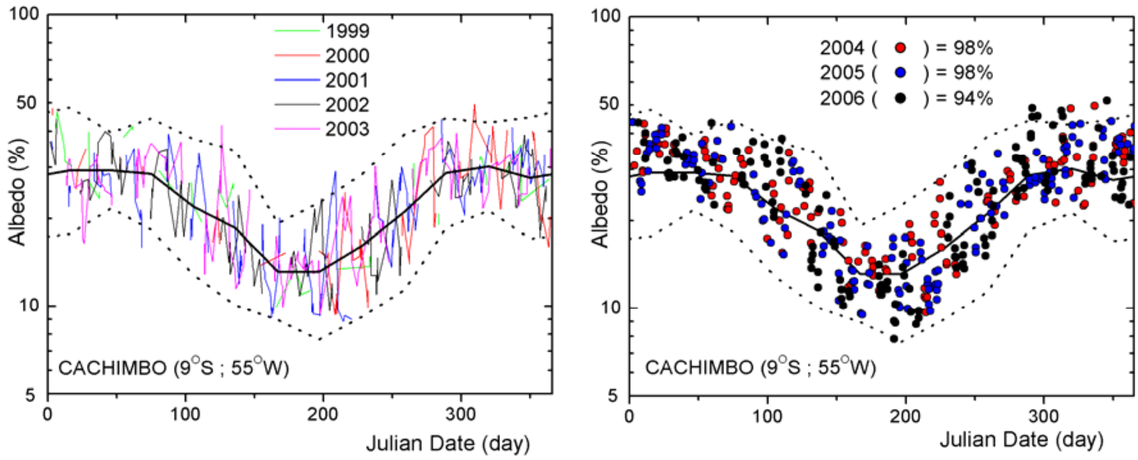

Figure 11 – Planetary albedo distribution seen by SCE on Cachimbo City, region 10 of Figure 9

Figure 11 shows a region with weak weather activity during the full year due to lower standard deviations. Probably, the geological characteristics of this region keep the stability.

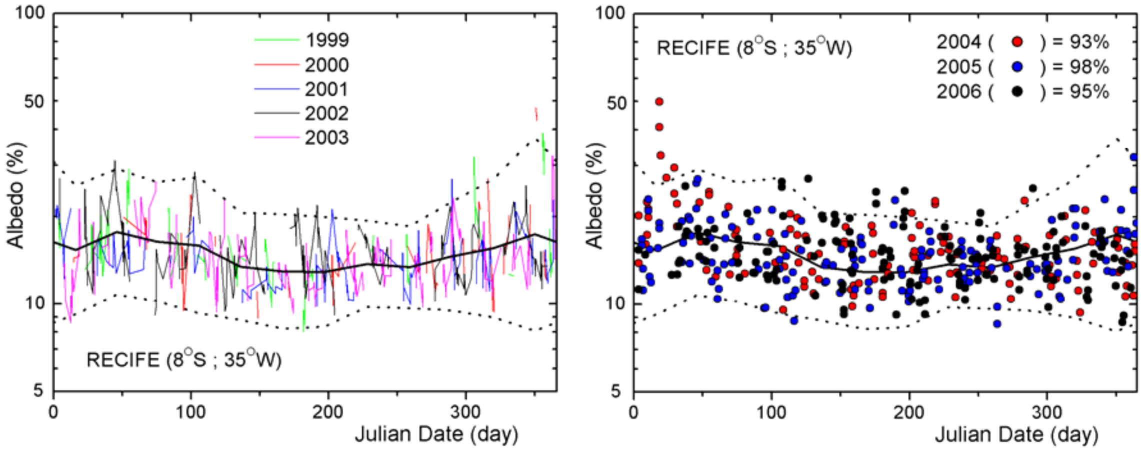

Figure 12 – Planetary albedo distribution seen by SCE on Recife City, region 11 of Figure 9

The Figure 12 region has a very stable minimum albedo, around 10%. The mean value ranges approximately 16% and the maximum is rarely higher than 25%. These values show a region with a very stable weather.

