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FAPESP RESEARCH PROGRAMME ON GLOBAL CLIMATE CHANGE (FRPGCC)
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1 CLIMATE CHANGE: A CONCERN FOR TODAY AND FOR TOMORROW

The Earth's climate is continuously changing. Most of these changes occur over time scales of months, years, millennia to millions of years and are natural (Figure 1). Variations in the amount of solar radiation received by the planet, small variations of the orbit, volcanic eruptions injecting gases and aerosols into the atmosphere, coupled to natural variations of ocean currents and atmospheric circulation, cause climate variability and change.

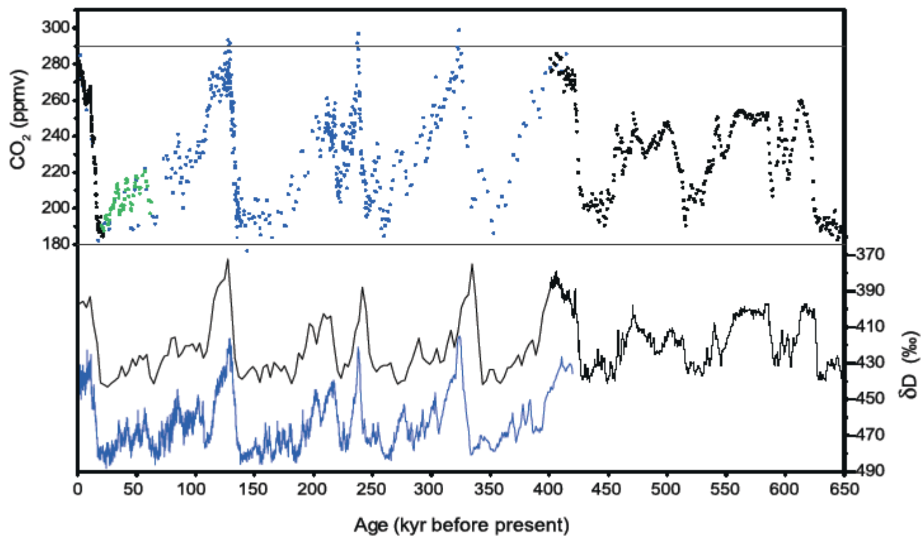


Figure 1. Composite carbon dioxide record from Antarctic ice cores from Dome Concordia (black, 0–22 thousand and 390–650 thousand years ago), Vostok (blue, 0–420 thousand years ago) and Taylor Dome (green, 20–62 thousand years ago); and composite delta deuterium record from Dome Concordia (0–650 thousand years ago) and Vostok (0–420 thousand years ago). From IGBP Science Plan, 2006, referring to Siegenthaler et al. (2005)

However, the greenhouse gases and aerosols in the atmosphere and the profound changes in the land cover of the planet provide an abundance of evidences that the rapid rates of environmental change observed in the last 100 years are likely result of a complex interplay of human-related and natural causes. The main human-related causes of change are the injection of greenhouse-gases (Figure 2) and aerosol and land cover change at a global scale, disturbing natural biogeochemical cycles, and affecting the climate system. In fact, the recently released IPCC Working Group I Report states that "*the global atmospheric concentration of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousand of years. The global increases in carbon dioxide concentration are due* *primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture*” (IPCC(a), 2007).

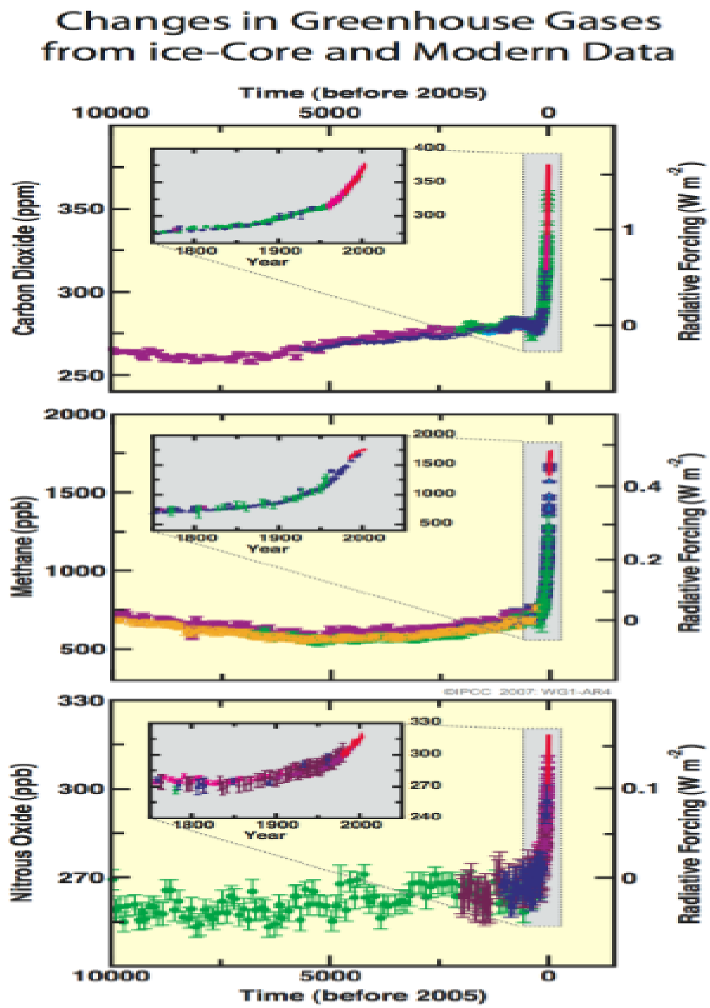


Figure 2. Atmospheric concentrations of carbon dioxide, methane and nitrous oxide over the last 10,000 years (large panels) and since 1750 (inset panels). Measurements are shown from ice cores (symbols with different colours for different studies) and atmospheric samples (red lines). The corresponding radiative forcings are shown on the right hand axes of the large panels. (IPCC(a), 2007)

The Fourth IPCC WGI Report (IPCC(a), 2007) is very clear in attributing observed climate change to human activities: “*most of the observed increase in globally averaged temperatures since the mid-20th century is very likely [confidence higher than 90%] due to observed increase in anthropogenic greenhouse gas concentration. Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns*”, as indicated further in Figure 3.

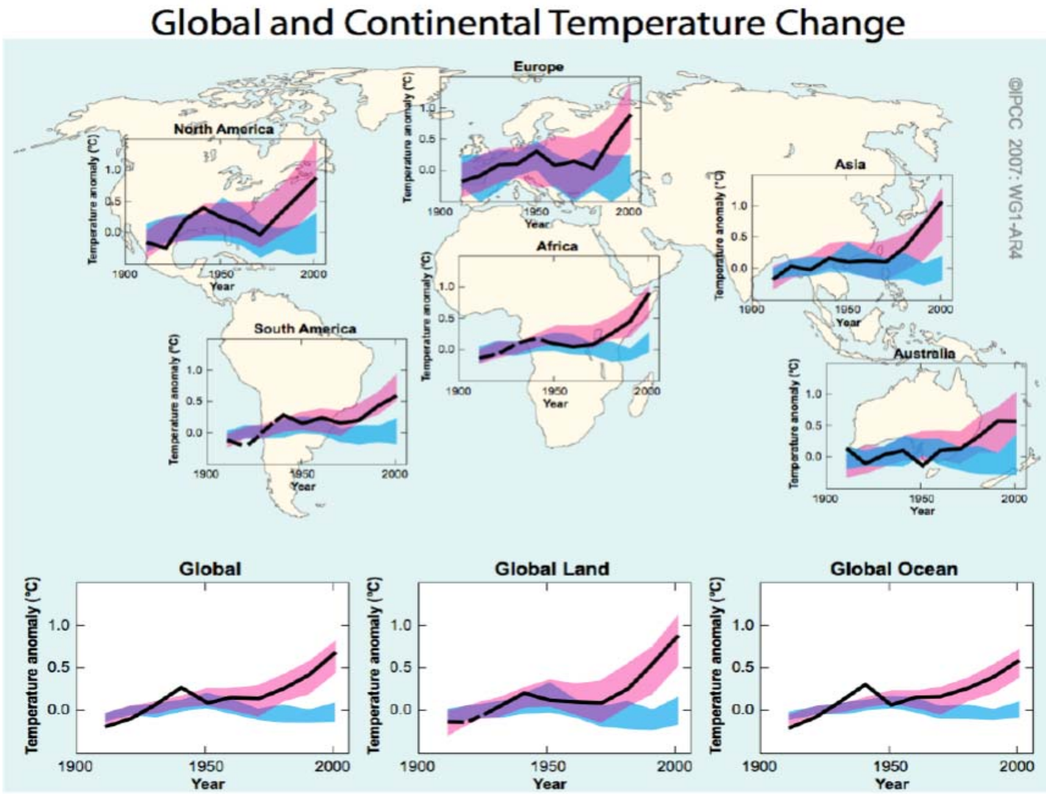


Figure 3. Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906–2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901–1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5–95% range for 19 simulations from 5 climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5–95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings (IPCC(a), 2007)

The projections of future climate change for the 21st Century and beyond based on a large number of simulations from a broad range of climate models indicated a warming of about 0.2 C per decade for a range of emissions scenarios for the next two decades (Figures 4 and 5), and substantial changes in precipitation (Figure 6) and runoff (Figure 7).

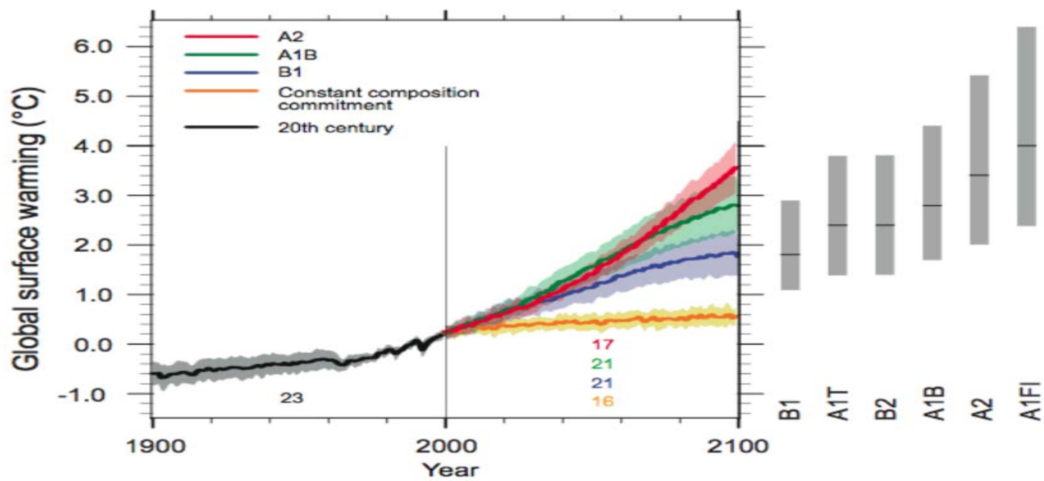


Figure 4. Solid lines are multi-model global averages of surface warming (relative to 1980-99) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the plus/minus one standard deviation range of individual model annual means. The number of AOGCMs run for a given time period and scenario is indicated by the coloured numbers at the bottom part of the panel. The orange line is for the experiment where concentrations were held constant at year 2000 values. The grey bars at right indicate the best estimate (solid line within each bar) and the likely range assessed for the six SRES marker scenarios. The assessment of the best estimate and likely ranges in the grey bars includes the AOGCMs in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints (IPCC(a), 2007)

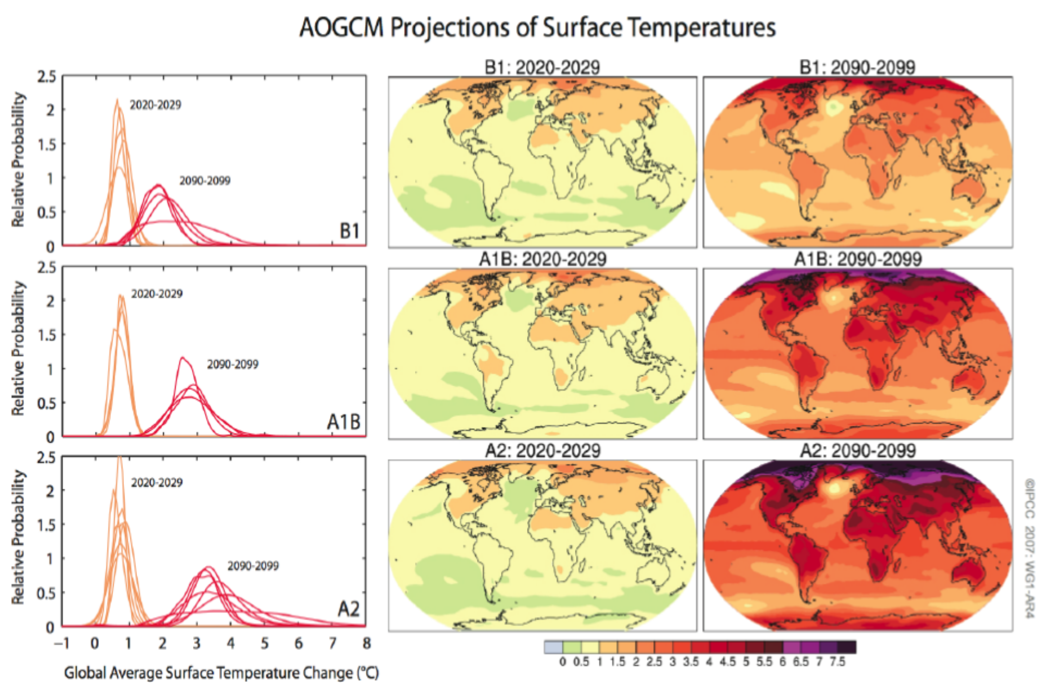


Figure 5. Projected surface temperature changes for the early and late 21st century relative to the period 1980–1999. The central and right panels show the Atmosphere-Ocean General Circulation multi-Model average projections for the B1 (top), A1B (middle) and A2 (bottom)

SRES scenarios averaged over decades 2020–2029 (centre) and 2090–2099 (right). The left panel shows corresponding uncertainties as the relative probabilities of estimated global average warming from several different AOGCM and EMICs studies for the same periods. Some studies present results only for a subset of the SRES scenarios, or for various model versions. Therefore the difference in the number of curves, shown in the left-hand panels, is due only to differences in the availability of results (IPCC(a), 2007)

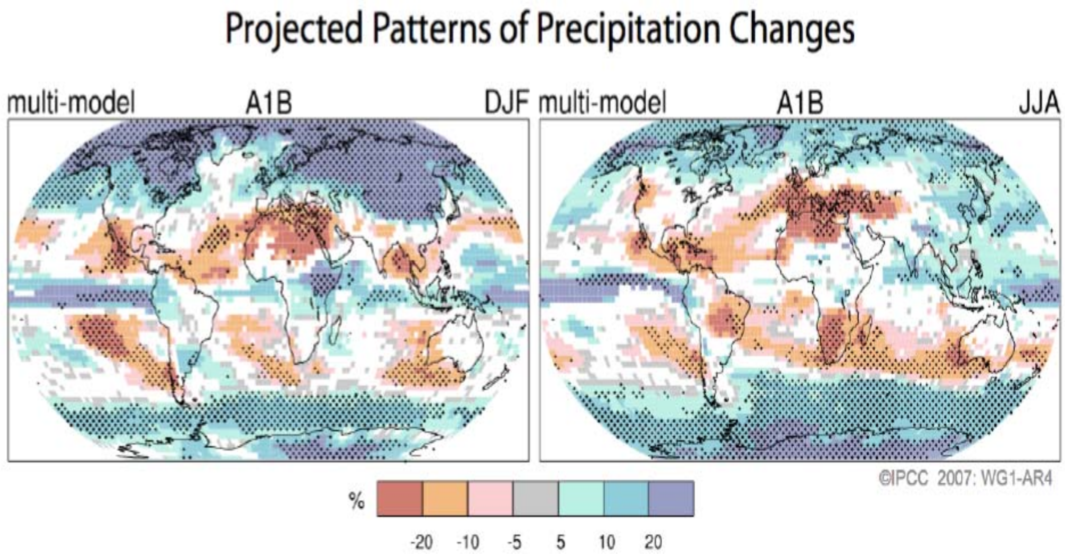


Figure 6. Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change (IPCC(a), 2007)

Continued greenhouse gas emissions would cause further warming and induce many changes in the climate systems during the 21st Century that would very likely be larger than those observed during the 20th Century (0,74 C increase in the global mean temperature) and anthropogenic warming and sea level rise would continue for centuries (IPCC(a), 2007).

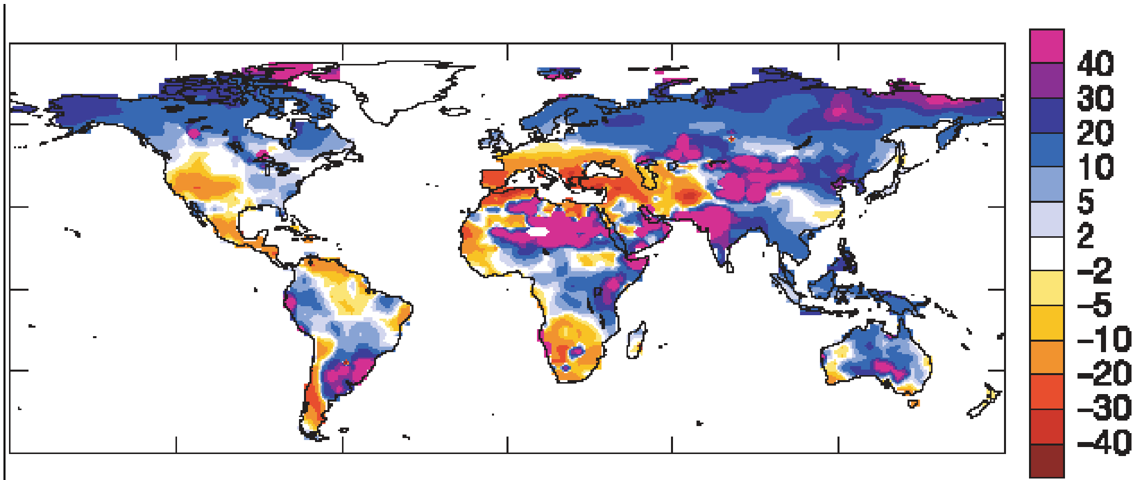


Figure 7: Ensemble mean change in annual runoff, in percent, by 2050 under the SRES A1B 46 emissions scenario, based on an ensemble of 12 climate models (Milly et al., 2005).

Global environmental change is more than climate change. For instance, changes in the atmospheric carbon dioxide concentrations are leading to consistent changes in the ocean water pH (Figure 8). Furthermore, multimodel projections based on AR4 SRES scenarios give reductions in pH of between 0.14 and 0.35 units in the 21st century, adding to the present decrease of 0.1 units from pre-industrial times. Changes on pH can lead to a reduction of the ocean buffer capacity, thus the capacity of the ocean carbonate system to absorb additional CO_2 from the atmosphere can eventually be disrupted. Thus, the build up of CO_2 in the atmosphere is increasing the ocean's acidity potentially affecting severely marine life (Elderfield, 2001).

According to the Millennium Ecosystem Assessment (2005), the last 60 years of the human kind history has seem more land conversion to croplands than in the eighteenth and nineteenth centuries combined, encompassing now approximately one quarter (24%) of Earth's terrestrial surface. Over this recent period, human population increased exponentially, and therefore, has changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fibre, and fuel. The intensive change can have serious impact in the biodiversity (Thomas et al., 2004; Miles et al, 2004).

In Brazil, land use and land cover change has been historically the most important local, regional and possibly global actor for environmental changes. Andreae and Crutzen, 1997 have pointed out biomass burning as a major driver affecting climate and air quality and an important source of aerosol particles and several trace gases. Recently La Rovere and

Romeiro (2003) showed that CO_2 emissions due to energy use in Brazil, in 2000, were equivalent to 1/3 of the total CO_2 emissions, letting the other 2/3 to biomass burning. Despite the total emissions, this pattern reflects in a relative low emission balance from the Brazilian energy system due to intensive use of renewable energy such as hydropower and biomass (wood, charcoal and fuel ethanol).

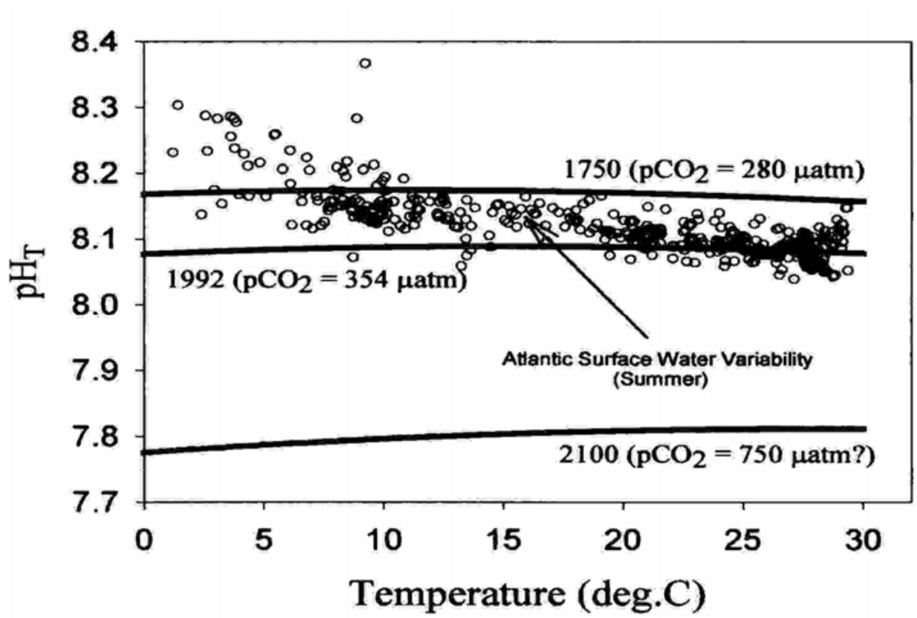


Figure 8. Atlantic surface water pH change: 1750-2100 (SOLAS Science Plan, 2004)

The natural biomes of the Atlantic rainforest and subtropical interior forests were almost completely altered over the course of a century (Joly, 2002). Sao Paulo State region was dominated by the Atlantic forest, but the pressure from agriculture, where the main actors were coffee (first cultivated in Sao Paulo in 1825 at Paraíba river valley), followed by sugar cane and citriculture, and pastures reduced the forest area to 7% of its original area. The Cerrado areas in the State have experienced strong land change pressure reducing drastically its original area (Silva. & Bates, 2002). More recently over the last 40 years, the tropical forests of Amazonia and the Cerrado vegetation have been also increasingly replaced by agriculture and pasture land (Nepstad et al, 1997).

On the global scale, a recent synthesis (Steffen et al., 2003) of a decade of coordinated global change research of the International Geosphere-Biosphere Programme (IGBP) highlighted that:

- Biological processes play a much stronger role than previously thought in Earth System functioning

- Global change goes beyond climate change. It's real, it's happening now and it's accelerating
- The Earth's dynamics are characterised by critical thresholds and abrupt changes
- Human activities drive multiple, interacting effects that cascade through the Earth System in complex ways with potentially catastrophic consequences
- The Earth is currently operating in a no-analogue state

There has been concern whether the Earth might be at a tipping point, that is, due to nonlinearities, positive feedback and hysteresis on the Earth system slow incremental changes in the build-up of GHG would prompt much larger and even abrupt changes, tipping the system into a point of no return. The Table 1 below indicates some threshold value of warming that might unleash profound changes in individual components of the climate system. However, uncertainties on our current representation of components of the Earth System prevent predictions on how and when a particular tipping point will be reached. As Walker (2006) remarks: "*The current level of greenhouse gases ensures that the world will continue to warm over the next decades, and the current structure of the world economy ensures that, over that time, there will be further increases in the greenhouse-gas level. The question is what will be done about and how soon.*"

Table 1. Critical Thresholds of the Earth System in Response to Global Warming

0.6 C	Coral bleaching
0.6 C	West Antarctic losing ice
0.7 C	Kilimanjaro glacier gone
1.0 C	Tropical Glacier in the Andes gone
1.6 C	Onset of melting of Greenland ice cap
3.1 C	Greenland ice cap gone*
2-3 C	Collapse of Amazon rainforest
4 C	Collapse of Thermohaline Circulation (THC)

Source: Schellnhuber HJ (2006) and * Gregory and Huybrechts, 2006

For South America and in particular for Brazil, a summary of climate variability and change studies points out that:

- There is high confidence of increases in rainfall in south-east Brazil, as well as increases in temperature of approximately 1°C in Mesoamerica and South America, and of 0.5°C in Brazil, were observed.

- Observational records show that South America, with a few variations, has been warming throughout the 20th Century, as for the rest of the planet and the warming trend in some regions have been accelerating over the last 30 years, especially since the1990's (IPCC(a), 2007) (Figure 3)

- Impacts of natural climate variability, including extremes, are very common throughout South America and affect all sectors and systems, as observed in several projects within the Assessments of Impacts and Adaptations to Climate Change (AIACC) (http://sedac.ciesin.columbia.edu/aiacc). There is an array of extreme weather and climate events commonly associated to significant impacts in this region (Alexander et al., 2006; Vincent et al., 2005; Wang and Chameides, 2005; Charvériat 2000; Meza et al. 2002; Gonzales 2005; Fearnside 2001; Cochrane 2003)

- Vulnerability and risk of the population and economic sectors to climate variability and extreme events seem to be increasing in South America as population increases and land use patterns change (GEO, 2003; ECLAC, 2002; Alexander et al., 2006; Vincent et al., 2005).

- Torrential rains and resulting floods area among the main natural hazards in South America, including most of Brazil, resulting in thousand of deaths and severe economic losses and social disruption (Haylock et al, 2006; Alexander et al., 2006; Vincent et al., 2005; Wang and Chameides, 2005; CRED 2004; Schultz et al., 2005. In fact, precipitation observations over the last 50 years show that intense rainfall episodes are becoming more frequent in parts of South America (Figure 9).

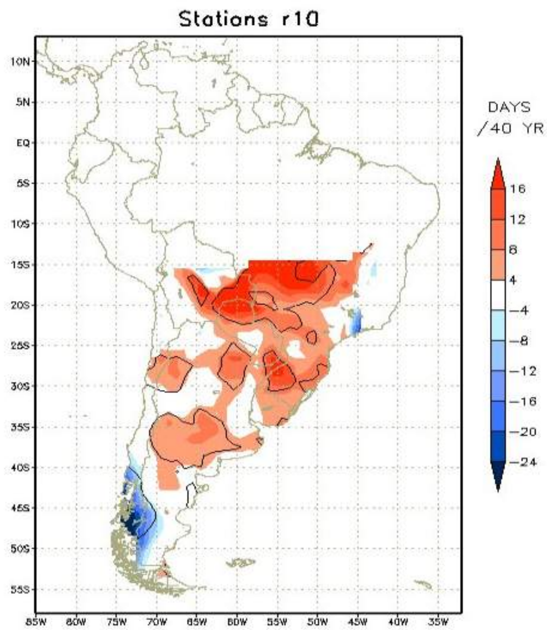


Figure. 9. Increase in the number of days with rainfall episodes > 10 mm/day from 1961 to 2000. The analysis covers only latitudes south of 15 S due to lack of data from tropical South America. Modified from Marengo et al, 2007

- El Niño and La Niña are the main climate phenomena associated to droughts in many parts of South America, but there other large scale climate factors inducing dry spells and droughts (Trenberth et al, 2004; Haylock et al, 2006). The cumulative effect of severe droughts especially those of Northeast Brazil, affect tens of million of people and impact natural ecosystems and agro-systems (Charvériat 2000).

- Weather extremes normally linked to intense or prolonged rains are a common natural hazard in São Paulo, causing floods and mudslides every year, and affecting severely tens of thousands of people; dry spell and droughts are common climate extremes impacting adversely agriculture, hydropower generation and water supply in São Paulo, affecting millions of people and the States' economy.

Increasing energy demand and droughts caused serious problems to the electricity production in eastern, central and northeastern Brazil in 2001, with a breakdown in the system and reduction of Brazil's GNP (Kane, 2002).

As for the future scenarios of climate change for South America, global climate models for a range of greenhouse gases emissions scenarios (SRES scenarios) indicate

- Very likely warm during 21st century over most of South America. The annual mean warming is likely to be similar to the global mean warming in southern South America but larger than the global mean warming in the rest of the area.
- Annual mean warming under one of the SRES (A1B) scenarios between 1980 to 1999 and 2080 to 2099 for most of South America ranges, respectively, from 1.8°C to 5.1°C and 2.6°C to 3.7°C.
- The highest values of warming are projected to occur over Tropical South America.
- Marked regional variations in precipitation patterns, with decrease over northern South America and over large parts of northern Brazil, and increase in south-eastern South America.
- Higher degree of uncertainty for precipitation, with a tendency of drier climate for Tropical South America in 2080.
- Uncertainty is even larger for southern South America precipitation changes for both winter and summer seasons (Haylock et al, 2006).
- More intense wet days per year over large parts of south-eastern South America and central Amazonia but with longer periods between rainfall events, and weaker precipitation extremes over the coasts of northeast Brazil.

Figure 10 shows scenarios of temperature and precipitation change for South America for the last decade of the 21st Century for two SRES emissions scenarios (A2 and B2).

Giving these scenarios of climate change for the current Century, key expected impacts of climate change in South America are

- Likelihood of large impacts on natural ecosystems, increasing species extinctions in low-land and altitude tropical forests to catastrophic levels for some animal and plant species. Eterovick et al. (2005) and La Marca et al (2005) have reported decline and disappearance of amphibian species following habitat degradation and deforestation. Burrowes et al (2004) and Ron et al (2003) have shown drastic decline of toads and frogs population from cloud forest with reducing in precipitation levels.

- Except for mid-latitude areas, where CO_2 fertilization effects may balance out negative effects of climate change, agriculture yields are expected to decrease throughout South America, mostly over tropical Brazil, at the end of the Century (Smith and Lazo, 2001).

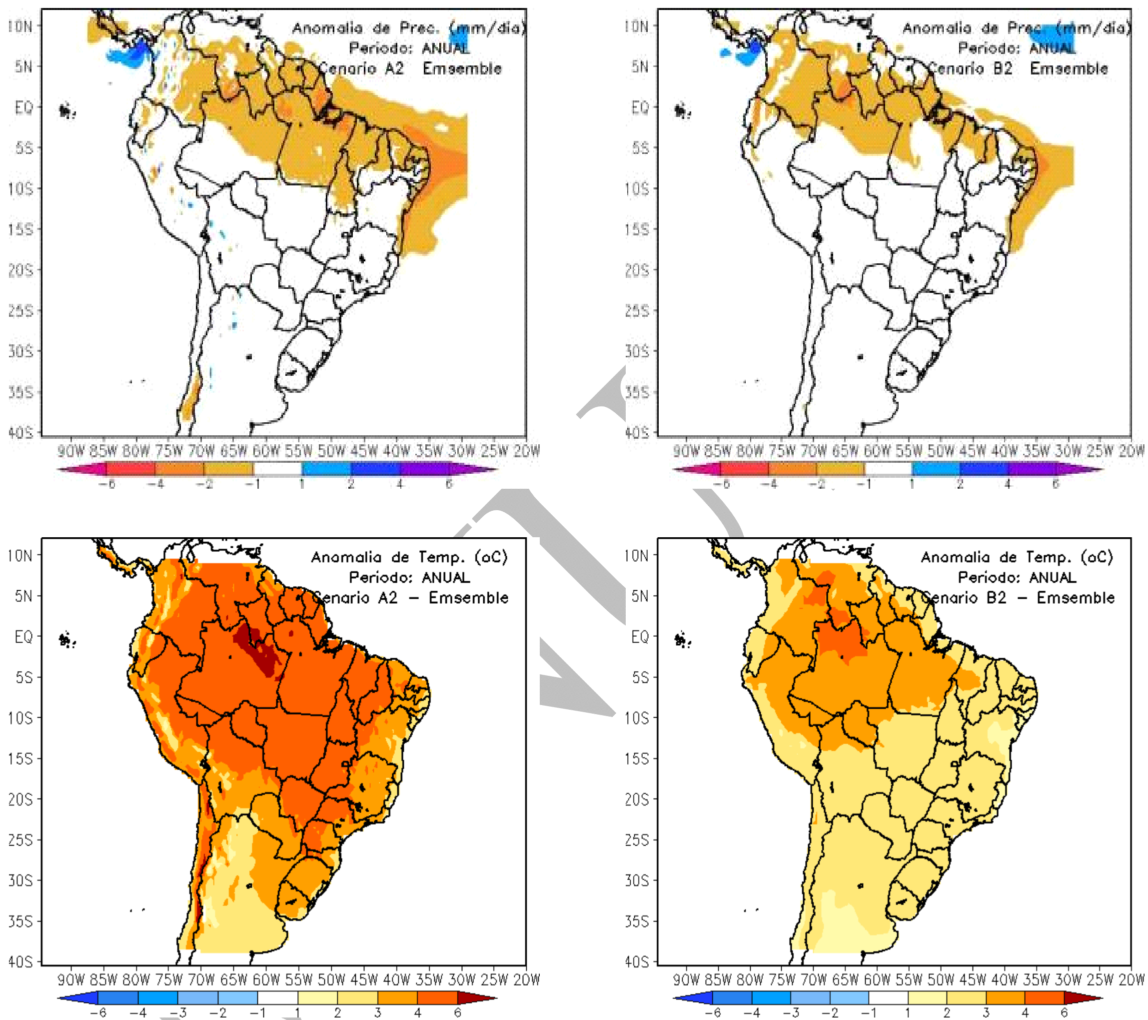
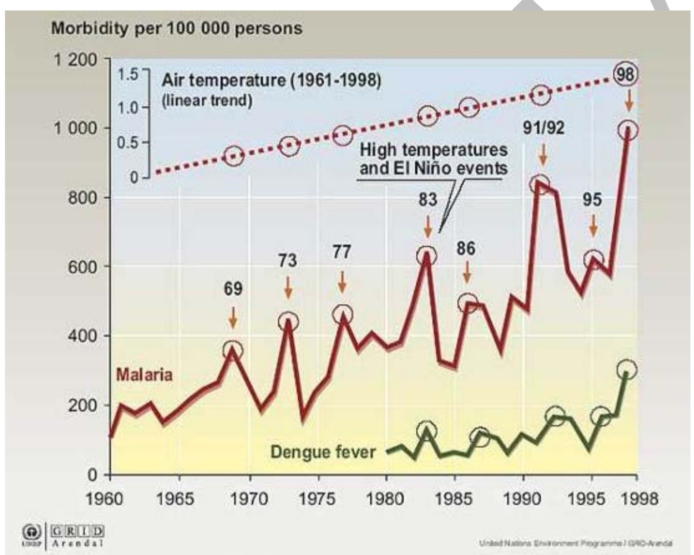


Figure 10. Projected changes of precipitation (upper panels) and temperature (lower panels) for two SRES emissions scenarios (A2 and B2) for South America for 2071-2100 with respect to 1961-1990. The projected changes are calculated as an averaged of 3 regional atmospheric models forced by the conditions of a global climate model (Hadley Centre). Source: Marengo et al., 2007.

- As for water resources, notwithstanding the uncertainty of precipitation and runoff scenarios, semi-arid and arid regions of South America are expected to be the most affected by a decrease of water availability. That is particularly serious for Northeast Brazil. The impact over hydropower generation is uncertain due to large uncertainties for runoff scenarios (Arnell, 2004; Garcia Vargas 2003; Planos and Barros 1999; Mendoza 1997), however projected increase of intensity of rainfall events and of seasonality of rainfall in Tropical South America may affect the operation and lifetime of hydropower plants.

- Sea level projected to rise between 28 cm to 59 cm (IPCC(a), 2007) during the 21st Century is expected to affect most coastal zones in South America. It presents a serious threat to low-lying mangroves, it will increase salt intrusion in freshwater resources, and increase the frequency and intensities of storm surges, coupled to atmospheric circulation changes (Grasses et al, 2000; Nagy et al., 2005).



Source: Colombia National Communication to the UNFCCC 2001

Figure 11. Climate impact and tropical diseases in Colombia. Source: UNEP/GRID-Arendal (http://maps.grida.no).

- Increased temperatures are likely to increase transmission rates of vector-borne diseases such as malaria and dengue fever, but drier future climate in parts of Amazonia could decrease malaria risk. Pini et al (1998), Espinosa et al (1998) and have reported outbreaks of hantavirus related to prolonged droughts in several South American countries. Franke et al (2002) reposted a significant increase in visceral leishmaniasis after two El Niño years in North East Brazil. Figure 11 shows comparative trend between air temperature in Colombia and levels of malaria and dengue fever. A combination of high precipitation and temperature favours the vector borne diseases, like malaria and dengue fever, to increase in frequency and distribution. These specific environments provide the best conditions for the growth and spread of Anopheline spp. and Aedes aegypti mosquitoes, (McCarthy et al 2001).

In a general way, health consequences of climate changes can potentially be manifested mostly in terms of increase in the number or in the severity of well defined conditions, such as heart diseases, asthma, cancer and infections. The consequences of such scenario are that drastic changes in temperature will probably cause few problems of hyper or hypothermia, but thousands might die because of heart attacks or respiratory diseases (Haines and Patz 2004; Haines et al. 2000; Patz 2004; Romieu et al. 1996).

Studies since the TAR have enabled more systematic understanding of the timing and magnitude of impacts related to differing amounts and rates of climate change. Figure 12 summarizes the likely impacts associated with global average temperature change for several systems and sectors. As mentioned before, impacts will vary by extent of adaptation, rate of temperature change, and socio-economic pathway.

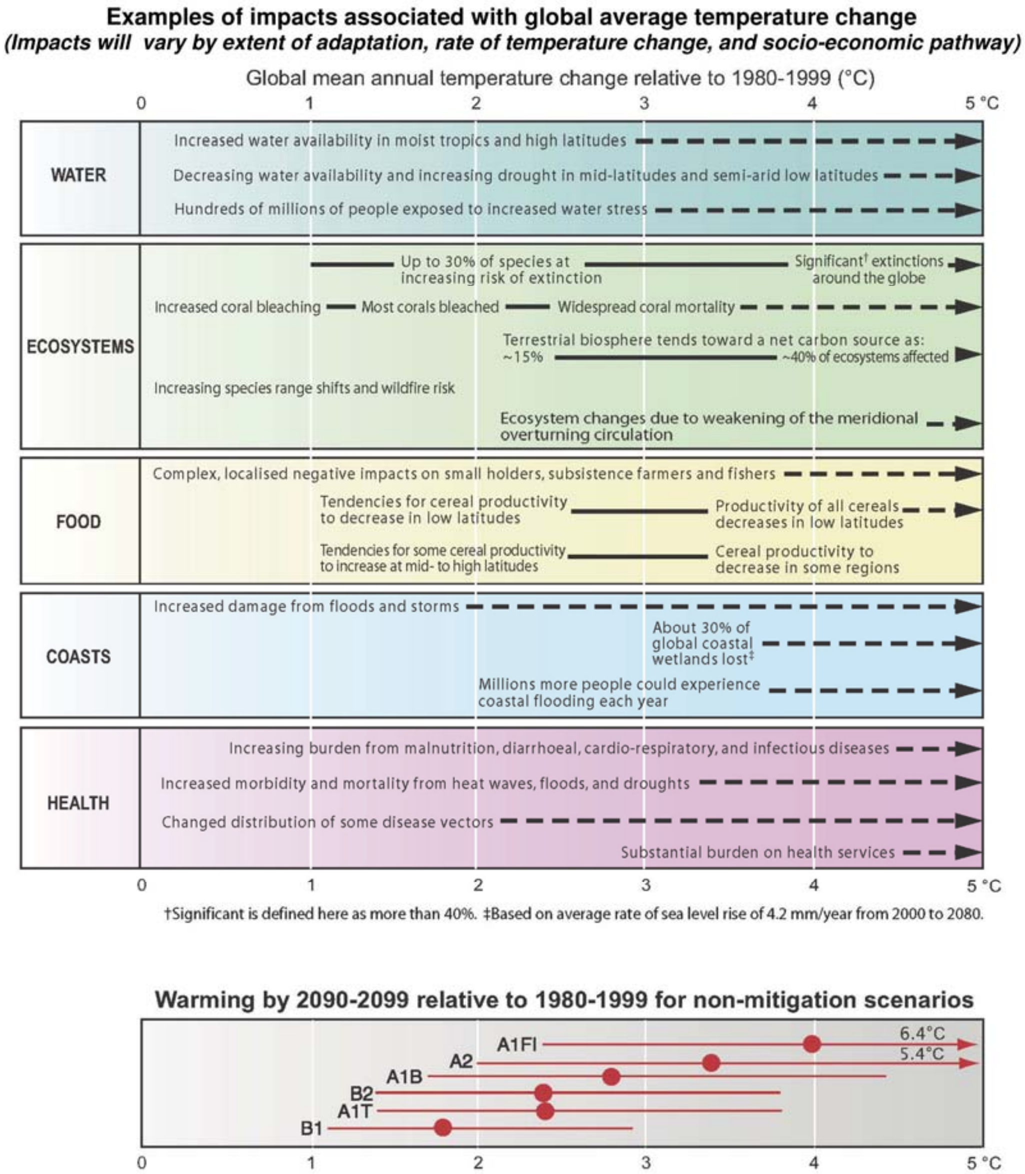


Figure 12: Examples of impacts associated with projected global average surface warming. Upper panel: Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric CO2 where relevant) associated with different amounts of increase in global average surface temperature in the 21st century. Lower panel: Dots and bars indicate the best estimate and likely ranges of warming assessed for the six SRES marker scenarios for 2090-2099 relative to 1980-1999 (IPCC(a), 2007)

Climate change in the São Paulo State could potentially affect adversely many sectors, activities, and natural and human systems. The projected increase in the frequency of extreme weather and climate events can wreak havoc for the most vulnerable of the population, normally the poor living in areas exposed to great risk of natural disasters. Additionally, the economy of the State is heavily dependent on renewable natural resources all linked directly or indirectly to environmental conditions, especially climate: hydropower generation is the most important energy source, the State is the leader in biofuel production, and rainfed agriculture is highly developed. Increased climate variability and change can potentially worsen an already complicate situation concerning water supply for domestic use in this region. Water supply is already stressed for some regions, particularly for the Greater São Paulo Metropolitan area and if the climate variability increases as a result of climate change, water scarcity might become an even more serious problem (Nascimento and Heller, 2005; Ducrot et al., 2005 and references thereafter).

As an illustration of potential impacts of climate change on an important economic activity in the State of São Paulo. Figure 13 presents the projected impacts of temperature increase on coffee plantation (*Coffea arabica L.*) in the State of São Paulo for the next 50 to 100 years. Notice that for large temperature increases this variety of coffee virtually disappears from the region since too many hot days would prevent the plants from flowering (Assad et al, 2004).

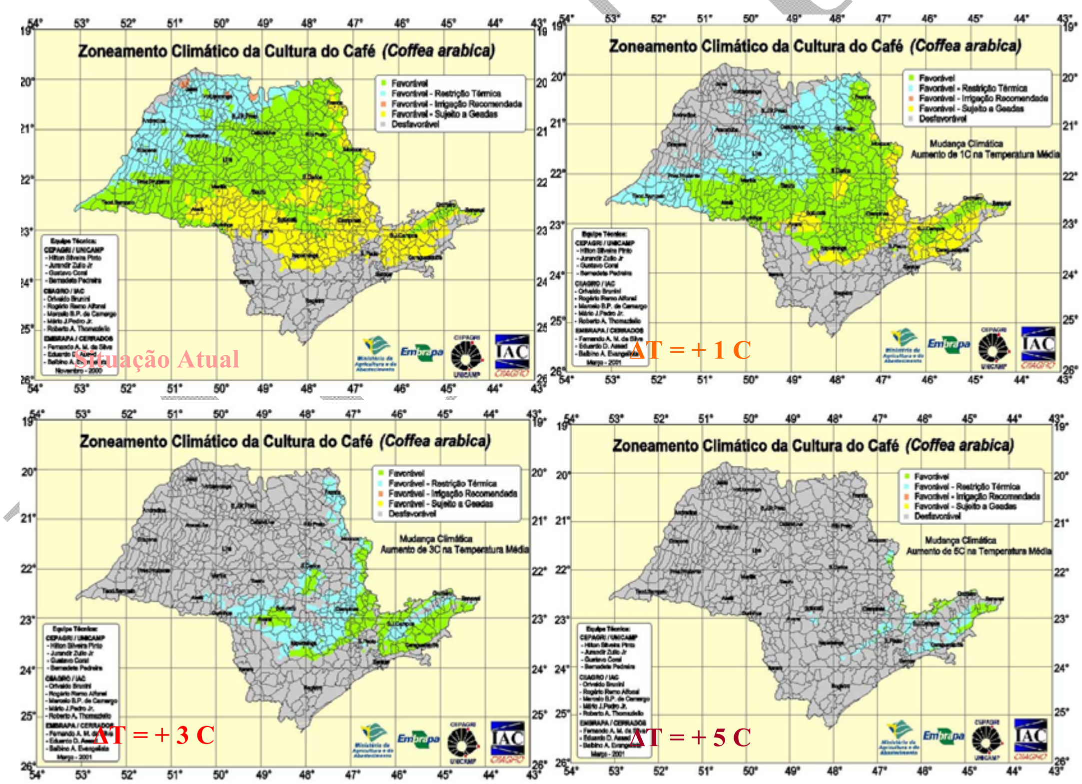


Figure 13: Maps illustrating effects in the coffee plantation zoning in the São Paulo State changing air temperature by 1º C, 3º C e 5,8º C above 1990 mean value, and increasing of 15% in the precipitation (after Assad et al, 2004).

Global climate change represents one of the most significant challenges for humanity. After many decades of scientific warnings, finally public policy formulation and international negotiations brought to light the **United Nations Framework Convention on Climate Change**. Active engagement of research groups and institutions in the preparation of the United Nations International Conference on Environment and Development—the so-called Earth Summit,, held in 1992, in Rio de Janeiro, offered multiple outcomes for the advancement of knowledge on climate. The Earth Summit developed an environmental agenda for the 21st Century (Agenda 21) and, in addition to the Climate Convention, established two other conventions: **Convention on Biological Biodiversity (CBD)**, and the **United Nations Convention to Combat Desertification (UNCCD).** The UNFCCC had its origins in that Conference, which was approved in 1992, put into effect in 1994 and presently ratified by more than 166 countries. More recently, the Kyoto Protocol, entering into force 16 February 2005, established obligations for industrialized countries to reduce their emissions of GHG from 2008 and 2012 and created the Clean Development Mechanism to allow developing countries access to cleaner technologies and effective participation at the global efforts to curb emissions of greenhouse-gases (GHG).

In addition to the environmental conventions, eight Millennium Development Goals (MDG) were endorsed by governments in 2002, in the Johannesburg Summit. The MDGs aim to improve human well-being by reducing poverty, hunger, and child and maternal mortality; ensuring education for all; controlling and managing diseases; tackling gender disparity; ensuring sustainable development; and pursuing global partnerships. For each MDG, governments have agreed to between 1 and 8 targets (a total of 15 targets) that are to be achieved by 2015. Slowing or reversing the degradation of ecosystem services will contribute significantly to the achievement of many of the MDGs. The three environmental conventions and the MDG shape the international pillars for sustainable development. However, as Sachs (2006) warns, our global policy is not adapted to the challenges of sustainability. Meeting the MDG by 2015 will liberate over 500 million people from poverty and integrate sustainable development into national and international agendas to reverse the loss of environmental resources. Are these objectives compatible? Many already see the objectives of global environmental sustainability as just one more burden, and as an impediment to much needed development in the poorest countries of the world (Nobre, 2006).

Research on Global Climate Change helps to understand causes and trends in climate. Such research endeavour needs advancement of knowledge at global, regional and local scales.

Complementarity among those three scales is essential to induce implementation of local and national public policies. A critical issue regarding global climate change is the assessment on mitigation, by reducing greenhouse-gases emissions today, at a certain cost, to gain the benefit of some reduction in socio-economical-ecological adverse impacts in the future. Another approach has been a reactive response through adaptation to global climate change or more generally to global environmental change.

2 JUSTIFICATION AND SCOPE OF FAPESP RESEARCH PROGRAMME ON GLOBAL CLIMATE CHANGE

2.1 Critical Assessment of Ongoing Global and Regional Climate Research in São Paulo State

The scientific community of the State of São Paulo has been dealing with themes associated to advancing understanding about the climate system, carbon cycle and sources and sinks of greenhouse gases (GHG), mostly in the last 10 years. Such interest reflects the adherence of the scientific community of the State of São Paulo to the scientific issue of global change, an issue of worldwide relevance. Many scientists regard global change and its consequences as one of the greatest challenges facing mankind. Annexes II through IV list a number of research projects on global and regional environmental change carried out by universities and research institutions in the State of São Paulo.

Considerable effort by research institutions and universities in São Paulo focused attention over Amazonia, in response to the urgency of understanding local, regional and global impacts on the environment and on biodiversity arising from the large rates of land use change and deforestation. Those research efforts whose pioneering field campaigns go back to the early 1980's culminated with the implementation of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), and integrated regional study in global change. LBA started its field phase in 1998 which has had important contributions by São Paulo researchers and substantial funding by FAPESP. More recently, a new research project sponsored by the Brazilian Ministry of Science and Technology (MCT) on Environmental Modeling of Amazonia (GEOMA Project) addresses questions of observations and modelling of land use change dynamics, causes and impacts, in Amazonia and involves significant participation of São Paulo State research institutions.

Although, as recently pointed out by the working group on vulnerability from the Brazilian Forum on Climate Change (FBMC), there are no official Brazilian Government actions towards elaborating a detailed picture of climate changes consequences in the country, taken as a whole, studies carried out in São Paulo State over the last 15 years have investigated issues linked to local or regional environmental changes. A number of studies dealt with climate variability and change at various space and temporal scales, ranging from the paleo-climate to projections of future climate change. The various facets of the biogeochemical carbon cycle received considerable attention, especially over Amazonia given the impact of deforestation on the global carbon cycle. A smaller number of ocean studies focused on the physics and biogeochemical cycles of the South Atlantic. Atmospheric chemistry and composition received increased attention for the last two decades with focus on tropospheric and stratospheric ozone and on aerosols from biomass burning and urban sources. Last but not least, the relationship between biological diversity of species and climate has been a focus of research of the BIOTA/FAPESP Programme which presents a number of examples on integrated approaches to study biosphere-atmosphere interactions for several types of natural ecosystems (*Ombrophylous* dense forest, Cerrado) and agrosystems (sugar cane and *Eucalyptus* plantation). However, except for projects developed under the umbrella of large programs, such as LBA and BIOTA/FAPESP, most of the past and ongoing research on climate, biodiversity, carbon and nitrogen budgets in Brazil were disconnected and lacked of common coordination.

Another issue that makes this programme timely and very important is the provision of high quality climate, environmental and ecosystems datasets and sites monitoring changes in physical and biological systems.. Figure 7 highlights the lack of long term time series in Brazil when comparing the number of sites to the ones in the North America and Europe. These time series are necessary not only for model assimilation but for validation, and will make an incomparable contribution from Brazil to the international community.