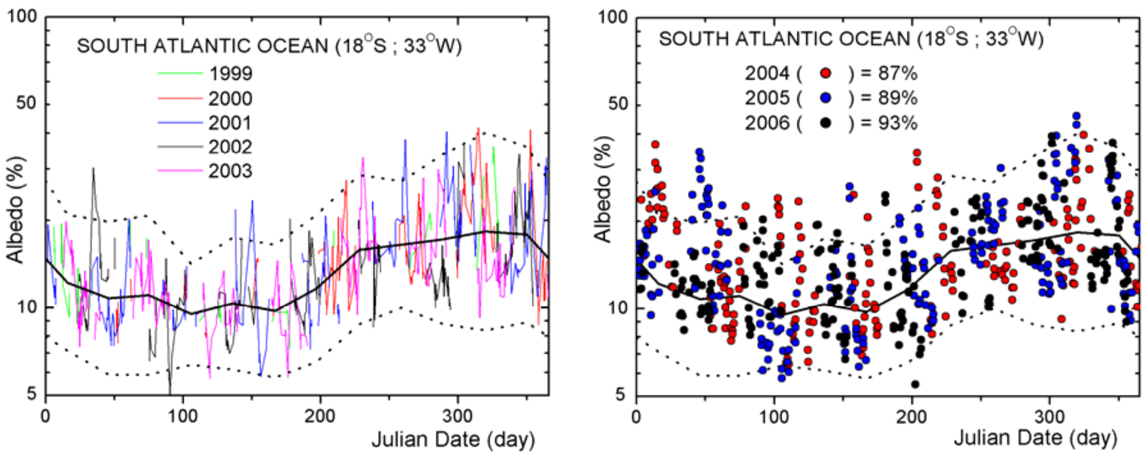

Figure 13 – Planetary albedo distribution seen by SCE on South Atlantic, region 5 of Figure 9

The Figure 13 region had a significant perturbation in the years 2004 and 2005. Dominant clouds appeared and raised the albedo values. The following year, this fact was not so intensive because this assurance level (93%) was 95% closer.

Tables 1 and 2 show the reliability level measured on the 15 regions of Figure 9.

Table 1 – Reliability levels measured on several regions; see Figure 9, based on planetary albedo obtained by SCE during the years 1999-2003. The reliability level remained 68%, between more or less one standard deviation

REGION	NAME	Latitude	Longitude	2004	2005	2006
1	Pacific Ocean	22°S	75°W	68 %	70 %	67 %
2	Atacama	23°S	68°W	66 %	67 %	66 %
3	São Paulo City	24°S	47°W	70%	60%	69%
4	Corumbá City	19°S	57°W	66%	68%	64%
5	South Atlantic	18°S	33°W	63%	63%	67%
6	Titicaca Lake	16°S	69°W	63%	65%	66%
7	Brasília City	16°S	48°W	74%	72%	62%
8	Salvador City	12°S	38°W	73%	71%	65%
9	Rio Branco City	10°S	67.5°W	73%	72%	72%
10	Cachimbo City	9°S	55°W	78%	76%	71%
11	Recife City	8°S	35°W	71%	79%	73%
12	Manaus City	3°S	60°W	71%	76%	73%
13	São Luis City	3°S	44°W	72%	75%	65%
14	Belém City	1°S	48°W	73%	77%	62%
15	North Atlantic	5°N	42°W	77%	69%	67%

Table 2 – Certainty level measured on several regions, see Fig. 9, based on planetary albedo obtained by SCE during the years 1999-2003. The assurance expected level, between more or less two standard deviations, is 95%

REGION	NAME	Latitude	Longitude	2004	2005	2006
1	Pacific Ocean	22°S	75°W	95%	96%	95%
2	Atacama	23°S	68°W	92%	93%	93%
3	São Paulo City	24°S	47°W	95%	94%	96%
4	Corumbá City	19°S	57°W	94%	92%	94%
5	South Atlantic	18°S	33°W	87%	89%	93%
6	Titicaca Lake	16°S	69°W	88%	92%	92%
7	Brasília City	16°S	48°W	98%	95%	93%
8	Salvador City	12°S	38°W	94%	96%	93%
9	Rio Branco City	10°S	67.5°W	92%	96%	91%
10	Cachimbo City	9°S	55°W	98%	98%	94%
11	Recife City	8°S	35°W	93%	98%	95%
12	Manaus City	3°S	60°W	95%	94%	97%
13	São Luis City	3°S	44°W	97%	98%	97%
14	Belém City	1°S	48°W	97%	94%	95%
15	North Atlantic	5°N	42°W	94%	91%	95%

CONCLUSION

The results show several climate characteristics. For example, Recife-PE (8°S, 35°W) has a fine weather nearly year round. São Paulo (24°S, 47°W), in contrast, is famous for its weather instability, with temperatures governed by cold fronts that come suddenly from the south. The described method for evaluating the planetary albedo of the Earth starts from a simple and relatively inexpensive experiment and does not rely upon sensor calibration because the measure is self-calibrated by the simultaneous reading of both irradiation peaks, namely from the Sun and its reflection by the Earth, during each spin of the satellite.