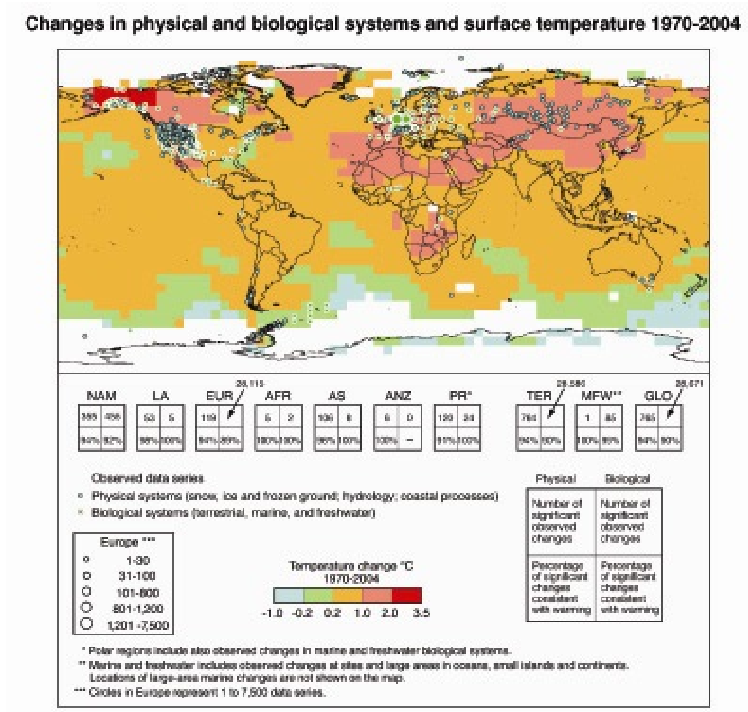


Figure 14: Locations of significant changes in data series of physical systems (snow, ice and frozen ground; hydrology; and coastal processes) and biological systems (terrestrial, marine, and freshwater biological systems), are shown together with surface air temperature changes over the period 1970-2004. Brazil does not show any long term time series (IPCC(b), 2007)

Very recently, the research community of São Paulo State has reached a significant capstone. A number of high-resolution regional climate models are being used to generate regional scenarios of climate change for South America. The spatial and temporal resolution of the numerical simulations of future regional climate up to 2100 is adequate for impact and vulnerability studies. The availability of such outcome is likely to spark a rapid development of impact, vulnerability and adaptation studies, since Brazil is lacking considerable scientific development in those areas.

2.2 Genesis of Programme

Prompted by the Kyoto Protocol entering into force in 16 February 2005, momentum was created towards the establishment of a Research Programme on Global Climate Change in the State of São Paulo. FAPESP responded to that and initially surveyed ongoing research activities on the theme of climate change. Based on that survey, a workshop was held at FAPESP in November 2005. The following questions were presented to the participants of the Workshop:

1. Which ongoing research in Brazil is related to global climate change issues and its impacts on society?
2. How is such research being financially supported? How should such research be articulated in the next 5 to 10 years?
3. How long should a Climate Change Research Programme last? What should be the size of such Programme?
4. How is research on Climate Change expected to be integrated with other FAPESP programs?
5. How is scientific knowledge expected to induce technological innovation? Which policies would induce technology innovation for greenhouse gases emission reduction?
6. Which Programme Evaluation criteria and tools should be adopted?

To respond to such questions, participant/researchers were divided in 4 groups of discussion according to major research areas:

- Group I Scientific Basis: Climate System and the Carbon Cycle: Umberto Giuseppe Cordani (USP) – moderator / Carlos Nobre (INPE) – commentator
- Group II Risk Measurement and potential socio-economic impact: José Tadeu Garcia Tommaselli (UNESP) – moderator and commentator
- Group III Mitigation by means of emission reduction projects and technological alterations in agribusiness and in industry: Pedro Leite da Silva Dias (USP) - moderator / Marco Antônio Fujihara (PWC) – commentator.
- Group IV Environmental and socio-economic adaptation and vulnerability of ecosystems (natural and anthropic): Carlos Alfredo Joly (UNICAMP) – moderator / Carlos Cerri (CENA) – commentator

The present document was developed from the main conclusions of the workshop.

2.3 Scope of Programme

Most of the past and ongoing research on global/climate variability and change in São Paulo State has been funded by FAPESP and CNPq and to a lesser extent by other national and international funding agencies. However, except for BIOTA/FAPESP, LBA and GEOMA, this type of discovery-driven research lacked articulation and coordination. The above-mentioned coordinated projects clearly show the advantages of comprehensive research programs, with clearly articulated goals and maximum synergies among the individual studies, participants and resources.

The FAPESP Programme on Global Climate Change must move beyond contributing solely to reducing uncertainties on emissions at a regional scale or on projections of regional climate change and it must provide the knowledge necessary for decision-makers nationally and regionally to make informed decisions with respect to risk assessment, mitigation and adaptation strategies. The Programme should have a substantial technological component for the development of the appropriate technologies of the future, and not only restricted to innovative technologies for mitigation emissions, but also technologies for adaptation in all sectors and activities, giving the inevitability of a certain degree of climate change to come. The programme must encompass an observational component, which should involve expansion of regional climate and paleo-environmental observations. That should be done in association with other funding mechanisms within and outside of the State, but should not be left out since the lack of research-quality observations is a major roadblock for scientific advancement on this theme in Brazil. Last, but not least, the Programme has also to include a research component on the science-climate policy interface.

To make a difference locally, nationally and internationally, the FAPESP Programme on Global Climate Change has to focus on some issues that will make it unique. In particular, the Programme should specially pay attention to the following topics:

- An overarching science question is to advance on the quantification and separation of climatic signals over South America by detection and attribution of causes (natural climate variability, climate change in response to land cover change, including associated aerosol emissions, or climate change due to global warming). There is also a need to advance interdisciplinary research on land use and land cover dynamics for Brazil as a whole, bringing forth the interaction of natural sciences and social sciences.
- Following that question, detailed knowledge of regional and local climate change consequent to an overall level of global climate change is needed. Applications of improved scenarios of climate change for the future are needed for rapid development of impact and vulnerability studies in several sectors and activities (natural ecosystems, agriculture and forestry, water resources, renewable energy, coastal

zones, wetlands, human settlements, human health, industry, etc.) for Brazil, given the recognition of the widespread lack of such studies.

- The predictability of impacts of agro-ecosystems and natural ecosystem on, and their vulnerability to, climate changes is expected to increase, resulting from cross-disciplinary frameworks combining physical, chemical, biological, and social processes. For that, increased knowledge on biogeochemical (carbon, nitrogen, trace gases, aerosols, nutrients; etc.) and biogeophysical (water, radiative energy, etc.) cycles is necessary for terrestrial, aquatic and marine systems.
- The combination of improved scenarios of climate change and rigorous assessments of impact and vulnerability should lead to the promotion of adaptation measures. The results of the FAPESP Programme on Global Climate Change should be the platform for a continued, long-term research programme in adaptation to climate change, with technological and public policy pillars.
- Methodologically the Programme should contribute to establishing a framework for Earth Systems science development in the State of São Paulo, as part of a national and international effort to develop the weather, climate and Earth System models of the future; it should include the provision of computer requirements for such development which would allow Brazil to carry out simulations of climate change with Global Climate and Earth System Models, a capability that only few countries posses; it should also help constructing research-quality environmental data sets from paleo-enviromental reconstructions to contemporary climate data and Earth observations from space to socio-economic census data.
- On the mitigation of emissions, a technological innovation component must focus on renewable energies (biofuels, wind and solar energy, hydropower, etc.) and energy conservation and efficiency, engaging the private industrial sector; it also must consider technological developments in geo-engineering such as fossil fuel carbon sequestration.
- It is also important for the FAPESP Programme on Global Climate Change to promote research on the science-climate policy interface of relevance to Brazil to inform policy-makers as far as international negotiations of the global environmental change conventions are concerned, on one hand, and, to support mitigation and adaptation policies nationally, on the other hand.

- The FAPESP Programme on Global Climate Change must have a built-in capacity development component aimed at multiplying the community of researchers in the State of São Paulo dealing with global change issues and an outreach component to disseminate its results to government and private sectors, to the educational system and to society in general.
- The FAPESP Programme on Global Climate Change must network and cooperate with international and national programmes on global environmental change research and assessments, such as IGBP, WCRP, IHDP, DIVERSITAS, IAI, IPCC, among others; additionally, the programme should address inter-linkages between the three environmental conventions at the regional and national levels. In terms of collaboration within Brazil and co-funding, the Programme must articulate with the national programme of climate change at MCT, and sectoral research funding agencies, especially CT-Petro, CT-Hidro, CT-Energ, CT-Agro, among others, in addition to the Fórum Brasileiro de Mudanças Climáticas e o Fórum Paulista de Mudanças Climáticas e Biodiversidade.

By addressing most of the scientific themes highlighted above, the FAPESP Programme on Global Climate Change should be able to gain a relevant position in the international climate change debate.

While the scientific components of this Programme will produce new and relevant scientific knowledge, it must be emphasized that the Programme must help spur national technological developments. An example is the mitigation of emissions of greenhouse gases and adaptation to climate change. Another is additional support for development of advanced Earth observation systems, including initiatives to support public policies to foster the participation of the industrial sector.

The Programme is intrinsically interdisciplinary, drawing on many disciplines from the natural and social sciences. For a successful implementation a focused effort has to be made to bridge the gap between natural and social sciences, since both are needed to understand the complex dynamics of the changing Earth System. In particular, the Programme must motivate social scientists to study aspects related to environmental change and human security, industrial transformations and urbanization, which are causes of environmental change and the new global, regional and national institutions needed to face the challenge of climate change.

3 ECOSYSTEM FUNCTIONING: BIODIVERSITY AND WATER, CARBON AND NITROGEN CYCLES

The 1992 Rio Earth Summit provided a global spotlight on the worlds destructive consumption patterns, and called for a sustainable development. To support the environmental aspects of Agenda 21, three international initiatives, the **Convention on Biological Biodiversity (CBD)**, the **United Nations Framework Convention on Climate Change (UNFCCC)** and the **United Nations Convention to Combat Desertification (UNCCD)** were agreed upon. All the three conventions have since entered into force and are in different stages of implementation.

While each convention addresses specific environmental concerns all three share the common goal - to achieve - sustainable development. Furthermore the processes of climate change, biodiversity loss and desertification are interrelated. For instance climate change affects drylands in which climatic feedback process can lead to prone and recurrent droughts and risen temperatures can lead to increase potential evaporation. This threatens biological diversity and can result in high vulnerability to poor populations' access food and water. Drylands degradation influences local climate changes and global carbon circle. Biodiversity and desertification are inter-related once the drylands provide a habitat for major animal and plant species. Thus, drylands degradation affects natural vegetation - and loss of plant and animal species and ultimately agricultural productivity. Biodiversity loss can lead increased pressures on degraded lands, as local populations become more vulnerable they could over exploit their habitat. Furthermore there is an intrinsic relation between the three conventions mentioned above and the **RAMSAR Convention on Wetlands**, ratified by Brazil in 1993. Since then Brazil has nominated 8 wetlands areas that, summed up, left the country in 4th place in a world rank of protected areas by this convention.

A Research Programme on Global Climate Change as being proposed by FAPESP, must take advantage of the international initiatives to foster synergy between this four conventions, such as the UNDP/GEF(Global Environmental Facility) funded project on "Coping with drought and climate change: best use of climate information for reducing land degradation and conserving biodiversity". So far, however, most work on inter-linkages has been undertaken at the global rather than regional or national levels, and that can be a role for FAPESP Programme.

3.1 Biodiversity

3.1.1 Evolution of the Neotropical region

The isolation of South America from Central America and Africa during the Tertiary Period left a strong imprint on the biota of the Neotropics. For almost 100 million years Neotropical flora, fauna and microorganisms evolved completely isolated.

The uplift of the Andes show a strong correlation with development and diversification of montane forests, as well as a diversification of the Amazon forests, that in terms of list of dominant families is remarkably similar to today's flora (Burnham and Graham, 1999).

The emergence of a continuous land bridge at 3 Ma between Central and South America is well documented and is demonstrated by the arrival of temperate elements in South American highlands and concurrent appearance of South American taxa in Central America. There is strong evidence of displacement of the Neotropical fauna, especially mammals, by northern immigrants, but the same is not observed in relation to plants. The mix of taxa in extant Mexican tropical floras derived from tropical South America, tropical Central America, and from remnants of northern tropical Eocene floras is strong evidence for the impact that the land bridge through the Panamanian isthmus had on the Neotropical region (Burnham & Graham, 1999).

Accumulating data on temperature changes during the late Tertiary and Quaternary Periods points to low-latitude temperature fluctuations of up to 6°C. Proposals of accompanying widespread rainfall fluctuations are more equivocal. Rainfall probably varied regionally, resulting in a mosaic of habitats controlled by river migration, sea level fluctuations, local dryness, and local uplift. Zones postulated as refugia provide testable hypotheses using neoecological and paleoecological data (Burnham & Graham, 1999). Although the refugia hypothesis is questioned today (Bush & Oliveira, 2006), undoubtedly the effects of climate change on vegetation physiognomy played a crucial role in shaping the extant mammalian faunistic patterns (de Vivo & Carmignotto, 2004).

The final result, of this long process of genesis and evolution of the Neotropical region, is that most of the actual Neotropical countries, such as Brazil, Colombia, Ecuador and Peru, are on the higher positions of any ranking of biodiversity richness. Brazil, in particular, occupies the first position in such rankings and is therefore considered the Megadiverse country. As recently shown by Jaramillo et al (2006) Neotropical biodiversity levels can be correlated to climate changes since the Cenozoic. So during millions of years there was a synergism between gradual and slow climate changes and speciation, giving time for natural selection and other evolutionary tolls to play their role.

Sometime between 50.000 and 20.000 years ago, man arrived in the Neotropical region, and started to change this scenario, hunting some species to extinction, burning some areas and promoting local changes in rivers and estuaries. But it was in 1.500 with the arrival of the European that land transformation processes really speeded up.

3.1.2 Brazilian biomes and climate changes

Today, Brazil is officially divided into 6 major terrestrial biomes: Amazon Region, Cerrado (a savannah like vegetation), Caatinga (semi-arid vegetation), Pantanal (wetlands of the Paraguay watershed), Atlantic Forest and Pampas (grasslands of the southern region). From this, two – Cerrado and Atlantic Forest – are considered biodiversity hotspots (Myers et al, 2000), and three – Amazon Region, Caatinga and Pantanal – are classified as high biodiversity wilderness areas (Mittermeier et al, 2002). Furthermore Brazil has approximately 7.500 km of coast, and our marine biodiversity also ranks among the richest on the world.

Atlantic Forest

The Atlantic Forest, as defined by Joly et al (1999), was the first biome to suffer dramatic changes due to human intervention, and today less the 7% of it survived. In the first century of occupation species like *Caesalpinia echinata* Lam. (pau-brasil) were overexploited, but later with the introduction of cultivated species, like the sugar cane in the Northeast and coffee in the Southeast, the Atlantic Forest was cut, burned and replaced by plantations.

Cerrado

Proportionally to the percentage of the original area already replaced by human activities the Cerrado is the second most threatened Brazilian biome. Almost 85% of it has been burned to produce charcoal, to raise cattle, to plant sugar cane or, more recently, to cultivate soybeans.

Siqueira & Peterson (2003) used a GARP (Genetic Algorithm for Ruleset Prediction) modelling system to predict the consequences of climate change for the Brazilian Cerrado. Global climate change scenarios considered were drawn from the general circulation models of HadCM2, both a conservative and a less conservative scenario of how climates could change over the next 50 year (Hadley HHGSDX50 and HHGGAX50 scenarios, respectively). Most species were projected to decline seriously in potential distributional area, with both scenarios anticipating losses of >50% of potential distributional area for essentially all species. **Indeed, out of 162 species examined, 18 in the optimist scenario and 56 in the pessimist scenario will be extinct by 2050**, and 91 (HHGSDX50 scenario) - 123 (HHGGAX50 scenario) species were predicted to decline by more than 90% in potential distributional area in the Cerrado region (Figure 13)

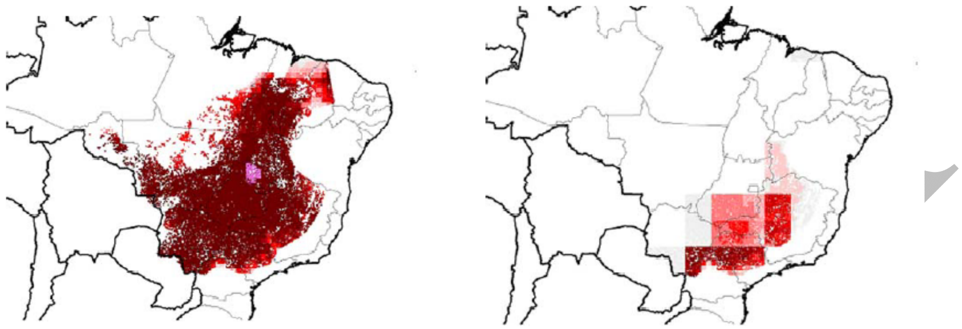


Figure 15. Patterns of predicted species richness among the 162 species of Cerrado trees analyzed in the core distributional area of Cerrado. Left - present (1961-1990); Right HHGGAX50 (less conservative) climate change scenario. From Siqueira, M.F. & Peterson, A.T. 2003. Consequences of Global Climate Change for Geographic Distributions of Cerrado Tree Species. Biota Neotrop. http://www.biotaneotropica.org.br/v3n2/en/abstract?article+BN00803022003

Caatinga

The extent of human changes in the Caatinga, a mosaic of thorn scrubs and seasonally dry forests, is difficult to identify. It is the less known of the terrestrial Brazilian biome, but endemism can be up to 50% in some vertebrate groups. Less then 1% of the Caatinga is protected by reserves.

The high climate variability in the region, coupled to inappropriate land use are accelerating desertification, which is currently threatening about 15% of the region.

Pantanal

The Pantanal, one of the largest wetlands on the planet, comprises 140,000km^2 of lowland floodplain of the upper Rio Paraguay basin that drains the Cerrado of central Brazil. The diverse mosaics of habitats resulting from the varied soil types and inundation regimes are responsible for an extraordinary rich terrestrial and aquatic biota. Until recently, deforestation of the adjoining Brazilian central plateau was considered the major threat to this area, but now deforestation is a critical problem within the floodplain itself. More than 40% of the forest and savannah habitats have been altered for cattle ranching through the introduction of exotic grasses. Only 2.5% of the upper Paraguay River basin is formally protected by reserves (Harris et al, 2005).

Major threats to the Pantanal are: the construction of the Paraná-Paraguay waterway; destruction of headwaters of rivers, and erosion; substituting native pastures for invasive species; opening up pastures and large areas of livestock farming to extensive cattle ranching; hunting and fishing. But climate changes can affect the uppermost important feature of the Pantanal, the “flooding pulse”. An increase in 3° to 4°C could eliminate 85% of the remaining wetlands, which are one of the most important terrestrial carbon sink.

Pampas

The southern fields of Brazil are known by several different names, including the pampas, campos sulinos, open savannah, or grasslands. Pampa is a term of indigenous origins meaning the plain or flat region covered by grass and other herbaceous species. Close to rivers there are bushes and, sometimes, “capões” (small areas) of forest. The climate is subtropical, with warm temperatures in the summer, and earlier with rains spread during the whole year. The main economic activity has always been cattle ranching, and much of the original ecosystem has been replaced by African grasses such as *Eragrostis plana* Nees. In the last three decades soybean plantation also became an important economic activity.

Amazon Forests

Covering almost half of Brazil the complex of forests, commonly designated as Amazon Forest, which spans to nine countries: Brazil, Suriname, Guyana, French Guiana, Venezuela, Peru, Bolivia, Ecuador, and Colombia and is Earth’s largest remnant of tropical rainforest. When the rainy season floods the Amazon River Basin, rivers and tributaries can rise up to 10 meters leaving some trees and vegetation submerged up to six months.

With an average of one person per square kilometre, low population density has slowed the exploitation of Amazonia although logging and plantation agriculture have increased (IBGE). More than 80 percent of the Amazon forests remain intact, offering an opportunity to protect a little more than half of the world’s remaining tropical forest.

Today more than 20 percent of the Amazon forest has been permanently destroyed. Typically, loggers cut profitable species, such as mahogany, then burn the land for farms or pasture, and more recently to plant soybeans. Land is also cleared for subsistence agriculture, mining, new roads and city expansion. For the last ten years, in average, 20.000 km^2 of forest were destroyed per year, peaking in 2004 (INPE, 2005; Ometto et al, 2005). However, since then, the rate of deforestation in the Amazon region has decreased by several thousands km^2 per year, with a projected 11,000 km^2 for 2007 (PRODES, 2007). However, deforestation rates for the second half of 2007 were much higher than for the same period of 2006, possibly indicating a reversal of the downward trend. (DETER, 2008)

Conservation organizations and scientists from around the world collaborate to analyze the region's biological status, set conservation priorities, and establish protected areas. The most notable of these were Brazil's recent creation of the largest tropical forest park in the world (3.8 million hectare) Tumucumaque National Park (located in the states of Amapa and Para), and the implementation of the **ARPA** Program (**Amazon Region Protected Areas Program**), a system of parks and other protected areas that, with funds from GEF, PPG-7, WWF and CI, shall double the extension of protected areas in the Amazon Basin.

3.2 Water

The water cycle plays a critical role in the functioning of the Earth system. Inadequate understanding of the water cycle is one of the dominant causes of uncertainty in climate prediction. The water cycle integrates the complex physical, chemical, and biological processes that sustain ecosystems and influence climate and related global change. New understanding of these processes will be essential to developing options and responses to the consequences of water cycle variability and change.

Key research questions related to the water cycle are:

What are the mechanisms and processes responsible for the maintenance and variability of the water cycle; are the characteristics of the cycle changing and, if so, to what extent are human activities responsible for those changes?

How do feedback processes control the interactions between the global and regional water cycle and other parts of the Earth system (e.g., carbon cycle, radiative energy, aerosols), and how are these feedbacks changing over time?

What are the key uncertainties in seasonal to interannual predictions and long-term projections of water cycle variables, and what improvements are needed in global and regional models to reduce these uncertainties?

What are the consequences over a range of space and time scales of water cycle variability and change for human societies and ecosystems, and how do they interact with the Earth system to affect sediment transport and nutrient and biogeochemical cycles?

How can global and regional water cycle information be used to inform decision processes in the context of changing water resource conditions and policies?

In particular for South America, what are the impacts of long term climate change on water use in different sectors (e.g., agricultural, hydropower, natural ecosystems)?

3.3 Carbon budgets in natural ecosystems

Land terrestrial ecosystems are pools of C and other chemical species originating greenhouse gases that exchange fluxes with the atmosphere and laterally by fluvial and eolian transports. In the Brazilian ecosystems the anthropogenic control of the regional C budgets is dominated by emissions from fire and deforestation, changes of soil carbon, land uses changes, and also by sinks from secondary forest regrowth over abandoned lands, and increasing area of planted forests (eucalyptus and pinus plantations). A suite of processes control the natural variability of energy, water and carbon exchanges between the terrestrial ecosystems and the atmosphere, that include soil and plant physiological responses to atmospheric temperature, CO_2 concentration, soil moisture and nutrient availability, soil humidity and temperature. The pattern of ecosystem functionality is constrained by intrinsic soil-vegetation properties that are controlled by local meteorological fluctuations and climatic variability, water and nutrient availability.

3.3.1 Current natural and anthropogenic ecosystem fluxes

The national estimates of anthropogenic fluxes were reported by the Brazilian inventory of greenhouse gases (MCT 2004), as of the 1994 budget. The most relevant contributions of emissions nationwide were equal to 1030 Tg of CO_2, 13.2 Tg of CH_4, 500 Gg of N_2O, all other greenhouse gases accounting for less than 0,5 Gg each one (1 Tg = 1000 Gg = 1000 ton). The national sector of Land use change and forestry (LUCF) was the largest contribution (776 $TgCO_2$ or 75.4% of the total CO_2 emission), while the remaining contributions were the sectors of Energy (23%) and Industry (1.6%). Therefore the ecosystems did play a key role in the national anthropogenic fluxes. Although the LUCF component contributed positively for the net emissions, its overall budget comprised either class of (positive) emissions, as well as (negative) sinks of CO_2. Emissions by deforestation were the largest (~952 Tg CO_2), being distributed over the several national biomes, respectively in Amazonia (59%), Cerrado (26%), Mata Atlântica (6%), Caatinga (5%) and Pantanal (4%). Changes of soil carbon ranked second with emissions of ~75 Tg CO_2. On the other hand, secondary forest regrowth over abandoned lands showed a sink of ~ -204 TgCO2, and planted forests (mostly resulted by increasing areas of eucalyptus plantations) showed a sink of ~ -47 Gg CO_2 (?)

The natural variability of CO_2 exchanges at the ecosystem level has been currently assessed by forests parcels and vegetation inventory data, investigations of leaf and tree-scale physiological processes, and by fluxes towers and river watershed carbon balance approaches (Ometto et al. 2005). Investigations over several tower fluxes experimental sites and biomes in Brazil have shown so far that CO_2 fluxes depict a clear seasonal variability partly forced by the climate, tied to the functional controls of vegetation physiology and regulation of evapotranspiration (Rocha et al. 2004, Goulden et al. 2004).

Structural differences between the tropical forests across Amazonia, and the different Cerrado physiognomies, were corroborated by measured eddy covariance fluxes. In Amazonia, there is a large spatial variability in seasonal CO_2 flux of *terra firme* forests that are dependent on regional climate variability and local geomorphological properties. In Amazonian eastern sites, CO_2 was mostly taken up in the dry season and released in the wet season (Saleska et al. 2003; Carswell et al. 2002; Goulden et al. 2004), a pattern explained by increasing soil respiration in the wet season and a substantial reduction in the dry season, while wood increment was slightly larger in the wet season. In central Amazonia the Net Ecosystem Exchange (NEE) shows weaker seasonal variability, and also suggested lower carbon uptake in the dry season rather than in the wet season (Araujo et al. 2002, Ometto et al. 2005). Also dependent to dry season length, largest seasonal amplitude of NEE appeared in eastern (~700 kg C ha^{-1} $month^{-1}$) than in central Amazonia (~150 kg C ha^{-1} $month^{-1}$) (Saleska et al. 2003; Araujo et al. 2002). In southern Amazonia, net carbon uptake reduces continuously along the dry season (June to August), as opposed to eastern, and with larger seasonal amplitude than over central Amazonia, a pattern influenced by recurrent cooler wintertime temperature and the semi-deciduous pattern of local forests (Ometto et al. 2005). Over the Cerrado, net carbon uptake is observed during the wet season, and strong positive emission happens in the late dry season, a marked pattern of the transitional mature forest (Cerradão) (Vourlitis et al. 2001), Cerrado restrito in Centre-east region (Miranda et al. 1996) and in southeast Brazil (Rocha et al. 2002).

Over wetlands it has been shown a different pattern compared to that of dry lands, and that are strongly dependent on the hydrological flood-pulse variability. Over tropical dry forests and savannas, Gross Primary Productivity (GPP) increases during the wet season, while, on the other hand, over seasonally flooded forests the stem increments during the terrestrial (dry) phase (Dezzeo et al. 2003), as inundation causes leaf shedding. Flux tower measurements in the ecotone-floodplain area of the Bananal Island suggested there is a hyper-seasonal pattern, different from either dry savannas or tropical forests: the high ecosystem carbon uptake during the early wet season was reduced with the onset and along the flood time, controlled by anoxia stress (Rocha 2004). The aquatic systems as a whole, from the small-scale riverine zones to large floodplains, have shown to have significant processes for the regional carbon balance, as CO_2 is lost over the surface water by diffusive processes. Current estimates for Amazon basin CO_2 evasion fluxes are from 0.3 Mg to 1.2 Mg C $ha^{-1}y^{-1}$) (Richey et al. 2002; Ometto et al. 2005).

Earlier reports of CO_2 annual sum for Amazonian tropical forests using eddy covariance indicated sinks as large as 6 MgC ha^{-1} yr^{-1}, which lacked ecological realism (Ometto et al. 2005). However, stand biomass growth data in tropical sites indicated a net gain of carbon over the last decades from to -0.3 to – 2 ton C $ha^{-1}y^{-1}$ (Philips et al. 1998, Baker et al. 2004), possibly attributed to the fertilization effect, although no conclusions so far have demonstrated such dependence. More recently, longer term measurements, and improvements of flux tower design and data interpretation, provided more accurate CO_2 annual budgets over Amazonian forests (Miller et al. 2004, Araujo et al. 2002; Saleska et al. 2003), that suggested the experimental sites can vary from sink to neutral, and even to a source mode of CO_2, depending on site-specific past disturbances that constrain the measured CO_2 flux variability. Particularly, the seasonality of carbon fluxes and increase of tree mortality is enhanced by extreme weather and climate (e.g. ENSO), what alters the NPP over dry and wetlands (Condit et al. 1995, Townsend et al. 2002, Schongart et al. 2004, Saleska et al. 2003). Modern experimental approaches using eddy covariance combined to advective fluxes are promising methods that can provide more accurate estimates of annual CO_2 sinks or sources over terrestrial ecosystems (Staebler and Fitzjarrald 2004, Feingenwinter 2004).

3.3.2 Regional budgets

Evidences of missing C sinks in global budgets pointed to the secondary forest regrowth in temperate forests as the main responsible mechanism, also stimulated by fertilization of combined increasing atmospheric CO_2 concentration and nitrogen deposition (Schimel 1995; Tans et al. 1998). However, the location and magnitude of these sinks is yet inaccurate. Using inverse models, Schimel et al. (2001) estimated that the tropical NEE did not show the pulse of tropical deforestation, a first evidence that an important carbon sink could be acting to compensate the anthropogenic emissions. Other model indicated a net source of 0.62 Pg C y-1 over tropical lands in Americas (Gurney et al. 2002). The authors stressed the large uncertainties in the tropics much greater than elsewhere due to the lack of an adequate and accurate CO_2 concentration measurement network. Amazonia is concerned as a potential key player in the global carbon cycle, partly due to the large C stock in biomass and soil, and the current deforestations rates. But also because its GPP and respiration rates are the largest worldwide, consequently highly sensitive to climatic variability that induces changes in regional carbon balance. Nemani et al. (2003) assessed the impact of global climatic changes on vegetation productivity such that mean global NPP increased 6% over the last 20 yrs. The authors showed the largest increase over the tropical ecosystems, wherein Amazon rain forests accounted for 42% of the global NPP increase.

3.3.3 Final Remarks on Carbon Budgets

The natural variability of the C pools over tropical ecosystems is yet some uncertain, as it oscillates on the seasonal and interannual basis. A major gap exists in understanding the terrestrial net sink or source in the tropical regions. For instance, the Atlantic forest has no information on CO_2 budget whatsoever. The future scenarios are still more uncertain, that is, it is unknown if the strength of terrestrial carbon sink/source will increase, decrease, or eventually levels off in next decades.

Regional and continental C budgets offer adequate pictures of the spatial and temporal fluxes, and increase the predictability of the stocks. This approach has been increasingly performed using the concept of “model-data fusion” that integrates observations and physical algorithms at multiple scales. The estimate of spatial GPP, NPP and NEE is optimized by using observational variables that constrain the model parameters. Techniques of multiple-constraint approach uses simultaneous local field data and remotely sensed data to contain different model parameters.

Advanced monitoring systems should integrate field experimental and satellite data, integrated to physical models that provide an upscale from local to regional spatial domains. Atmospheric inversion methods can be applied on regional and global scales, using either mesoscale or global models. More advanced technologies using remotely sensed CO_2 column space from the space is relevant to regional inversions.

The primary productivity over tropical biomes is the largest worldwide, under processes that show large sensitivity to climate and temporal persistence. It illustrates how the current economic Brazilian model can be affected, as it is very dependent on the agribusiness sector. In other words, it is anticipated there is a relationship that links social to climate and environmental issues under the same umbrella. The understanding of NPP and the whole carbon cycle over land terrestrial ecosystem is about to influence the regional economics. More generally, changes in NPP are clearly tied to the environmental services provided by ecosystems (fibres and food, water availability and flood control, and clean air), what is ultimately integrated to the concept of sustainability.

3.4 Nitrogen budgets in altered and natural ecosystems

Nowadays, approximately 852 million people suffer with some kind of food insecurity. This total is equivalent to 15% of the population of the Earth. In Brazil, approximately 15.6 million of people (9% of the population) have not enough food to meet their basic nutritional requirements.

Part of the problem is that low income populations have not enough to eat due to the lack of nutrients to fertilize their crops, where nitrogen (N) is one of the most critical nutrients. On the other hand, in some regions of our planet, there is an excess of N use, with high quantities of N supplied to crops, generally well above of plants requirements. Under this scenario, N becomes a pollutant, because its presence in excess starts a series of reactions and process extremely harmful to the environment and population health.

Therefore, the lack of N is one of the causes of hunger and poverty in the world. A recent outcome from the African Fertilizer Summit, in Abuja, Nigeria (June, 2006) is to increase the average nitrogen utilization in agriculture to 50kg/ha in the continent by 2015, promoting what was called the African Green Revolution. Nerveless too much mention that when used in excess N become an important pollutant. This duality is one of the major challenges that humanity has to face now and in the future.

Key questions are:

- How to supply N to low income regions of the world without causing environmental problems like we have seen in other parts of the world?
- How to mitigate these environmental and health effects in regions where N is supplied in excess?

Besides these social and economic aspects, N is also very important in natural systems, because as a limiting nutrient it regulates carbon acquisition and the composition of plant and animal communities. It is extremely mobile in nature, having several organic and inorganic forms. It is also present in most of the major reservoirs of the Earth, including a gaseous phase in the atmosphere where regulates important functions.

Most of the studies regarding N dynamics in natural ecosystems, where developed in temperate regions of the world. Conclusions about the N cycle achieved in these temperate systems may not fit in tropical ecosystems, mainly because tropical ecosystems are much less limited by nitrogen than temperate systems. Therefore, it is possible that the retention time of N in tropical systems will be significantly shorter than in temperate systems.

Key questions are:

- Why tropical systems are less limited by nitrogen than temperate systems?
- What are the consequences of such degree of limitations to the ecosystems functioning?

However, important drivers responsible for the increase of the production of N in the temperate zone are increasingly influencing the nitrogen cycle in rapidly developing regions of the world, such as the tropics and sub-tropics, including most of the countries of Latin America and the Caribbean. Advances in our understanding of the nitrogen cycle and the impact of anthropogenic activities on regional to global scales depend on the expansion of scientific studies to these fast-developing regions.

The American continents had, in 2003, the highest percentage of the population living in urban centres (78%), followed by Europe and Oceania, with 75% and 73%, respectively. In addition, 6 out of 20 mega cities of the world (population higher than 10 million people) are located in the Americas. Although from 1950 to 2003 there was an increase in urbanization in North America, the highest increase was observed in the developing countries located in Central and South America. In these countries migration of people from rural to urban centres occurred, while in North America both rural to urban migration and a migration from high density urban centres to low density suburbs surrounding city cores also occurred (urban sprawl). In both cases, urbanization led to the concentration of domestic and industrial solid wastes, air pollution, and problems associated with lack of sewage treatment. Fewer than 35% of cities in the developing world have treated wastewater. In Latin American and the Caribbean, only about 14% of the urban wastewater collected through sewerage systems is treated, while in megalopolises such as São Paulo city, Brazil, (with almost 18 million people) only 10% of the domestic sewage load is treated.

According to the Global Water and Sanitation Assessment (2000), the discharge of untreated sewage is especially hazardous to health where the receiving water bodies are rivers or lakes that serve as sources of drinking water to people, as it is commonly observed in developing countries of the Americas. In such cases, conventional treatment methods do not necessarily provide the proper degree of pathogen and toxins removal for health protection. In practice, inappropriate technologies are often used, and in Latin American and Caribbean region approximately 120 million people are not served with improved sanitation. In this project, we plan to make a detailed survey about sanitation status of the main urban areas of the Americas, and evaluate the effects of untreated nitrogen-rich sewage discharge on water bodies. The kind of information obtained will be fundamental to educate authorities about the necessity of improved sewage treatment systems in developing countries of the Americas.

In the US, information about the ecological consequences of improper sewage discharge to aquatic systems is widely available. It has been estimated that 40% of the estuarine area in the conterminous U.S. is severely degraded from eutrophication, and 67% is degraded to some extent. In the northeastern U.S., some 60% of estuarine area shows a high expression of eutrophic condition. The resulting eutrophication lowers biotic diversity, leads to hypoxic and anoxic conditions, increases the incidence and duration of harmful algal blooms, degrades the habitat quality of seagrass beds or even completely destroys them, and can lead to changes in ecological food webs that lower fishery production. Much less is known about N-driven eutrophication in estuaries and rivers of less developed countries of the Americas, although a few studies in southeast Brazil, for instance, have shown that the input of labile organic matter to rivers from domestic sewage, commonly rich in NH4 and labile organic matter, causes the organic matter to decompose and consume the oxygen dissolved in the water. Under anaerobic conditions, NO3- is denitrified and lost to the atmosphere while NH4+ accumulates in the water and promotes algal blooms and degradation of water quality even further.

3.5 Critical Assessment of Ongoing Biodiversity, Biogeochemistry and Climate Research in São Paulo State

Except for projects developed under the umbrella of large programs, like LBA and BIOTA/FAPESP, most of the past and ongoing research on climate, biodiversity and biogeochemical cycles, specially carbon and nitrogen, in Brazil were punctual and disconnected, focusing on a broad range of subjects that includes:

- Growth rings of arboreal species, phenology studies.
- Biochemical studies of carbohydrate metabolism in plants
- Global changes and growth rate of trees in the Amazon region.
- Climatological studies on resurgence.
- The role of the flux of nitrogen oxide from rivers to atmosphere in the Amazon region.
- Functioning of the hyper seasonal ecotone in the Bananal Island.
- Human occupation of South America during the dry periods of the Holocene: understanding the "Archaic Gap"
- Nitrogen balance in Piracicaba river watershed
- Green house gases emission by hydroelectric power complexes.
- Carbon dioxide and methane concentrations in the atmospheric column.
- Reduction of Green house gases in the State of São Paulo.
- The role of humic substances in carbon sequestration.
- The role of mangroves in carbon sequestration and mitigation of the global warming effects.
- Global changes and invasive plants.
- Regional climate change and biome redistribution in South America.

3.6 Research Priorities on Ecosystem Functioning: Biodiversity and Biogeochemical Cycles

Most of the past and ongoing research on biodiversity and carbon budgets in Brazil State has been funded by FAPESP and CNPq and to a lesser extent by other national and international funding agencies. Ideally, FAPESP Programme on Global Climate Change must focus into processes, past, present and future, and ecosystem functioning. In particular, priority attention should be given to:

1. Detailed reconstruction of past vegetation and fauna patterns of occurrence and changes linked to climate change events, particularly during the Quaternary.
2. Changes in phenologic patterns over the last century.
3. Effects of atmospheric CO_2 enrichment on native plants ecophysiology of photosynthesis, water efficiency use and decomposition rates.
4. Dynamics of deforestation and reforestation coupled with socio-economic and environmental systems, as well as modelling tools to project future scenarios.
5. Development and improvement of modelling tools, such as GARP (Genetic Algorithm for Ruleset Prediction), Bioclime, OpenModeller to be able to improve the accuracy of predictions of climate changes in species distribution/occurrence patterns; and biome models such as CPTEC Potential Vegetation Model to project biome redistribution in response to climate change.
6. Improve our knowledge on Carbon, Nitrogen and other chemical species originating greenhouse gases stocks and cycles in natural (Amazon Forests, Atlantic Forests, Cerrado, Caatinga, Pantanal, Lakes, Coastal Systems etc.) and agro-ecosystems (soybeans, sugar-cane, *Eucalyptus*, rice, etc.) by studying ecosystem functioning and how climate changes may affect their intrinsic properties.
7. Increase the density of studies in aquatic systems focusing on: (i) internal metabolism and changes due to nutrient load, untreated sewage, diffusive inputs from agriculture, efficiency of riparian zones as nutrient buffers; (ii) experimental responses of river communities to changes in water temperature and water quality; (iii) measurements and modelling of dissolved gases dynamics; (iv) links between aquatic systems and their respective watersheds; (v) hydrological and biogeochemical modelling.

4 ATMOSPHERIC RADIATION BALANCE, AEROSOLS, TRACE GASES AND LAND USE CHANGE

4.1 Atmospheric radiation balance, aerosols, trace gases and land use change

Relevant examples of the complexity of the interactions of the non-linear relations of the Climate System has been detected in South America in the context of the effect of biomass burning aerosols and land use change. Land use change is associated with ecosystems changes and it is known that ecosystems have an impact on the concentration of gases in the atmosphere both as a source and as a sink for many atmospheric constituents including the greenhouse gases (Davidson and Artaxo, 2004). Changes in land use and ecosystems also impact the water flow (hydrology), the energy balance (reflection and absorption of solar radiation), evapotranspiration and air circulation (surface properties and aerodynamics).

The atmospheric radiation balance is strongly influenced by greenhouse gases, as well as aerosol particles, clouds and surface albedo (Wielicki et al., 2002, Bellouin et al., 2005). Important feedbacks exist in the Earth climate system involving regional and global issues maintained by Earth biogeochemical system (Charlson et al., 1989). The so-called radiative forcing is a combined effect of several anthropogenic influences, were for each specific case, aerosols, clouds or surface albedo influences can be as strong as the greenhouse gases (Andreae et al., 2005). The aerosol effect on climate is generally separated in two components: the direct effect of scattering and absorption of radiation and the aerosol indirect effect trough cloud processing of the particles (Ramanathan et al., 2001). Regional effects such as surface radiative forcing from aerosols emitted by biomass burning in Amazonia can be very high, reaching -100 to -250 w/m² in Rondônia, while the heating from the long lived greenhouse gases is around +2.6 w/m² (Procópio et al., 2004). In the state of São Paulo, with large emissions from urban areas, agricultural and sugar cane burnings, the radiative forcing from aerosols can be large, influencing the vertical profile of the temperature, affecting the atmospheric stability.

Aerosol particles emitted trough biomass burning have important absorption properties, with large amounts of black carbon (Artaxo et al., 1998, Andreae and Crutzen, 1997). Large uncertainties in the climate effects of black carbon lead to significant differences in the projected temperature changes in 2100 simulated by GCMs (Andreae et al., 2005). Black carbon also reduces tropical cloudness (Ackerman et al., 2000, Andreae et al., 2004), and strongly influences radiation balance in Amazonia (Martins et al., 1998). Aerosol particles also has important role on the biogeochemical cycling of key nutrients in Amazonia and other regions (Artaxo et al., 1998). The dry and wet deposition of nitrogen, sulphur and other trace elements plays a key role in ecosystem functioning for both pristine and agricultural areas.

The effect of aerosol particles on clouds is a major climate uncertainty, affecting the regional and global hydrological cycle and the radiative budget (Graf, 2004). Globally, the average indirect aerosol effect is estimated as -1.2 W/m², but with a significant variability due to the important regional effects. Although the influence on aerosols on cloud formation inhibition is well documented, the effect of aerosols on precipitation is very difficult to analyze quantitatively. As the atmospheric aerosol loading increases it was observed a sharp decrease in cloud cover in Amazonia (Koren et al., 2005) and a increase in North Atlantic (Kaufman et al., 2005). Not even the signal of the aerosol effect on clouds is well established. The formation mechanisms of cloud condensation nuclei (CCN) in pristine remote conditions in Amazonia is not well know (Clayes et al., 2005) and is critical to the understanding of the natural hydrological cycle over Amazonia. The cloud microphysics properties of clouds influenced by biomass burning plumes in Amazonia changes significantly as a function of aerosol load (Andreae et al., 2004).

Biomass burning is a major source of several trace gases and aerosol particles that affect climate and air quality (Andreae and Crutzen, 1997). It is a common and natural phenomenon in many savannah areas such as the Cerrado in central South America and also in some higher latitude forests, as well as being a common land management practice. Biomass burning emissions is associated with deforestation, shifting cultivation, grazing in savannas, clearing agricultural residue, and fuelwood.

Changes in physical properties of surface can modify the fluxes of water (hydrological cycle) and energy (solar radiation, radiative forcing, heat exchange) that can have significant climate impacts at the regional scale, affecting air circulation, precipitation patterns and temperatures. The impacts are highly dependent on the geographical location and season, therefore, quite often, the mean global impact is very small and difficult to be detected. However, the effects associated with land use change in the atmospheric composition and properties may be very important in local scales. The main physical processes impacting regional climate through changes in land use and atmospheric chemical composition are:

a) **Changes in surface albedo** (fraction of solar radiation reflected back into the atmosphere). Surface albedo depends on the vegetation cover, and is lower in a forested landscape than in open land or agriculture. It has an important effect on the radiation balance.

b) **Evapotranspiration.** The transport of water from the vegetation to the atmosphere directly impacts the hydrological cycle, radiative forcing (directly by water vapour and indirectly via changes in cloud microphysics), and energy budgets. It is controlled by vegetation root depth, leaf area and soil moisture.

c) **Aerodynamic roughness of surfaces**. The surface of the landscape affects the circulation of air passing over it and thus also influences evapotranspiration and energy fluxes.

d) **Aerosol particles.** Aerosols directly and indirectly influence the radiative balance of the atmosphere with positive and negative feedbacks. Some aerosols are highly reflective and therefore decrease the solar energy flux available at the surface, having a cooling effect. Others are more effective in terms of absorbing solar radiation thus heating the atmosphere. But aerosols also strongly impact the cloud formation and structure since they act as cloud condensation nuclei.

e) **Trace gases**. Vegetation emits volatile organic compounds (VOC) that have a great influence on atmospheric chemistry, hydrology and climate though the production of tropospheric O_3, production of organic aerosols, cloud condensation nuclei and acid rain formation. Land use change may have a significant impact of the emission of VOC's because of the associated changes in the vegetation. Urban and biomass burning emissions of ozone precursors affects large areas far from the emission sites.

The replacement from forest vegetation to pasture, or agricultural crop, has a direct effect on surface albedo (increase) and roughness (decrease) and evaporation (decrease). Trees have deeper roots and sustain the evaporation for longer periods of time than the alternative vegetation. Therefore, the annual cycle of evapotranspiration in tropical forests has been shown to be rather flat even in areas where the dry season is very well defined (Salati, 1987; Gash and Nobre, 1997; Werth and Avissar, 2004). A possible feedback between soil moisture and the monsoon activity over tropical S. America has been discussed by Grimm (2003) thus making a plausible case for the interaction between deforestation and precipitation changes through soil moisture processes.

The impact of deforestation in the tropical areas is somewhat different in the wet and dry seasons (Avissar et al. 2002). In the dry season, the non-forested areas become hot and dry. Relevant impacts occur in deforested regions in a width scale of few hundreds kilometres surrounded by forest. During day time a local circulation develops from forest to non-forest areas leading to convergence of air in the non-forest area inducing vertical motion which enhances cloudiness. Also, a drier surface leads to enhanced thermal turbulence which favours cloud formations, and as a result, during the dry season, shallow clouds are seen in visible satellite imagery. The shallow clouds can potentially produce showers in clean conditions. During the wet season, evaporation in forest and pasture are about the same but the darker forest reflects less radiation. The excess radiation over forest goes into heating and generates more thermal turbulence which favours the formation of clouds and rainfall. In the wet season it rains more over forest than over non forested areas.

Some observational evidence of deforestation impact on clouds is available. During the dry season, Cutrim et al (1995) showed that the preferred regions for shallow cumulus clouds formation are deforested areas and over elevated terrain. Fisch and Nobre (1999) show significant differences in the evolution and structure of the planetary boundary layer (PBL) between the dry and the wet season, indicating that the height of the mixed layer over extensive pastures is larger in the dry season but decreases in the wet season; while over forest, the height of the mixed layer has basically little seasonal variation. Durieux et al. (2003) found that there are more shallow clouds over deforested areas during the afternoon, and there is less deep convection at night during the dry season comparing to the wet season in these areas. In conclusion, Durieux et al. point out to more precipitation over deforested areas in the wet season and less in the dry season and therefore increased seasonality.

The effects of deforestation on the regional climate have been studied through modelling techniques. Nobre et al (1991) showed that a complete replacement of forest by pasture in the Amazon Basin would lead to a local increase in temperature and decrease in precipitation. Several other studies have been published more recently, under scenarios of total deforestation in the Amazon and in general they point out to a reduction in order of 20-30% in the regional precipitation and warming in order of 2-3 ^{o}C (Silva Dias and Marengo, 1999, Nobre et al. 2004). These vegetation-climate modelling experiments have usually tested the effects of radical changes in vegetation, such as the complete replacement of forest with pasture, and have run the GCM to equilibrium following the implementation of this vegetation change. Using a set of simulations produced with the NASA Goddard Institute for Space Studies (GISS) general circulation model (GCM), Werth and Avissar (2002) find that the deforestation of the Amazon basin affects very significantly the hydroclimatology of the basin. Moreover, they find that this deforestation also affects the hydroclimatology elsewhere, including a significant reduction of precipitation in North America. In general, far away from the tropics, the weaker the teleconnected signals. Teleconnection studies (Grimm and Silva Dias 1995) have indicated the possibility of significant remote impact (e.g. Europe) from anomalous precipitation in the region of the South Atlantic Convergence Zone but small effect associated with the anomalous heating in the Amazon region.

Model work on the impact of more realistic patterns of deforestation, with a patches of the order of few hundred km to a few tens of km have been reported. Silva Dias and Regnier (1995) show that local circulation impose a low level mass and moisture convergence over the pasture of enough magnitude to explain local cumulus cloud formation. Baida Roy and Avissar (2002) and Silva Dias et al. (2002) investigated the impact of deforestation at the microscale and the mesoscale on the formation of convective clouds during the dry season. Using simulations produced with the Regional Atmospheric Modeling System (RAMS) supported with satellite images, they find that deforested areas (pasture) trigger cloud formation. They also emphasize that synoptic flow advects the clouds away from their original location but does not eliminate them. In a follow up study, Weaver et al. (2002) and Baida et al (2003) investigated the various parameters, in addition to land-surface characteristics, that affect the development of mesoscale circulation generating clouds as a result of landscape heterogeneity. They find that model configuration (e.g., grid size, nudging strength, among others) can have an impact as important as that of the landscape heterogeneity.

New developments in dynamic vegetation schemes and coupled climate-carbon models (Cox et al., 2000; Betts el al 2004, and Huntingford et al. 2004) have shown that the physiological forcing of stomatal closure can contribute 20% to the rainfall reduction in the Amazon associated with rising atmospheric CO_2 levels. The forest die-back exerts two positive feedbacks on the precipitation reduction: (1) a biogeophysical feedback through reduced forest cover suppressing of local evaporative water recycling, and (2) a biogeochemical feedback through the release of CO_2 contributing to an accelerated global warming (Betts et al. 2004).

Considering the non-linear interaction between the atmosphere and vegetation through the sensible, latent and momentum transfer, radiation and that, in the long time scales, climate exerts the main control on vegetation and that the biome type influences climate, it is possible to conceive the existence of multiple equilibrium of the climate/vegetation system. Oyama and Nobre (2003) coupled a dynamical biome model to the global climate model of Center for Weather Forecasting and Climate Research in Brazil in order to study the equilibrium solutions. They have shown the possibility of two stable solutions for the particular case of the biomes of South America: the first stable solution provides a biome distribution similar to the observed in the present; the second solution is characterized the savannah in the eastern

Amazon and semi-desert in the Northeast region of Brazil and the Atlantic Forest domain extended to the Central region of Brazil (Nobre et al., 2004; Oyama, 2003).

The impact of land use change in the regional climate of the State of São Paulo and southern Brazil regions should be viewed from the point of view of the impact of local and remote changes. It would be important to assess the relative importance of the local versus remote forcing from the point of view of understanding the origin of the observed climate change (i.e., the problem of attribution of causes for the observed climate change).