The SCE has no collimated optical system. It senses the luminosity in an instantaneous angle of view, which is theoretically of 180°. However, in a realistic way, this wide field of view is limited by geometric condition of the SCD2 orbit. The entire earth-atmosphere system, horizon to horizon, is visible from a maximum central 26’’angle given; see Figure 2. It shows the planetary albedo with few details concerning a good space resolution, which is sometimes undesirable when we wish to study global climate changing.

The albedo sensor described in this work is a byproduct of an experiment with solar cells, whose main objective was to study radiation damage in this device. It is very interesting to observe that the sensor (solar cell or photodiode) is largely used as radiation meter and the merit of the method is in the algorithm used to interpret the data. Additionally, the method is self-calibrated. The values of the Table 1 show no severe climate changing on South America during the years 2004, 2005 and 2006 (VEISSID, 2007, 2008).

The SCE data in the coming years will be able to identify the variation of albedo caused by human interference, like deforestation in the Amazon rainforest, or owing to natural effects confidence.

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THE SIGNIFICANCE OF THE OCEAN ON GLOBAL CLIMATE CHANGE

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ABSTRACT

In this article the role of the ocean on global climate change is discussed. The oceans and their biodiversity will irreversibly be affected by the impact of global warming associated with the changing climate. Large scale ocean circulation is one of the main mechanisms by which the ocean contributes for the climate and its variability. Global warming and the consequent melting of a substantial part of the polar icecaps may result in mean sea-level rise of the sea. The increase of the mean temperature of the planet will affect the wind regimen, rainfall and other interactions between the ocean and the atmosphere. The combined effect of these changes should significantly impact the manner in which the ocean moves. In counterpart, changes in the oceanic circulation may cause radical adjustments in the climatic balance, perhaps creating the possibility of unleashing a new glacial era.

Keywords: Climate change, Global oceanic circulation, Sea level rise.

INTRODUCTION

In the last years there has been a raising concern with respect to global warming and the associated climate changes. These changes, either global or limited to specific regions of the planet, imply in a series of economic, social and political consequences. The potential impact of global change has given the subject relevance at the international political level. At the top of this concern the scientific community has been engaged in the search for responses to fundamental issues on themes such as ways of manifestation, intensity and impacts of these changes, as well as their predictability. Nowadays, even with the certainty that some of these changes are already happening, much effort is still lacking to understand the distinction between these changes and natural climate variability from annual to inter-decadal time scales.

The oceans and their biodiversity will irreversibly be affected by the impact of global warming associated with climate changes. These changes, mainly induced by human activity, are associated to the drastic increase of the effects of greenhouse gases emissions. This is possibly the greatest challenge for the planet's future. The intensification of the *greenhouse effect* leads to the temperature increase on the planet's surface. According to the projections of the Intergovernmental Panel on Climatic Changes (IPCC), the warming effect caused by CO_2 increase in the atmosphere will be responsible for many consequences of planetary magnitude, such as: the rising of sea level (~45 cm), extinction of the arctic summer sea ice (year ~2050), decrease of the equatorial forests (~30%), etc., all with respect to the pre-industrial period. In this context, the ocean of the oceans is of fundamental importance. From approximately 7 Gigaton per year of CO_2 (Gt, = billions of tons) generated by anthropogenic activities, approximately 30% Gt of carbon has been stored *(long term sequestration)* by the oceans. The mechanisms of sequestration involves exchanges at the ocean-atmosphere interface and a later transference to great depths due to convective-dynamic processes associated to CO_2 exchanges in organic matter, through primary productivity of marine phytoplankton (*biological bomb)*.

Only around 60% of the estimated amount of CO_2 emissions per year is found in the atmosphere. It is believed that the ocean is still removing most of the other 40%. Moreover, it is also known that temperature increase reduces the ocean's capacity of absorbing carbon. With the reduction of the "carbon pump efficiency" in the oceans, global warming may unleash a process of positive feed-back, which will further increase CO_2 concentrations in the atmosphere. Recent studies suggest that ocean capacity to absorb Carbon has been reduced to half in the last 15 years.

In a general way, however, possibly due to the fact that we live on continents and within the atmosphere, the effects of the changes in these two components of the climatic system have been under significant consideration by the scientific community as well as politicians and decision makers. This interest bias and the high costs inherent to oceanographic research lead towards a misinterpretation of the ocean's role on the climate change problem. However, if its fundamental role in the storage and transport of heat, carbon and other elements that impact the climate system is considered, its importance becomes indisputable.