5 Climate Change and Agriculture and Animal Husbandry

5.1 Emissions of GHG due to Land Use/Land Cover Changes

Environmental consequences of human activities started with the human necessity of producing food and other supplies. Ruddiman (2005) reported that about 8 thousand years ago, humans began to modify the environment. However, more land was converted to cropland since 1945 than in the eighteenth and nineteenth centuries combined, and now approximately one quarter (24%) of Earth's terrestrial surface has been transformed to cultivated systems. Over this recent period, human population increased exponentially, and therefore, has changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fibre, and fuel (Millennium Ecosystem Assessment, 2005).

Roughly 40% of the world population lives in the tropics, and agriculture is a very important sector for the economies of most countries in the tropics. Given the current scenarios of enhanced temperatures and increased frequency of extreme events, climate change is likely to have significant impact in the tropics.

According to Zhao et al. (2005), humid and subhumid tropical conditions are found over nearly 50% of the tropical land mass and 20% of the earth's total land surface.

Recent National Communications ( ) on greenhouse gas (GHG; mainly CO_2, CH_4, N_2O) emissions, indicate that in general, GHG emitted in the tropics, are mainly related to deforestation and agricultural intensification, while in temperate regions GHG comes from combustion of fossil fuel in transportation and industry sectors.

The main reason for these facts is that temperate zones already achieved their needs on calories and yields and the population reached steady state equilibrium. On the other hand, tropical areas, such as Brazil, are the ones with more population, demanding more food.

Moreover, crop yields in the tropics are reduced, mainly due to lack of good practice adoption and poor technological resources. In order to compensate these adverse conditions, tropical native ecosystems have been converted. Mainly in the past ten years, part of the converted areas are been used to produce food for exportation and consequently improving the GDP.

In addition to food, Brazil is also producing fibres and bio-fuels, such as ethanol and bio-diesel. In the beginning, bio-fuels were generated to help developing countries to achieve their self sustainability on fuel consumption as a replacement for fossil fuel. However, nowadays bio-fuels produced in Brazil are being negotiated to be used as off-set of fossil fuel in Annex I countries[1], as a complementary action used to meet their targets on GHG emission reductions, proposed by the Kyoto Protocol.

Despite the great efforts of the Brazilian government, illegal deforestation has been happening and occurring randomly. Although the cleared land makes more area available for food production, it has various negative impacts. Firstly, it exacerbates global climate change, which has a negative feedback in the global food production. Food production can suffer from climate change impacts such as alteration in solar radiation period and extreme weather events (IPCC(b), 2007). Secondly, the illegal and randomly deforestation reduces the crop production by jeopardizing environmental services such as crop pollination, genetic resources, clean air and water supplies, soil fertility and erosion, pests and pathogens controls that help to maintain crop production.

Globally, terrestrial ecosystem store more than 2000 Pg of carbon (C) which is roughly three times the amount present in the atmosphere. Land use change mainly for agricultural practices immediately decrease carbon and nitrogen stored in the vegetation and soil and transfer them to the atmosphere due to slash-and-burn technique. Secondly, the conversion of native vegetation to agriculture/husbandry has often decreased soil organic carbon (SOC) stocks due to enhanced mineralization of soil organic matter (mainly to CO_2). A significant fraction of the ~32% increase in atmospheric CO_2 over the last 150 years stems from the breakdown of soil organic matter after forests and grasslands were cleared for farming.

Conversely, adoption of “best management practices”, such as conservation tillage, can partly reverse the process – they are aimed at increasing the input of organic matter to the soil and/or decreasing the rates at which soil organic matter decomposes. This mechanism has been called “soil carbon sequestration” and can be defined as the net balance of all greenhouse

[1] Developed countries and transition economy countries with commitments to reduce GHG emissions in the UNFCCC.

gases (e.g., CO_2, CH_4 and N_2O), expressed in C-CO_2 equivalent or CO_2 equivalent, computing all emission sources and sinks at the soil-plant-atmosphere interface. It must be noted that CO_2 fluxes are evaluated trough C stock changes in the different compartments and CH_4 and N_2O fluxes directly measured, or estimated with the best available estimates. Much progress has been made with respect to field measurement techniques and calculating possible SOC changes at various scales, using dynamic carbon models, but the uncertainties often remain large. Reducing such uncertainties is important in the context of the global conventions (UNFCCC, UNCDB) and for decision makers.

5.2. Impacts of Climate Change on Crop Yields

Increases in frequency of climate extremes may lower crop yields beyond the impacts of mean climate change (IPCC(b), 2007). For Brazil, it seems that climate change will affect some parts of the territory negatively, (Assad et al. 2004, Pinto et al. 2005, Nobre et al. 2005) although it will enhance prospects for crop production in other areas in Kenya, Zimbabwe and Senegal.

It is seen that climate variability and climate change, particularly in terms of frequency/ intensity of droughts, have larger impacts on the subhumid than on the humid regions. If climate variability – induced disasters become more common, widespread, and persistent, many countries in the humid and subhumid tropical regions will have difficulty in sustaining viable agricultural and forest practices. A good number of researchers have all concluded that climate change would affect agriculture as a result of increased temperatures, changes in rainfall patterns and increased frequency of extreme events, which could cause changes in pest ecology, ecological disruption in agricultural areas and socioeconomic shifts in land use practices.

Climate affects livestock in four ways: through (i) the impact of changes on availability and price of feedgrain, (ii) impacts on livestock pastures and forage crops, (iii) the direct effects of weather and extreme events on animal health, growth, and reproduction, (iv) changes in the distribution of livestock diseases.

The largest area with marked vulnerability to climate variability in Latin America is northeast Brazil. Sivakumar et al. (2005) pointed out that periodic occurrences of severe El Niño – associated droughts in northeastern Brazil have resulted in occasional famines. Under doubled-CO_2 scenarios, yields are projected to fall by 17 to 53% depending on whether direct effects of CO_2 are considered.

The effects of the climate change scenarios in the agroclimatic zoning of arabic coffee (*Coffea arabica* L.) is important in the main plantation areas in Brazil. The simulations presented by Assad et al (2004) indicate a reduction of suitable areas greater than 95% in the states of Goiás, Minas Gerais and São Paulo (Figure 12), and about 75% for Paraná in when the temperature increases in 5.8°C. In terms of annual crops production, the effects of the high temperatures are negative

5,3. Evaluation of Past and Ongoing Research Projects

The projects funded until now are generic, and not focused on agribusiness. The initial effort was to characterize the problem, with few results in the evaluation of impacts in the production systems. It is necessary to redirect the projects for more objectivity and with focus on the animal and crop production systems. In a preliminary review (Annex III) projects funded by FAPESP, it was observed that about 20 proposals were related to the keywords: “solo” (soil), “agricultura” (agriculture), “gas” (gas), “clima” (climate), “sequestro” (sequestration), “metano” (methane), “óxido nitroso” (nitrous oxide), “dioxide de carbono” (carbon dioxide), “CO_2”, and “N_2O”.

5.2 Research Priorities for the Development of Adaptations in Agricultural Systems

- Impact of global warming to food security;
- Monitoring of crop development and growth, including development of parasites, pests and weeds, under to current climate and simulated future climate scenarios to improve understanding of climate impact on agriculture;
- Effects of climate change in soils. Potential for soil carbon sequestration in different crop management, including erosion control, nutrient losses and conservation of moisture;
- Forecasting crop production and long term sustainable agriculture and forestry yield improvement;
- Development of physiological based animal models with well developed climate components are needed urgently to cover gaps in knowledge and for future projections.

- Better understanding of the role and importance of biodiversity for agriculture;
- Quantifying carbon sequestration in forest systems;
- Development of innovative new technologies (e.g, climate forecasting) alongside traditional methods (e.g, intercropping, mulching) will be needed for yield improvement;
- National inventories of greenhouse gas emissions due to land use, land use change and agriculture/husbandry (including CH4 from domestic animals)

5.3 Research and Test with Mitigation Options

- Whether or not there will be significant climate change, inherent climatic variability makes adaptation unavoidable. These are embedded on management strategies such as sustainability of land productivity, changes in erosion, degradation and environmental quality, reducing overgrazing in grasslands and can be drawn from both traditional and new technologies.
- Standardization of crop models for widespread agrometeorological application needed, with more modelling on the rainfall distribution and onset of the rainy season in tropical and subtropical regions.
- Changes in agronomic practices, such as earlier planting dates or cultivar substitution, and methods of microclimatic modification, for example, to cool animal environments as the climate warms.
- Improvement of carbon sequestration is required from agriculture and forestry by adopting permanent land cover, utilizing conservation tillage, reducing fallow land in summer, incorporating rotations of forage and improving nutrient management with fertilizers, reducing GHG emissions.
- Introduction of forage cropping into rangeland and pasture rotations can be applied for increasing the carbon sequestration. Improved manure management and feed rations with improved drainage and irrigation will contribute to diminishing emissions of carbon dioxide, methane and nitrous oxide

6 ENERGY AND GREENHOUSE GASES

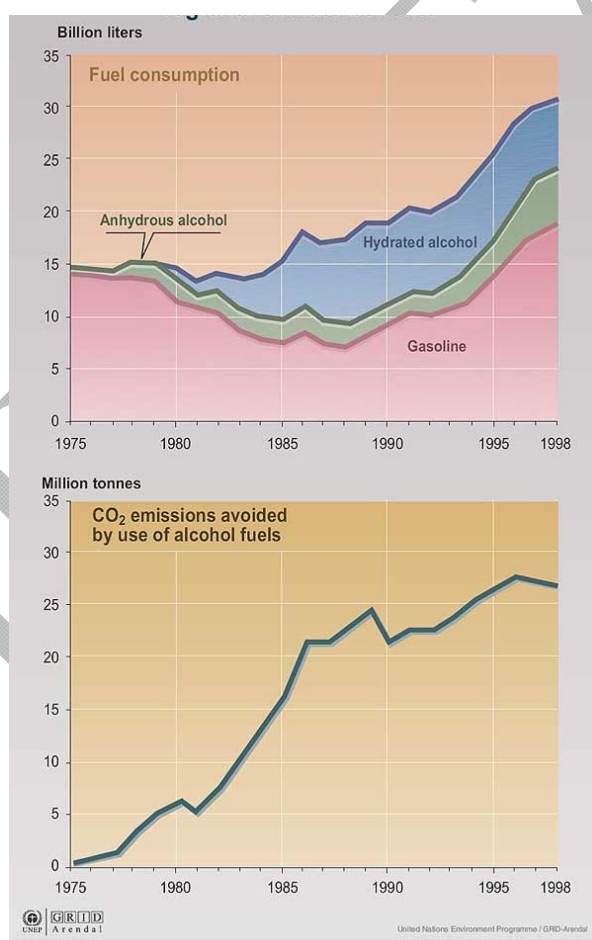
The exploration of natural resources for the production and use of energy results in significant social, environmental and economic impacts. The large scale use of fossil fuels and other non-renewable sources of energy and power for the generation of energy and power in all sectors have also resulted in the emission of billions of tons of carbon annually. The resultant emission causes serious anomalies in the climate system, land, oceans, ecological systems in general, and even in the chemistry of the atmosphere. These anomalies in the global environment can modify the capacity of the planet to sustain life (Necco, G., 2004).

There is a significant influence of the present production and consumption structures of energy on global climate change, as highlighted recently by the IPCC (IPCC(c) 2007). The use of energy, by itself, is responsible for more than two thirds of the greenhouse gas emissions (GHG) and accounts for about half of all the projects currently approved by the Kyoto Protocol carbon market flexibility mechanisms. Atmospheric pollution is associated mainly with the combustion of coal and other petroleum derived fuels including natural gas, although biomass burning and other land use changes are main sources of GHG in developing countries. The impacts generated by the burning of gasoline and diesel in the transport sector alone account for a large fraction of this environment degradation. Fossil fuels presently feed large sectors of the world economy, including the generation of electricity, industrial production, and transportation, totalling around 90% of commercial energy utilized in the world today.

During the 20th Century there has occurred an accelerated increase in the concentration of GHG in the atmosphere, altering abruptly its chemical composition. Reported values suggest an increase of the order of more than 31% for the CO_2 gas since the pre-industrial age to the present time, passing from 280 ppmv to more than 380 ppmv (parts per million in volume), more than 100% for methane CH_4, 15% for N_2O, besides the not well defined quantities for the halocarbons (Karl and e Trenberth, 2003, and IPCC(a), 2007).

Current GHG emissions due to the energy system in Brazil are considerably lower than those from land-use change. According to La Rovere and Romeiro (2003), CO_2 emissions due to energy use were at a level between 33% and 66% of CO_2 emissions from deforestation in 2000. The Brazilian National GHG Emissions Inventory (MCT, 2004) estimated that emissions arising from land use change accounted by about ¾ of total emissions of CO2 in Brazil during the early 1990's. Emissions from the Brazilian energy system are very low indeed with respect to population (0.527 tons of carbon per capita), but fairly high compared to economic activity (0.5231 kg of carbon per US$ of GDP), using data available from 2001. The reason for the relatively low per capita emissions in Brazil is the intensive use of renewable energy such as hydro and biomass (wood, charcoal and fuel ethanol).

The net amount of GHG emissions avoided by using sugarcane ethanol and bagasse, instead of fossil fuel in Brazil, has been well evaluated by Macedo (1997). The carbon released into the atmosphere when bagasse and ethanol are consumed for fuel is compensated for by an equivalent quantity of carbon which is sequestered or absorbed by the sugarcane plant while growing. This total of 9.45 MtC for the year 1990-91 corresponds to 10 % of the total emissions of carbon due to energy consumption in Brazil in 1990. Accounting only for the substitution of gasoline, the use of ethanol has avoided the release into the atmosphere of an average of 5.86 MtC per year from 1980 to 1990 (Figure 14).



Source: Federal University of Rio de Janeiro

Figure 16: Brazilian alcohol transport fleet and regional climate benefits. Source UNEP/GRID-Arendal (http://maps.grida.no)

Accordingly, the future expansion of the Brazilian Ethanol Programme could be ensured through an adequate flow of foreign investment, considering its global environmental benefits. A question can be raised whether it is feasible to consider such expansion in the framework of the Clean Development Mechanism - CDM approved at the Kyoto COP meeting in December 1997. Naturally, meeting the additionality criterion required for CDM eligibility will depend upon the baseline levels of sugar cane availability in the country as well as its use either for ethanol or sugar production. Also, including friendly environmental practices related to the agricultural production of the sugar cane itself is highly recommended, firstly for the natural resource conservation and secondly to meet CDM requirements. The importance of sugar cane must be stressed as an economic activity. For example, the sugarcane sector, involving cane, sugar and ethanol contributes about R$ 11 billion to the State of São Paulo economy employing around 600 thousand people directly and indirectly.

Lately, biodiesel, especially from highly productive crops such as palm oil, has received increased attention because of its potential to reduce emissions, particularly GHG emissions over the life cycle of the fuel. Studies, such as BIOCAP – Canada (2003) have shown that the emissions in the biodiesel life cycle are lower due to the relatively low fossil fuel energy demand required in the production of biodiesel, relative to petroleum based diesel. There is, however, more significant N_2O emission effects associated with agricultural practices used in crop production.

In the State of São Paulo the main sources of GHC emissions are transportation, industry, and agriculture. The adoption of ethanol as fuel has significantly contributed to alleviate emissions and air pollution particularly in the metropolitan area of São Paulo. Diesel is still intensively used in trucks and buses. The heavy fleet performance is quite heterogeneous due to use of aged vehicles and somehow obsolete engine technology. Use of natural gas in the buses in the metropolitan area of São Paulo seems to be an important and easier way to improve air quality and decrease emissions of pollutants.

As far as the agriculture is concern a significant effort is been conducted to eliminate sugarcane burning, a great source of CO_2 emissions and other pollutant gases and particulate matter. Environmental legislation guarantees that by 2020 sugarcane burning will be eliminated in the State of São Paulo.

6.1 Critical Assessment of the Research Projects Funded by FAPESP Related to Energy and Climate Change

The existing funds (public and private) for research on energy in Brazil are the following:

- R&D resources of electricity concessionaires (controlled by ANEEL, CSPE and operated by concessionaries)
- Sectorial funds: CTENERG, CTPETRO, CTAGRO
- Public funding agencies: FINEP and FAPs
- Private investments (e.g. Centro de Tecnologia Canavieira – CTC, Pulp and Paper industries etc.).

These funds can be utilized by researchers to study energy-climate change related issues. In the State of São Paulo they are currently been used mostly by public universities such as UNICAMP, USP, UNESP, CTA, UFSCar and government research centres such as IPT. Private research centres in this area are practically non-existent, with the exception of Centro de Tecnologia Canavieira-CTC (ex-Copersucar) and few other private companies with Research & Development (R&D) laboratories, consulting and small companies, and NGOs.

In order to structure the analysis, the energy sector will be divided as:

a) fossil fuels (petroleum, natural gas and coal). In this area the research is basically conducted by PETROBRAS and COMGAS with public universities, especially USP and UNICAMP. The resources allocated to fossil energy tend to be better utilized achieving more its goals because the fossil sector tend to be more centralized, the research more expensive and better guided through internal research and periodical call for proposals.

b) renewable energies. FAPESP has funded a number of biomass related projects, such as research on genetic improvement, biological control and new varieties of sugarcane, where there is more tradition in research in the State of São Paulo.

Recognizing the importance of ethanol to the economy of the State, FAPESP recently launched an ambitious applied research programme on ethanol in partnership with the private sector, encompassing all the production chain of sugar cane ethanol, including the development of an ethanol-based chemical industry.

6.2 Research Priorities

Brazil is not a country with abundant energy resources. Roughly speaking, it is possible to state that Brazil has good comparative advantages in hydro, biomass and solar energy (MME, 2005). In others energy resources including fossils such as petroleum, natural gas and coal and renewable energy such as wind the country does not have abundance. This is an enormous limiting factor for economic development.

Even regarding the resources in which Brazil is mostly competitive such as hydro and biomass, environmental impact appears as an important barrier. Brazil has an important hydro potential in the Northern Region (Amazonia) where environmental impact is limiting the expansion for new dams. Regarding biomass (wood, charcoal and sugarcane products such as ethanol and bagasse) environmental considerations are also the most important barrier together with the necessity of more research both in agriculture and processing.

The situation in State of São Paulo (around 3% of Brazilian territory) is not very different. The most important state in the country with 33% of its GDP and 25% of its population, São Paulo is totally dependent on petroleum, natural gas and charcoal and partially dependent on electricity and burning wood. Petroleum comes from Rio de Janeiro off-shore exploration and foreign sources. Natural gas comes from Rio de Janeiro and Bolivia. Some charcoal is basically imported from neighbouring states (MG and MS mainly) using obsolete technology for its production and expensive diesel for transportation.

Only with ethanol and bagasse, the State of São Paulo is self-sufficient and an exporter of those. However, as the domestic demand for ethanol and bagasse will grow and considering that environmental legislation will make sugarcane agriculture more difficult in the Piracicaba region, pushing it westward, it is possible to conclude that production of ethanol, bagasse and sugar will have to grow depending more on increased productivity than over ever expanding land use. This means research should be directed to productivity increase, improvement of sustainability indicators (such as fossil fuel dependence), lowering of costs and creation of more wealth and social benefits.

Research priorities on climate change, energy and greenhouse gasses should be:

- Energy conservation and efficiency: industry, transportation, commerce and residential
- R&D on Renewable Energies: biomass, wind and solar energy
- New and high performing technologies for energy generation and use
- Biological and geologic carbon capture and storage
- Sustainable agriculture production in energy-related crops
- Reduction in sources of methane and methane-energy conversion

- Aspects related to Refrigeration technology: ecological working fluids and insulation
- Economic instruments (e.g., CDM) for mitigation of emissions
- Impacts of projected climate change on renewable energies in Brazil (hydro, wind, biomass, solar).

Due to the nature of biomass technology where agriculture production requires intensive use of land and jobs, interdisciplinary research plays a very important role. It is desirable a strong research focus on Brazil for issues related to biomass technology. For example, there are important bottlenecks to be overcome with sugarcane to ethanol. To increase its productivity, producing more ethanol and electricity per cultivated area three technologies are considered key: development of new cane varieties, significant improvement of harvesting and trash collection and the hydrolysis technology. It is expected that with the combination of these factors productivity may increase from 6,000 to 14,000 litres/ha year in the next 20 years.

Finally, it can be said that FAPESP through the RPGCC could play an important role in helping to optimize research coordination with other funding agencies, public and private in the area of climate change, energy and greenhouse gases.

7 HEALTH EFFECTS OF CLIMATE CHANGES

Human activities are inducing unequivocal modifications on global climate. The mitigation strategies of process promoting an accumulation of greenhouse gases in the atmosphere implies in a reduction of the use of energy derived from fossil fuels, which, ultimately, implies in modifications of human habits, including consumption of goods and patterns of transportation. Increased concentration of pollutants, thermal stress, floods and droughts, aeroallergens, changed patterns of infectious diseases, are the hot spots in terms of health consequences of climate changes. In this line, health consequences of climate changes migrated from general science and environmental journals to get the pages of clinical journals such as JAMA (Haines and Patz, 2004) and Lancet (McMichael et al., 2006).

A general and simplified algorithm in Environmental Medicine applied to greenhouse gas emissions, can be depicted as follows (Figure 15), after adaptation from Kovats et al (2005).

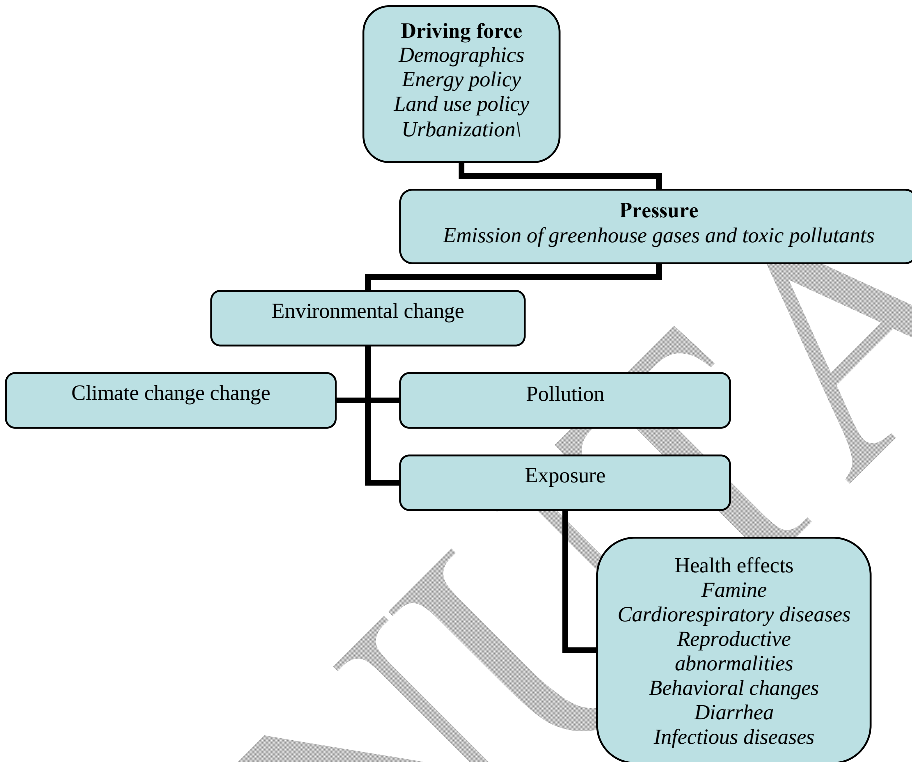


Figure 17: Algorithm for studying climate changes and health effects (adapted from Kovats et al, 2005).

7.1 Health effect

Changes in climate encompass a series of events to which billions of people are inevitably exposed to. Thus, a series of physiologic alterations may occur, the majority of them devoid of any clinical manifestation. Also, the time course of human responses has to be considered when trying to define adverse health consequences of a given environmental change. For instance, extremes of temperature or outbreaks of infectious diseases are examples of events that lead to health effects within a limited time span, leading to little chronic consequences. On the other hand, the exposure of populations to UV radiation or atmospheric pollutants will pay their toll in terms of health effects after decades. To make the situation more complex, there are few environmental situations that exhibit a characteristic fingerprint of their cause. There are few exceptions to this general rule, such as in the case of intoxication for heavy metals or organic compounds derived from industrial processes with ling time of residence in the environment. Thus, health consequences of climate changes will be manifested mostly in terms of increase in the number or in the severity of well defined conditions, such as heart diseases, asthma, cancer and infections. In such scenario, few will die due to hyper or hypothermia during waves of inclement weather, but thousands will die because of heart attacks or respiratory diseases. In general terms, the counts of people affected will depend on the severity of health outcome (numbers fall as severity increases, Figure 16), the availability of diagnostic tools and time of observation. For such reasons, projections of the burden of climate changes on health have been established in mostly in terms of mortality, which is clearly a gross underestimation.

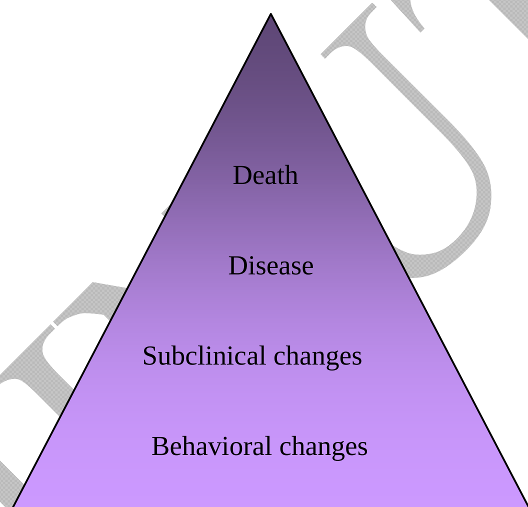


Figure 18: Population pyramid of the number of affected people with severity of the health consequences of climate changes.

Another point that deserves attention is about thresholds in the effects of climate change on health. In other words, effects on health occur only after a given amount of stress? In the case of temperature, the threshold condition is apparent, since cold and hot waves promote a sharp increase in mortality. However, for air contamination or UV radiation, there is no scientific ground for believing in safety thresholds.

7.2 Examples of health consequences of climate changes

Air pollution

Air pollution is a by-product of the emission of greenhouse gases, but that affect health regionally. The use of fossil fuel to produce electricity and for transportation represents one of the main causes of climate changes, with obvious health consequences. Even Brazil having potential sources of renewable energy and producing electricity mostly by hydropower, we did not have a consistent policy for transportation in our towns. An illustrative example of the present scenario is depicted in Figure 17, showing the time evolution of population and automotive fleet in the Metropolitan Area of São Paulo, in the last 10 years.

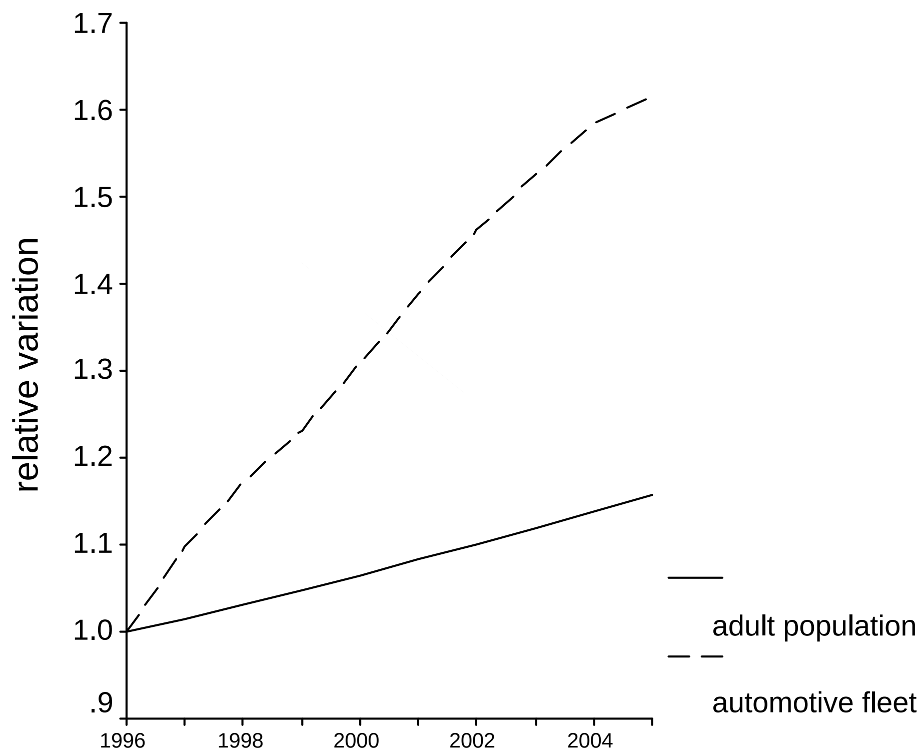


Figure 19: Graphic representation of the relative variation of adult population and automotive fleet in the Metropolitan Area of São Paulo, from 1996 to 2005.

Data presented in Figure 17 clearly indicate that São Paulo favoured individual transportation in detriment of more energy efficient transport modes, without evidences of a changing scenario. This policy is somewhat puzzling, because resulted in significant problems of locomotion, as well as in energy inefficiency. As a general rule, individual transportation spends 30 times more fuel per passenger in comparison with buses and 70 times more energy when subway is taken for comparison. Based on estimates provided by the Metro of São Paulo, a line of subway saves about 3 million barrels of petrol per year. Indeed, the same option towards individual transportation occurs in other Brazilian and Latin American metropolitan areas. Based on historical data on fuel consumption and the projected increase in automotive fleet, CO_2 emissions due to mobile sources are expected to increase steadily in Brazil (in a business as usual projection), as depicted in Figure 18.

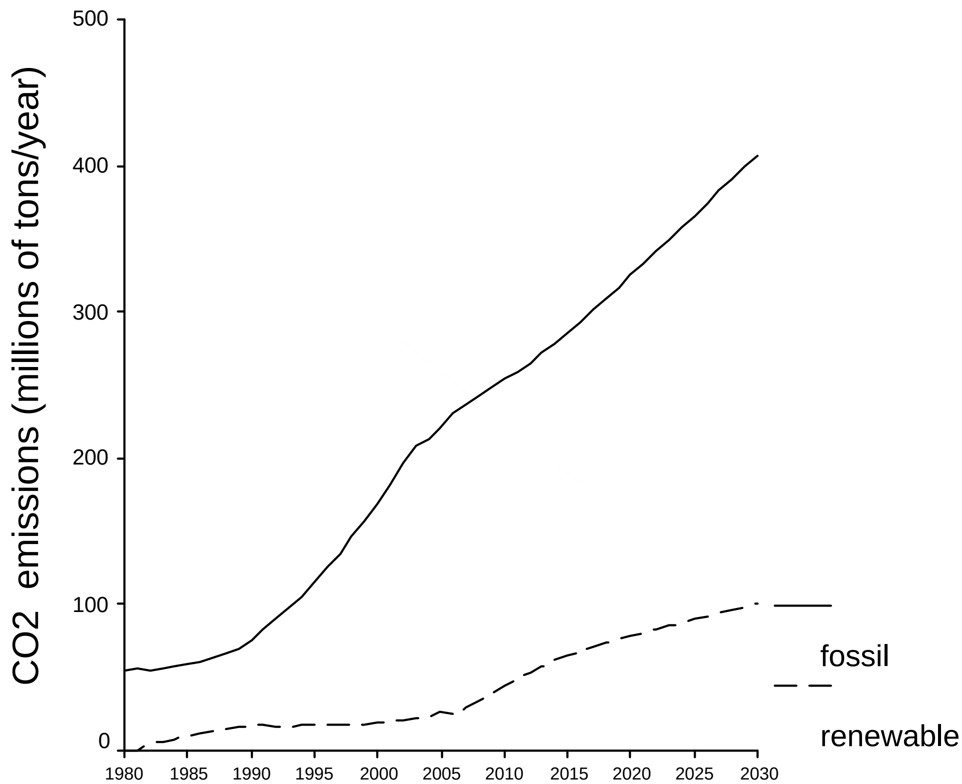


Figure 20: Graphic representation of the time course of CO2 emissions in Brazil due to automotive emissions using either fossil or renewable fuels. The future projections are based on business as usual conditions.

Thus, despite of the availability of renewable fuels, CO_2 emissions due to automotive sources using fossil fuels are expected to increase, if the present political path is maintained.

Why is so important to keep an eye on transportation and fuel policies in Brazil, when dealing with the health effects of climate changes? The reasons may be summarized as follows:

1. Emissions due to mobile sources contains, in addition to CO_2, several toxic chemical components, responsible for sizeable health effects;
2. In addition to global climate changes, automotive emissions are responsible for alterations of climate in smaller scales, responsible for islands of heat in the heart to the large urban conglomerates. Despite the small scale of such gradients in temperature and climate, the high population density of Metropolitan Areas leads to a large number of individuals at risk within a limited variation in space;
3. The aforementioned arguments – high emissions of toxic substances, significant climate changes in a small area and high population density – indicate that most of the observed consequences of climate changes will be experienced in the urban scenario;

Burning biomass also represents a significant source of greenhouse gases. In Brazil, biomass burning is due to agricultural activities as well as due to the use of solid fuels for cooking. The first point – agricultural processes – although well documented is not yet controlled. The continuous expansion of the area of agriculture is achieved by burning of forests and, regrettably, not properly regulated. The burning of sugar cane plantations is the preferential strategy of harvesting, despite the well documented adverse health effects caused by such approach (ref?). On the other hand, little is known about the health consequences of biomass burning indoors during cooking. Indeed, the use of biomass for cooking is inversely related to the income of a given population. Preliminary studies, biomass stoves were found in more than 60% of the houses in some locations of the Northeast of Brazil, where the indoor levels of air pollutants were one order of magnitude higher than those found in São Paulo, downtown, in periods of peak of traffic. In these houses, the relative risk for developing chronic airway diseases of wood stoves was similar to that of smoking, in line with estimates of WHO that estimated that burning biomass indoors represents about 2.6% of the Global Burden of Disease (Smith et al., 2004)

The production of toxic pollutants in the process of using fossil fuels or burning biomass is the most obvious part of the projected health consequences of global warming. In the case of São Paulo, the use of well defined concentration-effect functions estimates that keeping air pollution above the WHO standards cause about 4000 premature deaths/year, with a financial cost of US$ 450.000,00 per annum.

7.3 Extreme weather events

Extreme weather events encompass periods of very high or very low temperatures, torrential rains, floods, droughts and storms, in such intensity that overcome the adaptation (cultural, social, psychological and physiologic) developed by the population in analysis. **Thermal stress** is one of the conditions classically associated with health effects, exhibiting a U-shaped configuration as depicted in Figure 19.

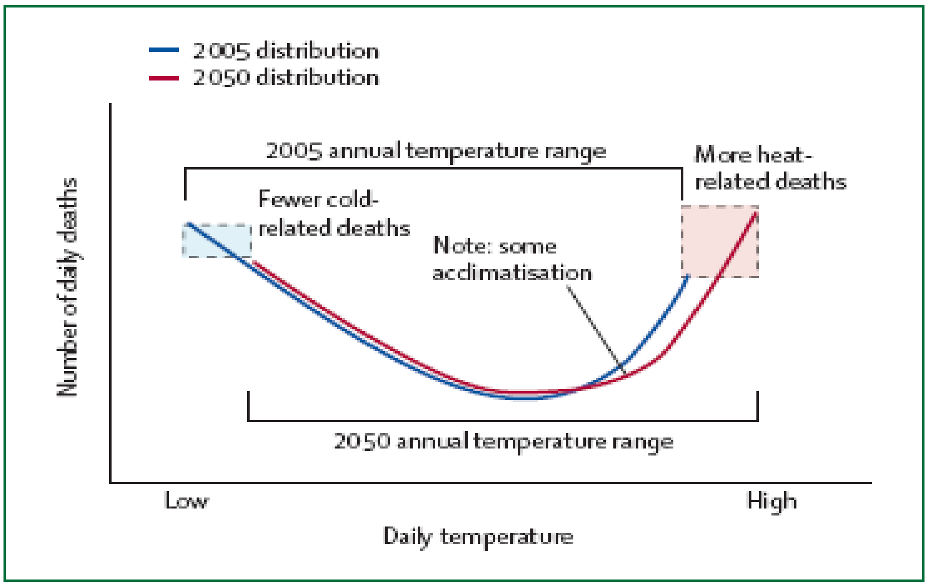


Figure 21: Schematic representation of the behaviour of mortality as a function of changes in ambient temperature (extracted from McMichael et al, 2006). In the case of an increase in temperature, the excess in deaths due to hot waves will outnumber the decrease of deaths during periods of low temperature.

As previously mentioned, temperature extremes affects preferentially children and elderly people, and those with pre-existing chronic cardiac and respiratory conditions. Urban areas are more affected that the rural setting, suggesting that islands of heat or urban canyons enhance the effects of temperature extremes. More subtle alterations, such as cognitive or behavioural consequences of thermal extremes were not hitherto characterized neither the modulation of such events by socioeconomic conditions. However, it is quite plausible that the more poverty and poor housing are significant effect modifiers of thermal stress.

Flooding is the most frequent natural disaster, killing about 100.000 people around the world per year and affecting something between one to two billion people in the same period (OFDA/CRED.EM-DAT: The international disaster database http://www.cred.be/emdat). It is expected that floods will increase as global temperature increases. In addition to the flood by itself, excessive rainfall (associated or not with flooding) facilitate the access of human and animal sewage to reservoirs of drinking water, increasing the probability of water-borne diseases, such as hepatitis and intestinal infections (Curriero et al, (2001).

Droughts are also expected to increase as consequence of global warming, and have obvious negative impacts on food production. Famine and its health consequences is the most obvious result of such condition.

7.4 Infectious diseases

Infectious agents, vector organisms, biological reservoirs and rate of pathogen dissemination are markedly affected by climate (Reeves et al., 1994; Lipp et al., 2002). In general terms, bacteria and viruses proliferate more rapidly when temperature increases. In addition, the change in climate may transport diseases of hot climate to more temperate zones as is happening with dengue fever (Hales et al., 1996). The increase of urban Leishmaniasis in São Paulo State may represent a potential consequence of climate changes, in addition to modifications in the use of soil.

7.5 Suggestion of priority research areas that may contribute to understand the possible health effects of climate changes in São Paulo

1. Modelling of infectious diseases: dengue and viral encephalitis;
2. Environmental epidemiology (time-series and spatial epidemiology), environmental econometrics and health geography
3. Respiratory and cardiac assessment in the context of panel studies relating weather to sub-clinical alterations;
4. Risk assessment and biostatistics.

8 HUMAN ROLES, IMPACTS AND RESPONSES: HUMAN DIMENSIONS OF GLOBAL ENVIRONMENTAL CHANGE

Unlike many other fields, the social sciences[2] were not led to the study of the environment through the gradual development of their major paradigms – what Kuhn called “normal” or incremental science. On the contrary, it was the irruption of serious environmental problems, and above all, of socio-environmental movements and the social conflict embedded in these movements, that placed the issue on social science agendas. While initial approaches in the

[2] As used here, the term “social sciences” includes also economics, history, demography, social psychology as well as several applied fields. As such, it is interchangeable with what, in Brazil, often is referred to as the “human sciences

seventies tended to be ad hoc attempts to delimit the field of environmental social science, the field today is thriving and diversified, with more clearly defined research orientations.

Although many social scientists thus came to study the social determinants and consequences of environmental change, they were even more unprepared to incorporate *global* changes in the scope of their work. The problems of future global warming and associated rises in sea levels, for instance, were remote from social science concerns, occurring on temporal and spatial scales which their research paradigms did not contemplate. And unlike environmental issues in general, global change did not at first generate socio-political movements in broader society demanding their attention. The early calls for social science involvement came from physical scientists who clearly saw that human activity was responsible for the acceleration of changes observed in world climate, and that it was necessary to engage social scientists in order to transform the current trends. The challenges of inter- and multi-disciplinary research, always stretching the vision of natural scientists (and often their patience as well), are considerably amplified when collaboration seeks to bridge the gap between natural and social science.

These considerations are important for understanding the development of what has come to be called the *human dimensions of global environmental change*, including the pace, institutional framework, geographical extent and (relevant) success of these developments and the timid response of Brazilian social science. Most importantly, they are essential for tracing a strategy of promoting and supporting social science involvement in climate research within the social science community of São Paulo.

8.1 Brazilian Human Dimensions Research

The Academia Brasileira de Ciências accompanied these moves, creating a Human Dimensions Committee in 1997. One consequence of this decision was a bid by Brazil to hold the Committee's 4th Open Meeting in Rio de Janeiro in 2001.[3] The preparation and the implementation of this meeting was, without doubt, the most significant activity of the Committee, and had as a major objective the mobilization of the Brazilian Environmental Social Science community, increasing interest and involvement in climate research. While this meeting coincided with the creation of the National Association for Graduate Studies and Research in Environment and Society (Anppas), which unites Graduate programs on society

[3] On this occasion, the Committee organized a book of commissioned chapters to present Brazilian views on human dimensions to the international community. This book, D. Hogan and M. Tolmasquin (eds.), Human Dimensions of Global Environmental Change: Brazilian Perspectives, Rio de Janeiro, Academia Brasileira de Ciências, Rio de Janeiro, 2001, remains one of the few publications on human dimensions in Brazil.

and the environment and promotes well-attended national meetings on a biannual basis, the Open Meeting did not significantly increase participation of Brazilians in this field and global environmental change continues to be a little-explored theme at Anppas meetings.[4]

The reasons for this are important to consider as FAPESP launches a programme on Climate Research. In the first place, the National Committee has been inactive, lacking the follow-through that the FAPESP programme may provide[5]. The international experience synthesized above makes it very clear that a pro-active role on the part of funding agencies is fundamental, something which has been lacking to date. Funding opportunities are essential for such research to take off; it will not take off on its own. Perhaps more important, however, has been the lack of response of the environmental social science community itself. Long-neglected and still without the necessary priority, more immediate and concrete environmental problems at the local, regional and national level tend to monopolize the attention of researchers and students in Brazil and other less developed countries.[6] In a field as new as environmental social science, graduate students and their theses are a major source of new knowledge. The issues which inspire students to seek out the 40 or so graduate programs in environmental sciences in Brazil are those to which they have been exposed in their role as citizens. Global climate change has not, thus far, been one of them.

Breaking this vicious circle of exclusive attention to pressing local problems is an important objective of FAPESP´s RPGCC Programme. In this respect, international experience is a useful guide. Four core projects galvanized the nascent “human dimensions of global environmental research community” for more than a decade at the international level. Such projects were important for two reasons:

First, sub-communities of researchers were organized into interdisciplinary, inter-institutional and international networks on themes sufficiently few in number and limited in scope to be able to conduct comparative research and synthesize results over a period of fifteen years. Projects interested in this exchange submitted their plans, which were accepted as part of the

[4] The IHDP’s Annual Report for 2004-2005 registers eight researchers from Brazilian institutions, only three of whom are social scientists. The other five became involved in human dimensions research as an aspect of their research in the exact sciences. Of the three social scientists, none participate in a core project: Eduardo Viola was co-chair of the 2005 Open Meeting; Roberto Guimarães is a member of the IHDP Steering Committee; and Daniel Hogan is a member of the Steering Committee of the Population-Environment Research Network, a joint activity of the IUSSP and IHDP.
[5] The Committee’s most recent activity was a workshop in Campinas in 2004, whose objective and final decision was a proposal to unite the Human Dimensions Committee with the Brazilian IGBP, under the aegis of the Academy of Sciences. See Hogan, D., et. al. (2005) Proceedings of the National Workshop on Global Environmental Change: A New Scientific Agenda in the Brazilian Context, Campinas, Brazil, September 2004.
[6] This attitude does not derive from any isolation of this community from international debate; indeed, Brazilian environmental social science has been at the forefront of research, participating intensely in international fora.

Scientific Committee's scope.[7] The exchange and visibility provided by the Open Meetings and publication and dissemination of results by the IHDP created a space for this research which had been lacking in conventional, disciplinary-oriented organizations. This collective effort, enabled by the network established by each core project, was fundamental in forging effective, sustained programs which create training possibilities and advance knowledge. This focusing favoured cumulative results, which gave both visibility and legitimacy to the field.

Secondly, the IHDP was realistic in the choice of core projects. Instead of centrally focusing on overly challenging questions such as: What are the human activities causing climate change and How do we stop them?, they took as starting points themes already the object of research, making obvious overlooked connections to global change, and focused on intermediate relations rather than direct connections between human actions and climate change. The four major issues - *land-use and land-cover change, environmental change and human security, institutions and industrial transformations* - are areas in which environmental social scientists had a long-standing focus and body of work, but which had not centrally included climate change:

Land-use and land-cover change had been studied due to concerns about (1) the loss of forest cover (to monoculture, cattle-raising and lumbering) and its impact on traditional livelihoods of small farmers and Indians, (2) the demographic occupation of new territories, and (3) the loss of biodiversity. Understanding the social, political, demographic and economic consequences of changes in land-use and land-cover would prove to be an important link between human activity and the carbon cycle – with its inherent effects on climate change.

Environmental change and human security, in the same way, moved from common concerns in the social science community to including the issue of climate change. What has been called the *risk society* places humankind in a new, vulnerable relationship to the world, and environmental issues are among the principal factors involved. The lenses of environment and security provide a path for incorporating concern about the effects of climate change on health and community well-being, as in approaches to *food security* (from labelling to diet patterns to transgenics to outright hunger), exposure to thousands of chemical compounds whose cumulative effect is unknown, and conflicts around such essential resources as water.

[7] The IHDP does not finance research, but the identification of a project with one of the core projects has proven useful in securing funding; the principal gain for participating groups has been through the collective work of defining concepts, research strategies and research designs, as well as the exchange of results.

The study of *institutions* is among the most traditional pursuits of sociology. The creation and development of institutions in the environmental field has generated much research in both the Northern and Southern hemispheres in the last quarter-century, as the environmental issue has become embedded in contemporary societies. Indeed, the institutionalization of environmental protection and of environmentalism itself is a major fact of our times. For sociologists and political scientists who study institutions, it is a logical step to move the focus on the role of environmental and resource regimes, or trade and investment regimes, to the role of global environmental changes and how to confront them. The conceptual basis for this move has already been well established.

The study of *industrial transformation* brings some reluctant participants into the discussion. Economics – most especially in Brazil – has not been at the forefront of environmental social science. Industrial transformation, however, has been a central issue for economists, and the move towards more environmentally friendly production processes, alternative fuels, and less energy- and materials-intensive production are issues which tie into some of the most basic links of human activity to climate change.

Among the newer core projects is that on *urbanization*. Environmental changes associated with urbanization had already been identified by the Brazilian Committee as central issues from the perspective of developing countries in 2000, when a chapter on the topic was commissioned for the above-mentioned book on human dimensions research in Brazil related to global environmental change. The rapid pace of urbanization in Brazil, especially in Amazônia and in the Cerrado, and all of the profound changes this has provoked in national life, means that this process is related to all of the issues mentioned above. As one of the major transformations of Brazilian life in recent decades, its implications for values, behaviour and national priorities related to climate change are multiple and profound. From the IHDP's point of view, this is an issue which is set to take off as a core project.

Finally, but very importantly, human dimensions research needs to develop critical insight related to the interface between science and policy. Social science research presently focuses overwhelming on how environmental problems are caused, felt and perpetuated by human populations. Research is needed which also examines knowledge production itself, as well as its uptake into decision making. This includes the "upstream" processes of deciding what kinds of research are being produced, with what tools, and to what effects. Research is needed which examines whether the knowledge produced under present science agendas is sufficient and effective: is it being used, and if not, why not and with what consequence? What lines of research are missing and how might they be developed. Such research needs to attend centrally to the needs of users, as perceived not only by analysts but also by users themselves.

It must seek to identify ways of producing high quality science that also is relevant decision-relevant, overcoming the long-standing, perceived separation between applied and basic science as well as the associated value system within science which favours the latter.

8.2 Concluding Remark

A reading of the international experience recommends both focusing on a limited number of themes and choosing themes in consonance with this experience. These issues are currently the object of research by the Brazilian environmental social science community, even though researchers have not often identified the link with climate change. If they can be induced to identify a place for themselves in this scenario and to recognize that climate change is being approached by way of issues they are indeed currently researching, they may be drawn into FAPESP RPGCC Programme. As a rather esoteric, remote issue, without clear links to current social processes, it will not motivate this community.

An analysis of projects funded by FAPESP in the environmental field does not identify the potential researchers on climate change. They are to be found, not in self-declared climate researchers (perhaps a small number of geographers), but in a diversified group of researchers whose incorporation of a climate change dimension is both desirable and feasible.

9 GLOBAL ENVIRONMENTAL CHANGE PROGRAMMES

The subject of global environmental change (GEC) is of world-wide concern and a number of national programmes have been established over the last 20 years to deal with it. We critically review below some of the international and national experience on GEC research, including international cooperation, with the aim of identifying those programs and research groups that would be worthwhile for FAPESP RPGCC Programme to cooperate with. It is important to remark that this is not a complete list of all relevant climate change research programmes in the world, but just a selection of some of them.

9.1 International Geosphere-Biosphere Programme (IGBP)

Global Change refers to biogeophysical, biogeochemical and socio-economic changes that are altering Earth System behaviour. Global Change is accelerating and will potentially affect all aspects of life on Earth. Responding to Global Change thus presents major political, economic and social challenges. The International Geosphere-Biosphere Programme (IGBP) -

http://www.igbp.net - aims to develop interdisciplinary scientific research necessary to understand and respond in a timely and effective fashion to global environmental change.

IGBP is an international scientific research programme that networks scientists from all around the world to conduct interdisciplinary Earth System science and global change research. IGBP was created in 1986 under the auspices of ICSU with the research goals of understanding the interactive physical, chemical and biological processes that define Earth System dynamics, the changes that are occurring in these dynamics, and the role of human activities in these changes. IGBP research is comprised of a suite of eight research projects focused on major Earth System compartments (land, ocean and the atmosphere), the interfaces between them (land-ocean, land-atmosphere and ocean-atmosphere) and system-wide integration (Earth System modelling and paleo-environmental studies).

Additionally, the challenge of understanding global change and providing policy-relevant information requires an unprecedented scientific effort that goes beyond the research mandate of IGBP. Recently DIVERSITAS, IGBP, IHDP and WCRP established the Earth System Science Partnership (ESSP, which provides a framework for addressing issues of global sustainability such as water resources, food production, the global carbon cycle and human health.

IGBP has played a central role in helping coordinating and facilitating global environmental research also in Brazil, specifically in association to the LBA Programme, where it played an important role. To a large extent, researchers in Brazil working on GEC research are directly or indirectly associated to the IGBP network, some of them in leadership roles. It is highly desirable that the FAPESP RPGCC Programme establishes close partnership with IGBP projects, which would contribute to them give RPGCC an international dimension, similarly to what LBA experienced.

This FAPESP programme will be integrated with international efforts being coordinated by the IGBP and other global environmental change programmes. Important partnerships will be established with several initiatives such as: iLEAPS (Integrated Land Ecosystem – Atmosphere Processes Study), CACGP (Commission on Atmospheric Chemistry and Global Pollution), IGAC (The International Global Atmospheric Chemistry), SOLAS (Surface Ocean - Lower Atmosphere Study), WCRP (World Climate Research Programme), PAGES (Past Global Changes), IHDP (International Human Dimension Programme), Global Land Project, LUCC (The Land Use and Land Cover Change) , LOICZ (Land-Ocean Interactions in the

Coastal Zone), IMBER (The Integrated Marine Biogeochemistry and Ecosystem Research) and AIMES (Analysis, Integration and Modeling of the Earth System) among others. Several Brazilian scientists are at the Science Steering Committee of these projects, and can help as a liaison person.

9.2 World Climate Research Programme

The World Climate Research Programme (WCRP) - http://wcrp.wmo.int/ - sponsored by the International Council for Science (ICSU), the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, is uniquely positioned to draw on the totality of climate-related systems, facilities and intellectual capabilities of more than 185 countries. Integrating new observations, research facilities and scientific breakthroughs is essential to progress in the inherently global task of advancing understanding of the processes that determine our climate.