Large scale oceanic circulation is one of the important mechanisms by which the ocean contributes for the climate and its variability. Global warming and the associated melting of the polar ice-caps will result in mean sea-level rise. The increase of the mean temperature of the planet will affect the wind regimen, rainfall and other interactions between the ocean and the atmosphere. The combined effect of these changes will significantly impact on the ocean circulation in the future. In counterpart, these changes in the oceanic circulation could cause radical adjustments in the climatic balance, perhaps creating the possibility of unleashing a new glacial era. In the specific case of South America many changes are bound to occur on a regional scale:

Coastal areas are particularly sensible to the impacts of the ocean subject to global warming. The rise in the sea level may cause flooding of immense coastal areas as well as changes in the coastal upwelling systems and intrusion of sea water into aquifers.

In Brazil, the coastal areas approximately 70% of the population and a large segment of the economy of the country. The rise of sea level, besides causing the loss of coastal lands in low areas, may destroy important ecosystems such as lagoons and mangroves, bearing a great impact on the economy of these regions. Sea level rise may also change the energetic balance of seashore environment allowing enormous erosive impact.

The increase of sea surface temperatures is already affecting the number and intensity of hurricanes. An unusual incidence of a cyclone with hurricane characteristics has occurred off the coast of Southern Brazil, in the South Atlantic ocean. The Catarina cyclone caused a disaster of never before seen proportions. The southern area of the State of Santa Catarina and the northern part of the State of Rio Grande do Sul were struck, affecting tens of municipalities, leaving more than l0 thousand people dislodged only in Santa. Catarina. The combination of melting ice and increasingly warming sea water inevitably induces an expansion of the oceans.

Changes in the El Niño phenomenon and also in the modes of variability of the Atlantic Ocean may result in important changes of the continental climate. Changes in the South American monsoon system may also modify the atmospheric circulation pattern over the continent, leading to changes in the rainfall regimen over a vast area of South America, including the Southern and Southeastern regions of Brazil and practically all the La Plata Basin.

A basic necessity for the advance on the understanding of climatic variability and predictability in time scales of years, decades or centuries, is the increase of the available ocean observations data base, accompanied by long term, continuous and systematic monitoring. The progressive development and assimilation of these observations into oceanic models or coupled ocean-atmosphere models is of equal importance. It is known, for instance, that the inter-annual variation of the sea surface temperature (SST) significantly affects global climate.

Given the immensity of the ocean, the observations necessary for a better understanding of their role in climate requires a high degree of international cooperation and coordination. This idea gained much *momentum* from the Toga-TAO program, in the 1980s, whose central objective was to study the coupled ocean-atmosphere effect known as El Niño-Southern Oscillation (ENSO). In addition to its great contribution in the understanding of ENSO, another important outcome of Toga-TAO was the realization that the study of the ocean is crucial for the understanding of climate. Since then several major international programs have been implemented in an increasingly synergistic cooperation between the meteorological and oceanographic communities. In Brazil, some important actions have been conducted in order to understand the role of the ocean in climate change, most theoretical studies through or by means of numerical models. Some observational studies have also been developed, such as the work of the Project PIRATA in the Tropical Atlantic and the SACC Consortium in the South Atlantic The first is a three-nations ambitious program, conducted by INPE and DHN (Brazil), the IRD (France) and NOAA (USA). The second is a consortium of institutions of Brazil, Argentina, Uruguay and the United States, funded by the IAI, with the main objective to understand the role of climate in the South Atlantic region. The contribution of Brazilian oceanographic community is not larger only because of limited floating resources for research. For example, one of the only ships entirely dedicated to Brazilian oceanographic research campaigns, the N / Oc Prof. W. Besnard, University of São Paulo, has long exceeded the limit of life.

LARGE SCALE OCEAN CIRCULATION

The huge volume of water that covers about three quarters of the earth's surface is constantly moving on spatial scales ranging from intermolecular distances to the planetary dimensions. On macroscopic scales, some of the main causes of movement are the gravitational pull of the Earth and other celestial bodies, the gradients of pressure and differences in density, resulting from differential heating of the planet's surface and the friction of the winds on the surface of sea. In the time domain, the movement **IS** also manifested in a variety of scales. The tides, moving from the combined effect of the attractions and the rotation of the astronomical world, phenomena which are more energy is concentrated in periods of about one day. This time scale of the order of a day is called "inertial range", to be associated with inertial effects resulting from the rotation of the planet.