The two overarching objectives of the WCRP are:

1. to determine the predictability of climate; and
2. to determine the effect of human activities on climate.

These two objectives underpin and directly address the needs of the UN Framework Convention on Climate Change (UNFCCC) and contribute to many other international policy instruments.

To achieve its objectives, the WCRP adopts a multi-disciplinary approach, organizes large-scale observational and modelling projects and facilitates focus on aspects of climate too large and complex to be addressed by any one nation or single scientific discipline.

Today, the WCRP encompasses studies of the global atmosphere, oceans, sea- and land-ice, the biosphere and the land surface, which together constitute the Earth's climate system. The four major core projects, diverse working groups, various cross-cutting activities and many co-sponsored activities of the WCRP are designed to improve scientific understanding and knowledge of processes that in turn result in better forecasts and hence benefits to users of climate research

One of the great achievements of WCRP was the initiation and coordination of the Coupled Model Intercomparison Project 3 (CMIP3), the largest model outputs archive to date, which helped the Intergovernmental Panel on Climate Change in consolidating predictions made for the recently published IPCC Fourth Assessment Report. WCRP, as well as IGBP, will be a key partner of FAPESP´s RPGCC Programme, where contributions can be made through WCRP´s cross-cutting activities: Anthropogenic Climate Change, Extreme Climate Events, Monsoons, Sea Level Rise, Seasonal to Decadal Prediction, and Atmospheric Chemistry and Climate. Several of these activities have important participation of Brazilian scientists who could lead the discussion in Brazil.

9.3 IHDP

The International Human Dimensions Programme on Global Environmental Change (IHDP) - http://www.ihdp.org/ - is an international, interdisciplinary science programme, dedicated to promoting, catalyzing and coordinating research, capacity-development and networking on the human dimensions of global environmental change. It takes a social and economic science perspective on global change and works at the interface between science and practice. IHDP is a joint programme of the International Council for Science (ICSU), the International Social Science Council (ISSC), and the United Nations University (UNU).

IHDP fosters high-quality research. The dynamics of climate change, land-use and land-cover change, interactions between institutions and global environment, human security, sustainable production and consumption systems as well as food and water issues, urbanization and the global carbon cycle are investigated in the context of global environmental change.

IHDP’s programme is designed around its three main objectives of research, capacity development and outreach and its mission is:

- To foster, coordinate, and conduct social science research that helps to understand and address the challenges of global environmental change and improve societal responses,
- To contribute to the interdisciplinary attempts, including both natural and social sciences, to understand the interactions of humans with the natural environment that cause global environmental change,
- To strengthen the capacities of research and policy communities toward a shared understanding of the social causes and implications of global changes,
- To facilitate dialogue between science and policy

IHDP has developed an effective programmatic structure over the course of the last decade.

This structure features a set of core projects operating as relatively autonomous activities, a number of joint projects managed on a collaborative basis with the other global change research programs and the Earth System Science Partnership, and several crosscutting themes of particular interest to the members of the IHDP scientific community. To support these efforts, the Programme has added a growing engagement in capacity development through initiatives such as the International Human Dimensions Workshops, and in networking and dissemination of research findings through activities like the triennial Open Meetings. Recently, IHDP has begun to explore the science-policy interaction pertaining to human dimensions of global environmental change issues.

9.4 DIVERSITAS

DIVERSITAS (http://www.diversitas-international.org/index.php) mission is to promote an integrative biodiversity science, linking biological, ecological and social disciplines in an effort to produce socially relevant new knowledge, and provide the scientific basis for the conservation and sustainable use of biodiversity**.**

DIVERSITAS is structured in:

a. An executive **Secretariat**, which under the leadership of the Executive Director, various support staff fulfil functions related to the Secretariat's prime responsibilities, which include providing central access to the Program, assuring its day-to-day operation, and assisting the SC in fulfilling its responsibilities;

b. An **International Advisory Board** that is composed by scientists from around the world, committed to the goals of DIVERSITAS, bringing visibility to the Program and promoting it in a number of ways; and

c. A **Scientific Committee** (**SC**) which comprises leading scientists from around the globe, including the chairs of IHDP, IGBP, and WCRP.

9.5 ESSP

The Earth System Science Partnership (ESSP) - http://www.essp.org/ - is a partnership for the integrated study of the Earth System, the ways that it is changing, and the implications for global and regional sustainability. It is a joint initiative of four international global environmental change research programmes: IGBP, WCRP. IHDP and DIVERSITAS

The central activities of the ESSP are Joint Projects on issues of global sustainability, designed to address the global environmental change aspects of four critical issues for human well-being: energy and the carbon cycle (GCP), food security (GECAFS), water resources (GWSP) and human health (GEC&HH). The ESSP is also currently developing a small set of

Integrated Regional Studies (IRS), designed to contribute sound scientific understanding in support of sustainable development at the local level. The first study is in Monsoon Asia (MAIRS). The Joint Projects, START and MAIRS all have a strong suite of capacity building and networking elements to their activities. ESSP Partners also collaborate closely with the Asia-Pacific Network for Global Change Research (APN) and the Inter-American Institute for Global Change Research (IAI).

The urgency of the challenge is great: In the present era, global environmental changes are both accelerating and moving the earth system into a state with no analogue in previous history. The ESSP is particularly interested in human-driven changes, which are multi-dimensional and have a cascading effect on the Earth System. These properties make them difficult to understand or predict. But integrated science approaches and the application of advanced modelling technologies are helping to develop a clearer picture of the past and project various scenarios for the future. We now have evidence to suggest that human activities could inadvertently trigger severe consequences for Earth's environment and habitat, potentially switching the Earth System to alternative modes of operation that may prove irreversible and inhospitable to humans and other life.

The ESSP's activities recognize the need to build bridges across disciplines in order to truly understand our life support system and the impact humans are having on it. More to the point, they seek to advance beyond description of natural phenomena to a deeper understanding of processes and system-level behaviour. The ESSP's intention is to contribute to the knowledge base required to develop science-based solutions that support sustainable use of our resources.

10 NATIONAL AND INTERNATIONAL EXPERIENCES AND COOPERATION

10.1 The Large Scale Biosphere-Atmosphere Experiment in Amazonia – LBA

The Amazon Basin contains the largest, contiguous extent of tropical forest on Earth, almost 5.8 million km^2. Over the past 40 years over 600,000 km^2 have been deforested in Brazil alone due to the rapid development of Amazonia, making the region one of ‘hot spots’ of global environmental change in the planet. The pace of development in the region does not allow one to foresee a reduction in deforestation rates. Field studies carried out over the last 25 years clearly showed local changes in the water, energy, carbon, and nutrient cycling, and in the atmospheric composition caused by deforestation, forest fragmentation and biomass burning. More recently, research of the Large Scale Biosphere-Atmosphere Experiment in

Amazonia (LBA) - http://www.lba.cptec.inpe.br - is uncovering novel features of the interaction of vegetation and the atmosphere in many spatial and temporal scales. The LBA Experiment is producing new knowledge on two overarching questions: (i) how Amazonia functions as a regional entity within the larger Earth system; and, how changes in climate and land use affect the physical, chemical and biological functioning of Amazonia's ecosystems.

The LBA Experiment has been lead by Brazil, but it is truly international from design during the 90's –when it was recognized the increasing importance of regional aspects of global change-- and implementation from 1998 through the present. LBA has been considered a flagship integrated regional study and it is serving as the model for similar studies in many parts of the planet. LBA comprises over 130 closely linked and coordinate studies in seven thematic areas: physical climate, atmospheric chemistry, carbon cycle, biogeochemistry and nutrient cycles, surface hydrology and water chemistry, land use and land cover change, and socioeconomic studies. LBA engaged over 1000 scientists and students from Brazil, other Amazonian countries, North America, Europe and Japan. Developing capacity in Amazonia has been a focus for LBA and the programme has trained hundreds of young scientists mostly from Amazonia. More than 500 master's and doctoral students are part of LBA research and that will be one of the legacies of the experiment for the region.

There are, however, caveats. One of the goals of LBA was to contribute sound scientific understanding in support of sustainable development. On that count, the advances made by LBA are indeed very small. Sustainable management of ecosystems needs appropriate public policies and regulatory frameworks, but translating the scientific knowledge created in LBA into public policies has proven to be far more difficult than anticipated. Key to overcoming these obstacles is the capacity to develop and disseminate appropriate technologies and methodologies for sustainable management of the environment. Brazil is not making substantial investments to develop this capacity, and building such knowledge and capacity is not high on government's priority list for Amazonia.

LBA is planning its second phase of science and implementation. Successful research topics from the first phase will be continued and research that can be used for applications will be highlighted. RPGCC without any doubt will contribute significantly to LBA, as FAPESP funded projects have been throughout LBA.

10.2 Inter-American Institute for Global Change Research (IAI)

Interaction with the Inter-American Institute for Global Change Research (IAI) - http://www.iai.int - located in São José dos Campos/SP is critical for the FAPESP RPGCC programme. The IAI is an intergovernmental organization supported by 19 countries in the Americas dedicated to pursuing the principles of scientific excellence, international cooperation, and the open exchange of scientific information to increase the understanding of global change phenomena and their socio-economic implications. The IAI pursues the principle of scientific excellence, international cooperation and the full and open exchange of scientific information relevant to global change. IAI is already sponsoring several research programs involving research institutions in the State of São Paulo, such as:

- SACC: An International Consortium for the Study of Global and Climate Changes in the Western South Atlantic. Oceanographic Institute of the University of São Paulo.
- Climate Variability and its Impacts in the Mexican, Central American and Caribbean Region (lead by the UNAM-Universidad Nacional Autonoma de Mexico).
- Development of a Collaborative Research Network for the Study of Regional Climate Variability and Changes, their Prediction and Impact, in the MERCOSUR area (lead by UBA-Universidad de Buenos Aires)
- Diagnostics and Prediction of Climate of Climate Variability and Human Health Impacts in the Tropical Americas (lead by FIOCRUZ-Fundacao Oswaldo Cruz)
- Enhanced Ultraviolet-B Radiation in Natural Ecosystems as an added Perturbation due to Ozone Depletion (lead by University of California)

Further partnership with IAI should be sought in order to make better use of the already existing connections with the scientific community in global change research.

10.3 Global Change Research Programmes in the USA, India, China and the United Kingdom

10.3.1 USA (from "Overview of the U.S. Climate Change Science Program (CCSP) Fact Sheet 1, January 2006)

Over the past 15 years, the United States has invested heavily in scientific research, monitoring, data management, and assessment for climate change analyses to build a foundation of knowledge for decision making. Over this period, the US Global Change Research Program invested over US$ 20 billion in research and technological development, making the US by a large margin the country with the highest expenditures in global change research.

The U.S. Climate Change Science Program (CCSP) was launched in February 2002 as a collaborative interagency programme, under a new cabinet-level organization designed to improve the government wide management of climate science and climate-related technology development. The CCSP incorporates and integrates the U.S. Global Change Research Program (USGCRP) with the Administration's U.S. Climate Change Research Initiative (CCRI). The Program is under the direct supervision of the Presidential Office cabinet-level Committee on Climate Change Science and Technology Integration.

The Program's mission is to "facilitate the creation and application of knowledge of the Earth's global environment through research, observations, decision support, and communication".

The management strategy of the CCSP is to "integrate U.S. Government-supported research on climate and global change, as conducted and sponsored by 13 departments and agencies. The CCSP adds significant integrative value to the individual Earth and climate science missions of its participating agencies and departments, and their national and international partners. A critical role of the interagency programme is to coordinate research and integrate and synthesize information to achieve results that no single agency, or small group of agencies, could attain".

The USGCRP was established by the Global Change Research Act of 1990 to enhance understanding of natural and human-induced changes in the Earth's global environmental system; to monitor, understand, and predict global change; and to provide a sound scientific basis for national and international decision making. The relevant research continues to be coordinated through the National Science and Technology Council in accordance with the Global Change Research Act of 1990.

The CCRI builds on the USGCRP, with a focus on accelerating progress over a 5-year period on the most important issues and uncertainties in climate science, enhancing climate observation systems, and improving the integration of scientific knowledge into policy and management decisions and evaluation of management strategies and choices.

The guiding vision of the US Climate Change Science Program is: "A nation and the global community empowered with the science-based knowledge to manage the risks and opportunities of change in the climate and related environmental systems." The US Global Change Research Program and its successor the US Climate Change Science Program are strictly maintained as policy-neutral and are not directly associated with the assessment of climate change process in any significantly formal way. The current budget of the Program is

US$ 3 billion annually, and encompasses both basic research of global environmental change and technological aspects or mitigation of and adaptation to global change.

Within the agricultural sector, US Department of Agriculture (USDA) established an office – the Global Change Program Office (GCPO)--which operates within the Office of the Chief Economist and functions as the Department-wide coordinator of agriculture, rural and forestry-related global change program and policy issues facing USDA. The Office ensures that USDA is a source of objective, analytical assessments of the effects of climate change and proposed response strategies.

The scale of the US Climate Change Science Program is so vastly huge that any comparison to expenditures in Brazil would pale. However, four aspects of that program are worth considering for discussions within the FAPESP RPGCC Programme. Firstly, the neutral-policy approaches of such a research programme in terms of the climate and biodiversity assessment process within Brazil. Given the small number of Brazilian scientists dwelling on these areas of research, most of them engaged as advisers to Government in policy-making, it would be unrealistic to prevent such association. The US Program also has a narrow, short-term focus on reducing uncertainties of projections of climate change. However, it is clear that, although contributing to reducing uncertainties on emissions at a regional scale and also on projections of regional climate change, the FAPESP RPGCC Programme must move beyond that and provide the knowledge necessary for decision-makers nationally and regionally to make informed decisions with respect to mitigation and adaptation strategies. Secondly, the US Program has very strong a technological component for the development of the technologies of the future. That should be also a critically important element of the FAPESP RPGCC Programme, not only restricted to innovative technologies for mitigation emissions, but also technologies for adaptation in all sectors and activities, giving the inevitability of a certain degree of climate change to come. Thirdly, the programme has an observational component, which is in fact an expensive portion of it, and involves expansion of global climate observations and paleo-environmental observations. By and large in Brazil, including in São Paulo, establishment, expansion and modernization of observational networks is not associated to research projects. Lastly, the Programme engages the coordinated efforts of research and operational agencies (for instance, those which would be responsible for either mitigation or adaptation). It is worth considering designing a similar inter-agency coordination organization within São Paulo, involving FAPESP, the research institutions, Universities, the "Forum Paulista de Mudanças Climáticas e Biodiversidade", State-level agencies (e.g., Instituto Florestal, Instituto Biológico, Instituto Agronômico, Instituto de Pesquisas Tecnológicas, etc.), and the private technological sector.

10.3.2 India

The Government of India has set up a National Committee to Assess the Impacts of Climate Change is chaired by the Principal Scientific Advisor to the Prime Minister, and includes meteorologists, climate modellers, hydrologists, energy economists, as well as representatives of key Ministries. The Committee is evaluating the impact of climate change on key development activities, and assessing options to mitigate climate risks. However, it seems that there is no national coordinated research effort in climate change. It sponsors a number of GEF projects, mostly in energy efficiency. The Government of India claims that it is investing in enhancing the capacity of renewable energy installations, improving the air quality in major cities and increasing afforestation, in sum "putting economic development on a climate-friendly path". The Indian Government, however, has made significant contributions to the enhancement of the ocean observing system in the region, particularly through the Indian National Centre for Ocean Information Services (INCOIS). INCOIS was very active in helping the development of the Indian Ocean Implementation Plan for Sustained Observations: Understanding the role of the Indian Ocean in the climate system (ICPO, 2006).

But apparently, research developments in India with respect to the science of climate change are, similarly to Brazil, scattered over many research institutions, normally associated to meteorology, climate, oceanography, environment, but lacking a coordinated national effort. It seems that more effort is going to the technological sector of clean energies. The climate modelling community in India does not participate currently in the IPCC process as providers of Global Climate Model scenarios.

10.3.3 China

China has established a National Coordination Committee on Climate Change. It is an inter-ministry body engaging 12 federal agencies and is responsible for deliberation and coordination on climate related policy issues and activities, and negotiations with foreign parties. The State Meteorological Administration takes the lead for participating in the work of Intergovernmental Panel on Climate Change. The Chinese Academy of Science is part of the Committee and some of the recent involvement of Chinese scientific institutions in climate change research has been sponsored by the Academy. From IPCC's Third Assessment to the Fourth Assessment, there has been a large increase in Chinese input into the process, including inclusion of a Chinese Global Climate Model in the IPCC process. The Chinese government has published its National Climate Change Programme (National Development and Reform Commission, 2007) and a white paper entitled “China’s Scientific and Technological Actions on Climate Change” (Chinese Ministry of Science and Technology et al., 2007)..These two documents show China´s commitment to climate research and mitigation processes. Particularly, studies of Asian monsoon activity and variability and their contributions to drought and flood in China were concluded with important findings that draw the world’s attention.

The enhanced effort of China in the last few years in investing in climate change science is likely to put China as the top scientific player in the developing world in terms to scientific contributions. A number of national climate change research institutes have been set up and one core climate change expert team has been formed in China with expertise in economics, social sciences, energy, meteorology, ecology, environment and other disciplines. In a recent meeting of global change science in China, a summary of research indicated over 1000 peer-reviewed articles published by Chinese scientists of Chinese institutions in one year. In comparison, the Brazilian scientific community has probably published not more than 100 peer-reviewed articles a year.

In view of the growing economic and technological exchange between Brazil and China, it is desirable that the FAPESP RPGCC Programme establishes collaboration with similar research programmes in China.

10.3.4 United Kingdom

The Oceans 2025 programme, funded by the Natural Environment Research Council (NERC), is designed by and implemented through seven leading UK marine centres. Oceans 2025 addresses some key challenges that the UK faces as a result of a changing marine environment. It will increase our understanding of the size, nature and impacts of these changes and will:

1. improve our knowledge of how the seas behave, not just now but in the future;

- help to assess what that might mean for the Earth system and for society;
- assist in developing sustainable solutions for the management of marine resources for future generations;
- enhance the research capabilities and facilities available for UK marine science.

- The marine centres are working together in coordination and will also be supported by cooperation and input from government bodies, universities and other partners.

Oceans 2025 addresses nine major science themes: Climate, ocean circulation and sea level, Marine biogeochemical cycles, Shelf and coastal processes, Biodiversity and ecosystem functioning, Continental margins and the deep ocean, Sustainable marine resources, Technology development, Next generation ocean prediction systems, and Integration of sustained observations in the marine environment. Some of these themes will, through fieldwork, analysis and modelling, provide detailed knowledge of how the Atlantic, Arctic and Southern Oceans are responding to, and driving, climate change, in addition to development of state-of-the-art ocean models needed for the next decade.

The whole programme will receive approximately £24 million per annum from NERC over five years, 2007-12. The Strategic Ocean Funding Initiative (SOFI) provides an additional £6.3 million (including Sustainable Marine Bioresources for wider involvement in the programme). Giving the level of funding and the wide range of climate research which will be funded through this programme, it is necessary that FAPESP RPGCC Programme establishes a strong collaboration and partnership with UK´s climate science community.

10.4 National and International Experiences in Biodiversity Programs

10.4.1 BIOTA/FAPESP: The Biodiversity Virtual Institute

The Research Programme on Characterization, Conservation and Sustainable Use of the Biodiversity of the State of São Paulo, called **BIOTA/FAPESP, the Virtual Institute of Biodiversity** (http://www.biota.org.br), is the result of the articulation of the scientific community in compliance with the **Convention on Biological Diversity.** The major aim of BIOTA-FAPESP is to inventory and characterize the biodiversity of the State of São Paulo, by defining the mechanisms for its conservation and sustainable use.

The BIOTA/FAPESP Program is structured in:

a) A **Coordination**, which under the leadership of the Coordinator, ensure the functioning of al components of the Program (SinBiota, Atlas, BIOprospecTA and the electronic peer reviewed journal Biota Neotropica), evaluate new research proposals, organize annual meetings of Project leaders as well as Evaluation Meetings, with the participation of the Scientific Advisory Committee;

b) A **Scientific Advisory Committee**, which comprises leading scientists from around the globe that every two years meet with the Coordination, plus Project Leaders and Research Teams, to evaluate de development of the Program.

All major public universities (USP, UNICAMP, UNESP, UFSCar, UNIFESP), some private universities (such as PUC, UNAERP and UNISANTOS), research Institutes (such as the Instituto de Botânica, Instituto Florestal, Instituto Geológico, INPE), EMBRAPA Centers, and NGOs (such as Instituto Socioambiental, Fundação SOS Mata Atlântica, Conservation International and Reference Center on Environmental Information/CRIA) are taking part of the Program. When considering researchers linked to these institutions within the State of São Paulo, there are approximately 400 with at least a PhD, plus 500 hundred graduate students involved in the Program. In addition there are 80 collaborators from other Brazilian states and approximately 50 from abroad.

In six years, with an annual budget of approximately US$ 2.000.000,00 the Biota/FAPESP Program supported 75 major research projects - which trained successfully 150 MSc and 90 PhD students, produced and stored information for about approximately 10,000 species and managed to link and make available data from 35 major biological collections. This effort is summarized in 464 articles published, in 161 scientific journals from which 89 are indexed by the Institute for Scientific Information (ISI) data base. Among the indexed periodicals, Nature and Science have the highest impact factor, and the median value among all indexed periodicals that authors of the Biota program have published was equal to 1.191. Furthermore, the program published, so far, 16 books and 2 Atlas.

In 2001, the program launched an open-access electronic peer-reviewed journal, Biota Neotropica (http://www.biotaneotropica.org.br), for original research on biodiversity in the Neotropical region. In five years the journal became an international reference for in its area and it's already indexed by the Zoological Record, CAB International, Directory of Open Access Journals and the Scientific Electronic Library Online/SciELO.

Last, but not least, in 2002 the program began a new venture called BIO*prospec*TA (http://www.bioprospecta.org.br), in order to search for new compounds of economic interest, which has already submitted 3 new drugs to patent.

As said by the international Scientific Advisory Board that evaluates the Biota/FAPESP Program "science in most BIOTA projects is of high quality equivalent or exceeding to that in other countries and in several projects it is of outstanding quality at the cutting edge of international efforts. In many respects the BIOTA program provides an example and sets standards that many countries would be happy to follow".

10.5 International Assessments: IPCC and MEA

10.5.1 Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC) – http://www.ipcc.ch - has been established by WMO and UNEP in 1988 to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. The IPCC does not carry out research nor does it monitor climate related data or other relevant parameters. It bases its assessment mainly on peer reviewed and published scientific/technical literature. IPCC has published three series of assessment reports (1990, 1995, 2001) and has recently published its latest and Fourth Assessment report (2007). The assessments are divided in three Working Groups, respectively: the scientific basis (http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf); impacts, adaptation, and vulnerability (http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf) and mitigation (http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-spm.pdf). These reports have world wide been considered as authoritative and have a strong influence on international and national climate policies. IPCC expects to prepare a Fifth Assessment Report around 2013 (a decision is to be made in 2008).

Apart from these periodic general assessment reports, IPCC has published emission scenarios that function as benchmarks for many policy makers, policy analysts, and many scientists world-wide. Emission scenarios (containing emissions of greenhouse gases and its precursors, and aerosols) are used in models that simulate the global climate (notably Global Circulation Models, GCMs). IPCC published emission scenarios in 1990, 1994, and in 2000 (the SRES scenarios). The latter are based on four families of ‘story lines’ depicting different global socio-economic pathways up to 2100, and are extensively used throughout the scientific community to date. IPCC also published an assessment on Land Cover, Land Cover Change and Forestry, in 2000, in addition to methodological volumes on GHG accounting and best agricultural management practices.

A small number of Brazilian scientists have taken part on the assessments and this number is growing. If the FAPESP RPGCC Programme starts soon, it is desirable that its first results influence the Fifth Assessment, which will likely review research results up to 2012.

10.5.2 Millennium Ecosystem Assessment

The Millennium Ecosystem Assessment (MA) – http://www.millenniumassessment.org - is an international work programme designed to meet the needs of decision makers and the public for scientific information concerning the consequences of ecosystem change for human well-being and options for responding to those changes. The MA was launched by U.N. Secretary-General Kofi Annan in June 2001 and was completed in March 2005. It will help to meet assessment needs of the Convention on Biological Diversity, Convention to Combat Desertification, the Ramsar Convention on Wetlands, and the Convention on Migratory Species, as well as needs of other users in the private sector and civil society. If the MA proves to be useful to its stakeholders, it is anticipated that such integrated assessments will be repeated every 5– 10 years and that ecosystem assessments will be regularly conducted at national or sub-national scales.

The MA focuses on ecosystem services (the benefits people obtain from ecosystems), how changes in ecosystem services have affected human wellbeing, how ecosystem changes may affect people in future decades, and response options that might be adopted at local, national, or global scales to improve ecosystem management and thereby contribute to human well-being and poverty alleviation. The specific issues being addressed by the assessment have been defined through consultation with the MA users.

The MA synthesizes information from the scientific literature, datasets, and scientific models, and includes knowledge held by the private sector, practitioners, local communities and indigenous peoples. All of the MA findings undergo rigorous peer review. More than 1,300 authors from 95 countries have been involved in four expert working groups preparing the global assessment, and hundreds more continue to undertake more than 20 sub-global assessments. The findings are contained in the fifteen reports listed in the box above.

The MA is an instrument to identify priorities for action. It provides tools for planning and management and foresight concerning the consequences of decisions affecting ecosystems. It helps identify response options to achieve human development and sustainability goals, and has helped build individual and institutional capacity to undertake integrated ecosystem assessments and to act on their findings.

Assessment process

The MA was governed by a Board comprised of representatives of international conventions, UN agencies, scientific organizations and leaders from the private sector, civil society, and indigenous organizations. A 15-member Assessment Panel and a Review board composed of leading social and natural scientists oversaw the technical work of the assessment supported by a secretariat with offices in Europe, North America, Asia, and Africa and coordinated by the United Nations Environment Programme.