With respect to climate and its variability, it is essential to understand the movements of low-frequency ocean - periods much longer than the inertial - which are also movements of large spatial scales (order of tens of kilometers or more). At such large spatial and temporal scales, the main energy suppliers are the terrestrial gravity, the density gradients resulting from the different distributions of temperature and salinity, and wind drag on the surface of the sea.

WIND DRIVEN CIRCULATION

Wind is the predominant agent at the upper layers of the ocean. The resulting movement of the force of the wind is restricted, at most, to the first thousand of meters in depth, with typical speeds around 0,1 to 1,0 m/s, and is usually called “wind driven circulation.” The expression “circulation” results from the fact that this movement is characterized by closed circuits. I.e., the parcels of fluid circulate along “current lines”, completing a “horizontal rotation” in a determined period of time. The subtropical regions of the oceans are characterized by large cells of anti-cyclonic circulation (clockwise in the northern hemisphere and counter-clockwise in the southern hemisphere), as illustrated by Figure 1. Due to its spherical form and the rotation of the Earth (Coriolis effect), the flow at the western side of the basins is much more intense than at the eastern side.

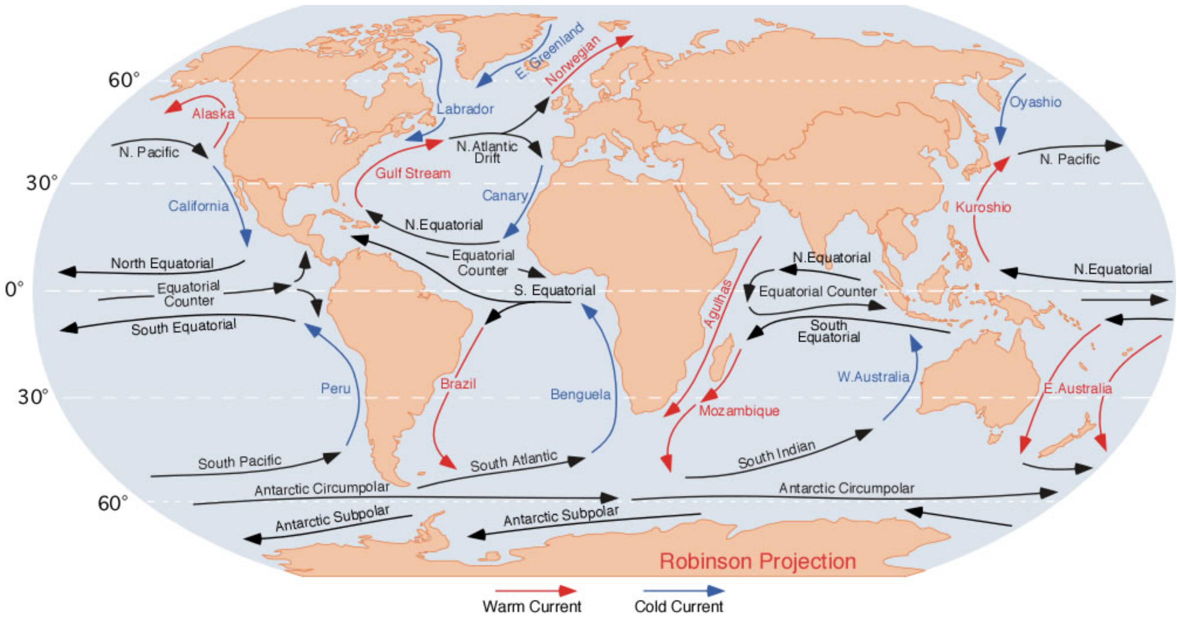

Figure 1 – Thermoheline Circulation. Artistic representation of the wind-driven circulation in the world ocean. The current patterns are dominated by the anti-cyclonic subtropical gyres, the predominantly zonal flows in the tropical regions and the Antarctic Circumpolar Current in the southern ocean.

Source: PhysicalGeography.net.

THERMOHALINE CIRCULATION

The motion resulting from latitudinal differences in temperature and salinity is called the "thermohaline circulation" and runs to the depths of the ocean. On a global scale, the average thermohaline circulation can be represented by a three-dimensional circuit that resembles a conveyor belt, leading and redistributing heat from all ocean basins (Figure 2). In the Atlantic, the thermohaline circulation is part of a cell in the vertical / north-south direction o called the Atlantic Meridional Overturning Cell (AMOC). This cell is maintained by the following mechanism: surface water from other ocean basins entering the South Atlantic by the Drake passage and southern Africa are transported to the North Atlantic. While passing through the equatorial region of the Atlantic, these waters are warm and become more saline due to evaporation. To reach high latitudes in the northern hemisphere, particularly in the Norwegian Sea, the waters from the warmer south releasing heat into the air and, because of higher concentration of salt compared to the waters of local origin, become heavier and sink . The resulting body of water that "sinks", is known as the North Atlantic Deep Water (NADW), flowing then, back to the South Atlantic, which is exported to the other ocean basins, completing the thermohaline circulation.

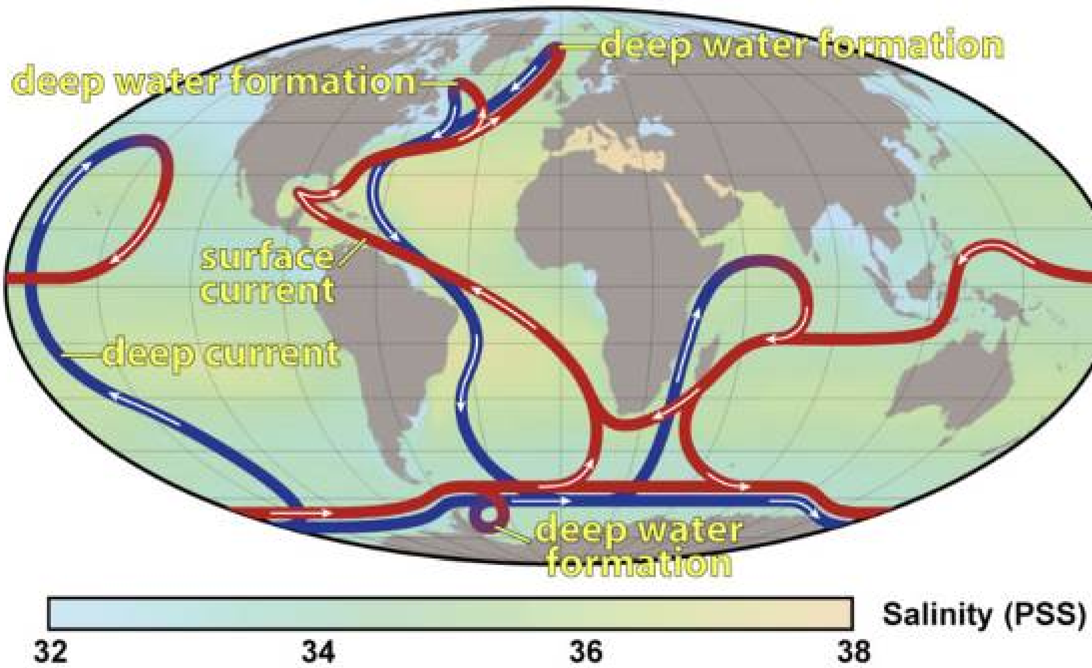

Figure 2 – Wind-Driven Ocean Circulation. This map shows the pattern of the Thermohaine Circulation, also known as "meridional overturning circulation". This collection of currents is responsible for the large-scale exchange of water masses in the ocean, including providing oxygen to the deep ocean. The entire circulation pattern takes ~1000 years.

Souce: Robert Simmon, NASA. Minor modifications by Robert A. Rohde and released public domain. ***"NASA material is not protected by copyright unless noted"***.

THE OCEAN ROLE IN CLIMATE

The water molecule is composed of two hydrogen atoms and one oxygen atom arranged in a spatial configuration such that the molecule is polarized, i.e. it has a positive side and one negative. This polarization results in a series of physical and chemical properties such as high power ion dissolution, formation of polymers and high specific heat. The specific heat of water, some thousand times greater than the air and one of the highest among all known substances, represents its large thermal capacity. That is, the change of water temperature is relatively slow and involves an exchange of large amounts of heat with the environment. This high "thermal inertia", associated with the large amount of water covering the surface of the planet, is a key element in the control of climatic conditions. The complex chemical reactions that led to the emergence of life as it is on planet Earth certainly occurred in the thermally stable environment posed by the oceans, and maintenance of that life is only possible due to large net mass covering the planet.

The sun is the main source of the energy that preserves the planet's climate. Basic principles of Thermodynamics assert that all bodies that receive heat, warm up and emit heat up to a temperature of equilibrium, when the amount of emitted heat is equal to the received heat. Thus, along millions of years the planet has presented a balanced temperature by means of giving back to space the heat received from the sun. The simple fact that the reader is at the present moment reading these words definitely confirms the fact that this balanced temperature has been kept for an extent suitable to life, at the length of a long period of the planet's history. Less obvious, however, is the fact that this balanced temperature remains distributed without great variation in space.

The balance between the heat received from the sun and the radiation emitted back to space varies in latitude. At low latitudes there is a liquid gain of heat, i.e., the radiation of short waves received from the sun is greater than the long waves radiation returned to space. At high latitudes the inverse occurs. In the absence of a mechanism that transfers the excess of heat from the low toward the high latitudes, the mean temperature of the tropical region would be much superior, and that of the sub polar regions much inferior than the present values. Trully, these temperatures would be so different that life as it is on Earth would only be possible in a very narrow strip of mean latitudes. The movement of the fluid cloak formed by atmosphere and the oceans is the mechanism responsible for the southern transference of heat, resulting in latitudinal variations of temperature that allow Life all over the terrestrial surface.

In the atmosphere, the heat transfer is done mainly through synoptic movements, or deviation from a standard climatological average. In the oceans, the average circulation is the main mechanism in the poleward transport of heat Overall, the combined role of these two important components of the climate system is as follows: In middle and low latitudes, the average movement of the ocean transports heat toward the poles. In middle and high latitudes the heat brought by the oceans is absorbed by the atmosphere and redistributed on different oceanic and continental regions. After loosing heat to the atmosphere, the water mass transported by ocean currents from low latitudes end up at high latitudes, denser than waters of local origin and sink, slowly returning to lower latitudes. In the absence of the Continents, the mean pattern of oceanic circulation, due to this heat exchange, would be similar to the Haddley and Walker cells in the atmosphere. However, because of the distribution of the continents, the mean pattern of oceanic circulation presents itself as the large thermohaline conveyor belt represented by Figure 2.

THE ATLANTIC OCEAN

In general, this global transport mechanism in the upper layers waters of the Pacific and Indian Oceans towards the South Atlantic. At the south of Africa, waters originated from the Indic enter into the Atlantic by means of a process known as the "Agulhas Return Current". Otherwise, enormous amounts of warmer and more saline waters from the Indic imprisoned in "rings" detached from the Agulhas Current, due to hydrodynamic instabilities in the region, deflect and turn eastward (Figure 3). This water pathway between the two basins is known as the "Hot Route".

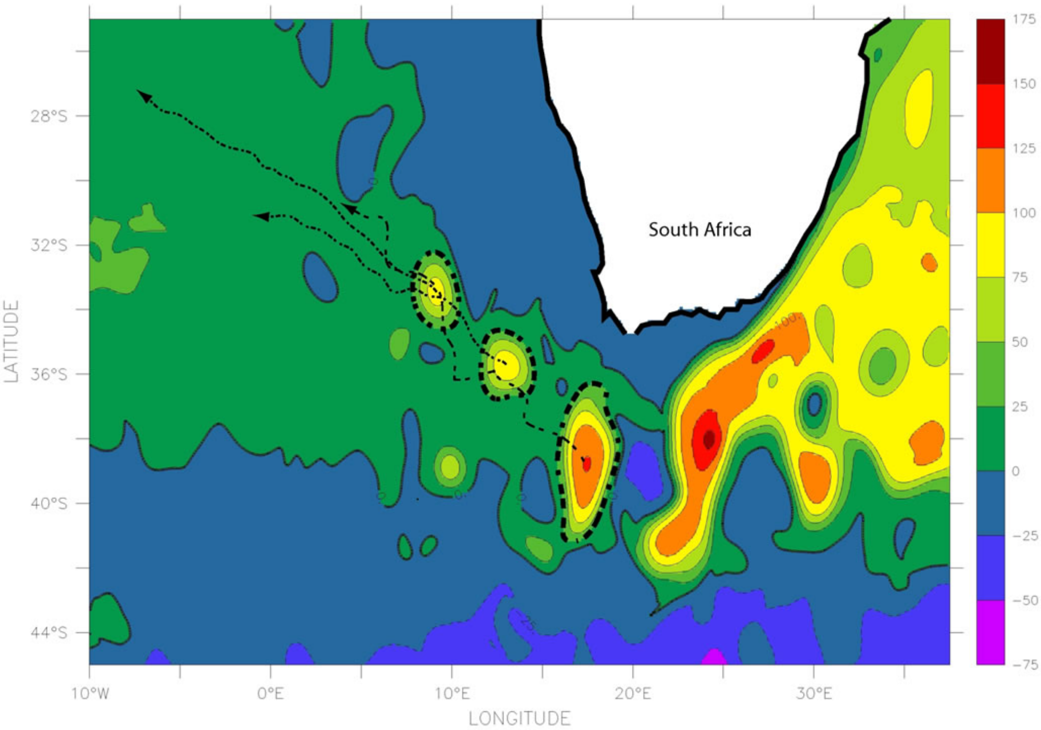

Figure 3 – The Agulhas Retroflection and Rings. The Agulhas Current flows southward along the eastern coast of Africa and, after 'running out" of the continental barrier, it turns back on itself (a phenomenon referred as "retroflection" in oceanography) and continues to flow eastward. Due to hydrodynamic instabilities, from time to time a "ring" of Agulhas waters detach from the retroflection and travels northwestward carrying huge amounts of Indian Ocean water into the South Atlantic basin. There are about six of such rings per year, totalizing a transport of 10 to 12 Sverdrups (1 Sv = 1 million cubic meters per second).

Souce: Impact of cooling on the water mass exchange of Agulhas rings in a high resolution ocean model, J Donners, S S Drijfhout and A C Coward, *Geophys Res Lett.*, (2004), 31, L16312.

From the basin west side , to the south of South America, colder and more saline waters, carried by the Antarctica Circumpolar Current (ACC), enter the South Atlantic and part of these waters flow to the north, along the Argentina continental platform, taking the form of the Malvinas Current. At approximately 38° S this current meets the Brazilian Current and turns southeast newly integrating the ACC. At the region of confluence with the Brazil Current (BC), part of these Pacific originated waters mix with local waters contributing to the formation of the water mass of the upper regions of the South Atlantic. This route of waters entering through the Drake Passage is known in literature as the “Cold Route”.

At the upper layers of the subtropical region of the South Atlantic, the waters transported by the two routes feed the South-Equatorial Current. This current takes the northwest course, getting close to the Brazilian coast, approximately between 5° S and 10° S, where it forks. The southern section of this fork gives origin to the Brazilian Current. The northern section constitutes the Brazilian North Current, transporting water toward the Equator, providing a complex system of currents that result in a liquid water transport from the southern hemisphere to the north, carrying heat excess from the tropical regions toward the high latitudes of the North Atlantic.

THE DAY AFTER TOMORROW

In the “The day After” movie, Hollywood approaches a theme related to the ocean’s response to global warming in a sensationalist way, although with certain scientific basis. To simplify, one of the effects of the planet’s warming issue is the defrost of the Coral Reefs layers. The absorption of CO_2 excess into the ocean-atmosphere interface also contributes to the reduction of the ocean’s capacity of CO^2 absorption. The pH reduction beyond a critical point, could lead to a CO_2 flow from the ocean back into the atmosphere, increasing even more the local warming. In this scenario the oceans would loose the role of a climate moderator.

With the rising tendency of atmosphere CO_2 increase and the uncertainties of the oceanic processes previously described, many studies and reviews have been made by the scientific community, with the purpose of trying to clarify the controversial issues and find more environmentally correct and viable solutions. All these studies have been providing basic subsidies for the understanding of the CO_2 cycle in the oceans. However, a contextualization for the South Atlantic region is still necessary. Brazil, due to its enormous seashore running parallel to the South Atlantic and its significance in the socio-political scenario among the countries that border this ocean basin, ought to provide a significant scientific contribution linked to the proposed thematics.

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INDEX OF AUTHORS

Climate Change involves many aspects, part of them polemic. However, they are not any longer questioned even if the studies on warming causes and on the consequences that they will engender are still in development. Thus, it is fundamental to intensify the debate on these issues. This book presents the global changes in different perspectives, as follows: international relations and public policies, mitigation, adaptation and consequences to the natural systems. In the first part are the considerations that approach the complex web of relations among the countries for a necessary reduction of the greenhouse-effec gases. In part II are found the articles that discuss the appliance of the Clean Development Mechanism in Brazil. In sequence there are contributions turned to necessary actions of adaptations to global changes. To close the study, collaborations were gathered from authors dedicated to understand the adjustments of various natural systems. The peoples will be affected in distinct ways, as well as the natural systems. It is mandatory to discuss the adaptations that should be made in the cities and in the agricultural productive systems in the world, specially in the South America. It is expected that this book will bring more elements to this debate.