The MA was conducted a "multiscale" assessment, consisting of interlinked assessments undertaken at local, watershed, national, regional and global scales. The MA sub-global assessments were designed to meet needs of decision-makers at the scale at which they are undertaken, strengthen the global findings with on-the-ground reality, and strengthen the local findings with global perspectives, data, and models. There are 18 MA-approved sub-global assessments, and an additional fifteen with an associated status.

10.6 National and International Experiences on Energy and Climate Change

Significant efforts are been made by research centres, universities and enterprises abroad on energy-climate change R&D related issues. Research about energy has been intensified among OCDE countries motivated by environment-climate change issues together with high prices of petroleum.

The oil companies are devoting a significant effort to extend the oil age as it approaches its half-life. More costly oil extraction and refining will tend to force prices up. Several oil companies are becoming "energy companies" diversifying their activities to include renewable energies in their portfolio. This is the case of SHELL and BP for example. The amount of money devoted to non-oil activities are increasing particularly in wind, solar energy and biomass. Petrobras has also plans to become an "energy company" in the future. It has acquired experience with the Brazilian ethanol programme for over 20 years and it is investing in the development of biodiesel-production technology.

On fossil resources a special attention is being concentrated on coal technology. It is expected that coal will substitute oil as the predominant energy source. Part of the energy on the coal will be utilized to generate a cleaner output. Natural gas and nuclear energy are also been more utilized in the EU and the USA. Methane hydrate is also an important research topic by the DOE (http://www.energy.gov/energysources/index.htm).

The electricity companies are also throughout the world investing more on energy conservation and better use of natural resources. As energy becomes more expensive and the politically more important the use of renewable energies natural gas use was intensified together with biomass such as wood chips, chicken manure and biogas, and co-firing technology. Cogeneration technology using biomass residues as the energy source has progressed incredibly in the EU, Japan and the USA. Another important area is recycling and waste disposal for energy generation and environmental reasons.

The USA energy policy is also devoting a great importance to hydrogen (http://www.energy.gov/energysources/hydrogen.htm). However, although many experiences are in progress on hydrogen throughout the world, the automobile industry is also introducing the hybrid technology. In addition it is being emphasized by the Bush administration that more efforts should be considered in the use of higher percentages of ethanol blended in gasoline. The driving force in the USA is not only concern for global warming and high energy prices but national security. Leading research centres in the US are NREL and ORNL both coordinated by the DOE.

In Japan the main research centre that is more involved in energy issues is NEDO (New Energy and Industrial Technology Development Organization). More about NEDO at: http://www.nedo.go.jp/english/. They have very well oriented R&D on energy production and use technology.

In the case of the EU there has been active research on wind energy in countries like Germany, Denmark and Spain; biodiesel in Germany and France; and solar energy in the Mediterranean countries. It is expected that in the EU by 2010 5.75% of all automotive fuel consumed will be renewable, either biodiesel or ethanol.

Many European countries have adopted national programs addressing climate changes. The energy sector, the largest contributors to GHG emissions, is a focus of policies. The programs included: a) Energy and CO_2 taxes (e.g. Denmark, Finland, Italy) have introduced or increased taxes on energy use and/or CO_2 emissions; b) Promotion of renewable energy: wind power (e.g. Germany, Denmark), and solar photovoltaic electricity (Germany and Spain), c) Promotion of biomass for electricity (e.g. Finland, Sweden, Austria), d) Promotion of combined heat and power – CHP (Denmark, The Netherlands, Finland) (EEA, 2002).

10.7 International Research on the Human Dimensions of Global Environmental Change

Three related initiatives have been fundamental in establishing the scientific agenda, promoting exchange and publishing and disseminating results of human dimensions research. The Open Meeting of the Human Dimensions of Global Environmental Change Research Community, as a venue for these activities was first organized at Duke University in the United States, in 1995, followed by meetings in Austria (1997), Japan (1999), Brazil (2001), Canada (2003) and Germany (2005). While the Human Dimensions Programme of the International Social Science Council (launched in 1990) and, since 1996, the International Human Dimensions Programme on Global Environmental Change, with support of several countries, have been active in the preparation of the Open Meetings, each has been independently organized, with the election of a Steering Committee at each meeting. This loose association of researchers, centres, national and international agencies permitted the identification of a research community, whose identity has consolidated over time. The second, more structured initiative was the creation of the IHDP itself in 1996. Since the completion of its core project on Land Use and Land Cover Change (co-sponsored with IGBP) in October 2005, the IHDP has six Core Science Projects:

- Global Environmental Change and Human Security (GECHS)
- Institutional Dimensions of Global Environmental Change (IDGEC)
- Industrial Transformation (IT)
- Urbanization and Global Environmental Change (UGEC)
- Land-Ocean Interactions in the Coastal Zone (LOICZ) (co-sponsored with IGBP)
- Global Land Project (co-sponsored with IGBP and successor of LUCC and the IGBP core project on Global Change and Terrestrial Ecosystems)

The Vienna Open Meeting was the moment when competing topics were sorted out, and LUCC and the first three of the above projects were selected.[8] Researchers who participated in these projects first produced a Scoping Report for the IHDP Scientific Committee; when approved, this was followed by a Science Plan, a Scientific Steering Committee, the preparation of an Implementation Strategy, and collaborative research. Successive Open Meetings, meanwhile, widened the range of topics, some of which evolved as core projects.

The third related initiative was the participation of the national academies of science. In many countries, the academies established national committees and created formal lines of

[8] Among the projects **not** selected was GOES – the Global Omnibus Environmental Survey, a project which would have conducted periodic international surveys to monitor public opinion on global change. Led by the Survey Research Center of the University of Michigan, GOES was the first project to mobilize the Brazilian Social Science community. In the year preceding the Vienna meeting, researchers from Unicamp, USP, UFMG, UnB and ISER met several times, in Brazil and at the University of Michigan, to prepare this project. While the IHDP did not select it as a core project, GOES was carried out in the late 1990s. Without international funding, it proved impossible to carry out a national survey in Brazil, although pre-testing was done in Campinas, Belo Horizonte, São Paulo and several other sites. The results are published in Peter Ester, Henk Vinken, Solange Simões, Midori Aoyagi-Usui (eds.), Culture and sustainability: a cross-national study of cultural diversity and environmental priorities among mass public and decision makers, Dutch University Press, 2003. It includes chapters by S. Simões, E. Viola and D. Hogan on partial Brazilian surveys.

research support. Most of the significant work on human dimensions has been the fruit of these activities.[9] Sixteen countries have created National Committees on Human Dimensions and another 16 have created Global Change Committees which integrate human dimensions into the larger research community.

11 PROGRAMME MANAGEMENT, COMMUNICATION AND REVIEW

The operation of the FAPESP Research Programme on Global Climate Change will be organized using:

a) An Executive Committee responsible for the Programme design, coordination and follow up. This Executive Committee will be composed of scientists, leading research projects belonging to the Programme.

> a.1) Besides an Executive Coordinator responsible for implementation of the Executive Committee guidelines, the Executive Committee must have a coordinator for Knowledge Diffusion and Public Policy and another one for Intellectual Property and Cooperation.

b) An International Advisory Board to supervise programme design, implementation and follow up, and assist in the establishment of international partnerships.

c) The programme structure will be appointed by and will work under the general supervision of the Scientific Director of FAPESP

The Executive Committee is the focal decision making unit responsible for coordinating programme operations and development. In addition, this Committee will promote, through symposiums and workshops, integration among research groups working in several aspects of climate change. Graduate students participating in the programme projects and members of the International Advisory Board are expected to be intensely involved in integration initiatives as symposia and workshops.

An Assessment Meeting, organized by the Executive Committee, is expected to occur every other year, in which external reviewers will assess the Programme performance, based on Annual Report information, meetings with project coordinators and visits to institutions and research groups participating in the FAPESP Programme for Research on Global Climate Change.

[9] Google provides a measure of the success of these activities: a search for *climate change* produced approximately 212,000,000 results, while a similar search for *human dimensions of climate change* produced approximately 11,200,000 results, nearly 20% of the total.

The Executive Committee will propose a number of international programmes or groups to network with FAPESP Programme for Research on Global Climate Change. Each two years after an appraisal of on going cooperation, the number of institutions will be expanded based on achieved results. Research quality, international recognition and geographical distribution are the proposed criteria to select international programmes or groups to network with FAPESP Programme for Research on Global Climate Change.

As far as the management structure of the Programme is concerned, it must engage the coordinated efforts of research and operational agencies (for instance, those which would be responsible for either mitigation or adaptation) within São Paulo, involving FAPESP, the research institutions, Universities, the "Forum Paulista de Mudanças Climáticas e Biodiversidade", State-level agencies (e.g., Instituto Florestal, Instituto Biológico, Instituto Agronômico, Instituto de Pesquisas Tecnológicas, etc.), and the private technological sector.

Duration and funds

The programme will have an initial duration of 10 years, with biennial assessments by an External Advisory Board and a mid-term external review after 5 years.

Funding will start at the range of R$ 10/12 million per year. The Programme will look for and obtain complementary support from state, federal and international agencies. Scientific collaboration with researchers from other states in Brazil is considered an essential feature.

As for additional funding sources, the Programme can be relevant to the international global environmental conventions (Climate Change, Biological Diversity and Desertification) and seek funding via the Global Environmental Facility as part of overarching national or multi-national projects.

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Adaptation

Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects.

Climate

The statistical description of the mean and variability of relevant measures of the atmosphere-ocean system over periods of time ranging from weeks to thousands or millions of years.

Climate Change

A statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or to external forcing, including changes in solar radiation and volcanic eruptions, or persistent human induced changes in atmospheric composition or in land use.

Climate Feedback

An interaction among processes in the climate system in which a change in one process triggers a secondary process that influences the first one. A positive feedback intensifies the change in the original process, and a negative feedback reduces it.

Climate System

The highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the land surface, the biosphere, and the interactions between them. The climate system evolves in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations, and human-induced forcings such as the changing composition of the atmosphere and land-use change.

Climate Variability

Variations in the mean state and other statistics of climatic features on temporal and spatial scales beyond those of individual weather events. These often are due to internal processes within the climate system. Examples of cyclical forms of climate variability include the El Niño Southern Oscillation, the North Atlantic Oscillation, and the Pacific Decadal Oscillation.

Decision-Support Resources

The set of observations, analyses, interdisciplinary research products, communication mechanisms, and operational services that provide timely and useful information to address questions confronting policymakers, resource managers, and other users.

Global Change

Changes in the global environment (including alterations in climate, land productivity, oceans or other water resources, atmospheric chemistry, and ecological systems) that may alter the capacity of the Earth to sustain life (from the Global Change Research Act of 1990, PL 101-606).

Mitigation

An intervention to reduce the human-induced factors that contribute to climate change. This could include approaches devised to reduce emissions of greenhouse gases to the atmosphere; to enhance their removal from the atmosphere through storage in geological formations, soils, biomass, or the ocean; or to alter incoming solar radiation through several "geo-engineering" options.

Observations

Standardized measurements (either continuing or episodic) of variables in climate and related systems.

Prediction

A probabilistic description or forecast of a future climate outcome based on observations of past and current climatological conditions and quantitative models of climate processes (e.g., a prediction of an El Niño event).

Projection

A description of the response of the climate system to an assumed level of future radiative forcing. Changes in radiative forcing may be due to either natural sources (e.g., volcanic emissions) or human-induced factors (e.g., emissions of greenhouse gases and aerosols, or changes in land use and land cover). Climate "projections" are distinguished from climate "predictions" in order to emphasize that climate projections depend on scenarios of future socioeconomic, technological, and policy developments that may or may not be realized.

Weather

The specific condition of the atmosphere at a particular place and time, measured in terms of variables such as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation.

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ANNEX I - Main conclusions of the Workshop held at FAPESP, 25 November 2005 about the establishment of a FAPESP Program on Global Climate Change.

The following are some of the conclusions reached at the end of the workshop:

- FAPESP should start a Research Program on Global Climate Change (RPGCC Program). This program is expected to have a minimum duration of 5 years and a maximum duration of 10 years in its first phase.

In the design of the Program, FAPESP should draw upon its program management experience with BIOTA, GENOMA Programmes, among others

- Projects supported by the RPGCC Program must achieve synergy and multi-disciplinarity among several research areas and induce synergy with other climate change programs, both at national and international levels. RPGCC must also prioritize synergies with most of FAPESP programs and other aspects of global climate change, such as biodiversity and desertification.

- RPGCC should give support to research activities provided it is within the institutional mission of FAPESP.

- The expected outcomes of RPGCC should be applied to related research fields in the public and private sectors, for national public policies and in the preparation of international negotiation strategies (in the context of UNFCCC, CBD and others). In addition, it would be desirable that the Program could generate easily assimilated knowledge for classrooms at universities and high schools as outreach activities of CLIMA.

- RPGCC shall have a permanent communication channel with society, either by means of technical publications (as for instance FAPESP Magazine), general publications, Internet, periodic workshops, among others. The training of journalists could help in the dissemination of Program's outcomes. Other way to transfer knowledge could be through *Fórum Paulista de Mudanças Climáticas e Biodiversidade.*

- Program funding could be expanded to establish partnerships with private sector and with other financing institutions, for instance World Bank, and federal agencies such as MCT, CNPq and FINEP.

- Program evaluation would be carried out by an International Steering Committee which would include among its members leading scientists in the field of global environmental change and recognized researchers of neighbouring countries

  - RPGCC must create a consolidated climatology database.

ANNEX II – Resumo do Grupo I – Base Científica do Workshop FAPESP realizado em 24/11/2005

Introdução

Os temas ligados à base científica sobre o sistema climático e sobre o entendimento do ciclo de carbono, fontes e sumidouros de gases de efeito estufa (GEE), são aqueles que têm recebido mais atenção da comunidade científica do Estado de São Paulo, principalmente nos últimos 10 anos. Este interesse tão somente reflete a aderência desta comunidade ao tema mudanças ambientais globais, assunto de acentuada relevância científica atual. Muitos cientistas consideram este tema como um dos maiores desafios a serem enfrentados globalmente pela sociedade de todas as nações. Parte considerável do esforço científico de instituições paulistas enfocou a Amazônia, haja vista a urgência de entender os impactos locais, regionais e globais dos altos índices de alterações dos usos da terra naquela importante região tropical. Tais esforços culminaram com a bem sucedida realização do Experimento de Grande Escala da Biosfera-Atmosfera na Amazônia (LBA), que teve expressiva liderança científica de pesquisadores paulistas. Mais recentemente, um novo esforço nacional, o Projeto GEOMA (Modelagem Ambiental das Amazônia), no âmbito do MCT, enfoca o entendimento da dinâmica de alteração dos usos da terra e, semelhantemente, conta com decisiva participação de instituições do Estado de São Paulo.

O Anexo I procura listar de forma não exaustiva temas de pesquisa, agências de financiamento e instituições participantes, em assuntos ligados às mudanças ambientais globais, com ênfase na visão sistêmica de entender o Sistema Terrestre, com seus ciclos biogeoquímicos (destacando o ciclo de carbono) e biogeofísicos e suas interações. Várias pesquisas tratam do entendimento do clima, suas variações e mudanças em escalas temporais que se estendem do clima do Quaternário até os possíveis climas do futuro. As várias facetas do ciclo de carbono, principalmente na Amazônia, receberam igualmente considerável atenção. Muitas outros estudos concentram-se na física e nos ciclos biogeoquímicos do Oceano Atlântico Sul. Finalmente, observações e a química do ozônio troposférico e estratosférico e de espécies químicas precursoras de sua formação foram objeto de pesquisas por mais de duas décadas.

Grande parte destas pesquisas foi financiada pela FAPESP. CNPq e MCT igualmente financiam vários dos estudos e uma parte menor recebeu financiamentos internacionais. No conjunto destas pesquisas, estão envolvidos cerca de 50 doutores e aproximadamente o mesmo número de alunos de pós-graduação, constituindo massa crítica importante, e de liderança nacional.

Pesquisas Futuras Necessárias: Sugestão de Projetos Temáticos

- Projeto Temático 1.
  Detecção e atribuição de sinais de variabilidade e mudanças globais na América do Sul e Antártica

- Projeto Temático 2
  Ciclos biogeoquímicos, com ênfase no carbono, nos ecossistemas terrestres, de água doce e marinhos: novas metodologias de observação e estudo de processos.

- Projeto Temático 3
  Estudos interdisciplinares de paleoclimas e paleoambientes do Quaternário Superior e Holoceno no Brasil: lições para o futuro.

- Projeto Temático 4
  Atividade solar, radiação solar e interações com o clima terrestre.

- Projeto Temático 5
  Estudos de química atmosférica: ozônio, aerossóis e GEE.

- Projeto Temático 6
  Desenvolvimento de um Protótipo Brasileiro de Modelo Integrado do Sistema Terrestre: desenvolvimento de uma rede de pesquisa brasileira para propor e desenvolver os protocolos e ferramentas de integração de componentes de um modelo integrado do Sistema Terrestre.

- Projeto Temático 7
  Modelagem, validação e acoplamento de componentes atmosférico, oceânico e de vegetação do Sistema Terrestre e suas interfaces, com ênfase em lacunas de pesquisa no Brasil, como a modelagem da criosfera e de ciclos biogeoquímicos.

- Projeto Temático 8
  Cenários de mudanças climáticas para o Estado de São Paulo até 2200, incluindo projeções de extremos climáticos e estudos sobre mudanças abruptas do sistema climático e dos ecossistemas sob estresses múltiplos.

- Projeto Temático 9
  Desenvolvimento de Cenários sócio-econômicos futuros levando em conta cenários de mudanças climáticas, vulnerabilidades e impactos em setores sociais, econômicos e nos ecossistemas naturais e modificados pelas atividades humanas.

- Projeto Temático 10
  A importância do Oceano Atlântico Sul e as mudanças climáticas: sistemas de observação da circulação termohalina em escala de bacia

Considerações sobre o Programa

Este programa deve ter duração não inferior a 10 anos. A escala financeira das pesquisas futuras para expandir a Base Científica, ilustradas através da lista tentativa de Projetos Temáticos acima, deve ser de R$ 10 a 12 milhões/ano. Além da FAPESP, podem-se mencionar como possíveis fontes financiadoras destes projetos órgãos federais como o MCT, CNPq e FINEP, e, principalmente, sugere-se explorar a oportunidade de alocação de vultosos recursos no Global Environment Facility, do Banco Mundial, em projetos voltados para mitigação e adaptação no âmbito da Convenção-Quadro das Nações Unidas sobre as Mudanças Climáticas, e também no âmbito das Convenções sobre Diversidade Biológica e Combate à Desertificação. Ainda com respeito a necessidades infra-estruturais, deve-se mencionar que muitos estudos observacionais sobre mudanças no clima e no ambiente brasileiros ressentem-se da falta de um banco de dados climatológicos consolidado. É importante que não se perca de vista esta necessidade.

Em termos de articulação com as demais linhas temáticas e com outros programas da FAPESP, nacionais ou internacionais, entendemos que estes projetos temáticos, tomados no seu conjunto, devem contemplar:

- O fornecimento de cenários de climas futuros com discriminação científica de incertezas, vistos como fator essencial para o desenvolvimento das demais três linhas de pesquisa.

- O suporte às políticas públicas do país, principalmente quanto à Convenção sobre Mudanças Climáticas, mas também quanto às Convenções sobre Biodiversidade e Combate à Desertificação.

- A harmoniosa integração com os temas de biodiversidade tanto junto às demais linhas de pesquisa apoiadas pelo Programa, mas também com outros programas de biodiversidade (e.g., Biota FAPESP) e vinculação com as três convenções internacionais.

- Uma estreita articulação com o Fórum Paulista de Mudanças Climáticas e Biodiversidade, com o objetivo de dar suporte aos programas que definem políticas públicas das Secretarias de C&T, Agricultura, de Meio Ambiente e de Recursos Hídricos, do Estado de São Paulo.

- A disseminação dos cenários climáticos futuros aos tomadores de decisão nos setores públicos e privados.

Ainda que a base científica terá como produto final principal a geração de novos e relevantes conhecimentos científicos, não diretamente relacionados ao desenvolvimento de novas tecnologias para redução de emissões de GEE, enfatiza-se que este programa da FAPESP deve servir de estímulo adicional ao desenvolvimento tecnológico nacional de sistemas avançados de observação da superfície, da atmosfera e dos oceanos *in situ* e a partir de sensores orbitais. Neste tocante, há margem inclusive de apoiar políticas ativas de políticas industriais nas áreas de tecnologia espacial, entre outras.

Finalmente, menciona-se sucintamente algumas sugestões sobre mecanismos de avaliação.

- Implementação de Coordenação do Programa (e.g., Biota FAPESP)

- Workshops periódicos
- Avaliação externa por comitê de avaliação internacional bianual (ou trianual) do Programa
- Manutenção dos mecanismos de avaliação de projetos Temáticos
- Workshops com tomadores de decisão dos setores públicos, privados, ONGs, sociedade civil organizadas

Tabela não exaustiva de pesquisas em andamento sobre mudanças globais em Instituições no Estado de São Paulo (título ou linha de pesquisa / agência(s) de financiamento / instituição(ões) participante(s) /

TÍTULO OU LINHA DE PESQUISA	**AGÊNCIA(S) FINANCIAMENTO**	**INSTITUIÇÕES PARTICIPANTES**
Mudanças Climáticas do Atlântico do Sul	IAI, FAPESP, CNPq	IO/USP, INPE, FURG, UFRJ, UFF, UBA, U Concepcion, U Republica, OSU, U Miami
Mudanças dos usos da terra e ciclos biogeoquímicos em sistemas aquáticos	FAPESP, CNPq, NASA, NSF	CENA/USP, ESALQ/USP, MBL, U Washington, U Utah, UFMT, UNITINS, UNIR, UFAC, MPEG, UFPA, INPA, INPE
Seqüestro de carbono por sistema de cultivo	CNPq	IAC e I Botânica
Mudanças paleoclimáticas no Brasil no Quarternário Tardio	FAPESP, CNPq, AEIA	CENA/USP, ESALQ/USP, IG/USP, U Waterloo, U Toronto, IRD UFSergipe, UNICAMP
Antártica e clima	FAPESP, CNQp	IO/USP, NCAR, UCLA
O papel da circulação de revolvimento meridional nas trocas entre sub-trópicos e equador	FAPESP	IO/USP, U Reading
Papel do Atlântico Sul no clima nos últimos 20 mil anos	FAPESP	IO/USP
Futuras mudanças dos sistemas de monções da América do Sul e nos padrões de teleconexões do HS	CNPq, IPCC	INPE
Modelagem acoplada o-a global e variabilidade e mudanças climáticas sobre a América do Sul	FAPESP, CNPq	INPE
Variabilidade climática na América do Sul	IAI	INPE, USP, UFPR, UBA, U Republica, U Nacional Assuncion
Regionalização dos cenários climáticos futuros na América do Sul	PROBIO/MMA, Governo Britânico	INE, USP, FBDS, Hadley Centre
Relações de carbono e água dos ecossistemas com a atmosfera	FAPESP, CNPq, NASA	IAG/USP, ESALQ/USP, CENA, I Botânica, UNICAMP, EMBRAPA Meio Ambiente, DAEE, U Califórnia, U Arizona
Influência da atividade solar no clima	FAPESP	INPE
Variabilidade e transporte de umidade da Amazônia para a bacia do Prata	FAPESP, IPCC	INPE, IAG/USP, UBA
Pontos anfidromicos e variações sazonais do Atlântico Sul (PAVASAS)	CNPq, FAPESP	IO/USP, EPUSP, UNICAMP, U Liverpool
Medição do nível absoluto do mar no Estado de São Paulo nas bases de Ubatuba e Cananéia	FAPESP	IO/USP, UNESCO, COI, DHN, CIRM, GLOSS

Modelagem de mudanças de vegetação e impactos no clima	FAPESP	INPE
Emissões de GEE em áreas alagáveis	FAPESP, Furnas, CT/Energ	INPE, CENA/USP, COPPE/UFRJ, IEE/USP
Mudanças do uso do solo e implicações climáticas na Amazônia (I Milênio LBA2)	MCT	USP, INPE, INPA, etc.
Interação Biosfera-atmosfera na Amazônia	FAPESP, NASA	USP, INPE, etc.
Cenários Amazônico, impactos das mudanças climáticas nos biomas da América do Sul	Moore Foundation	INPE, CTA
Biodiversidade e evolução geológica da Amazônia	FAPESP	INPE
Equars, monitoramento da atmosfera (GPS) perfis de temperatura e umidade	CNPq	INPE
Monitoramento e dinâmica dos usos da terra na Amazônia	FAPESP	INPE, CRIA, etc.
Medidas de pCO2 no Atlântico Sul	CNPq, MMA	IO/USP
Deposição de Nitrogênio	Nitrogen Institute, FAPESP	INPE, CRIA, etc.
Cenários de aumento do nível do mar no litoral brasileiro	CNPq, MMA	IO/USP
Ciclos biogeoquímicos na Mata Atlântica	FAPESP	UNICAMP, USP
Monitoramento da cobertura vegetal do Brasil	MCT, MMA, FAPESP	INPE
Detecção de mudanças climáticas no Brasil	MCT	INPE
Registros paleoclimáticos do Quaternário e Holoceno associados a sistemas cársticos no Brasil	FAPESP, CNPq	IG/USP, IAG/USP, U Massachussetts, U New México, Berkeley Geochronology Center (BGC)

Pesquisas Futuras Necessárias Destacadas pelo Grupo de Trabalho

Observações, Detecção e Atribuição (apoio principal pelo Programa FAPESP. Cooperação internacional)

- Detecção e atribuição de sinais de variabilidade e mudanças globais (com ênfase nas mudanças climáticas) no América do Sul e Antártica (aquecimento global verso mudança nos usos da terra); requer a infra-estrutura de consolidação de banco de dados climatológicos.
- Sistemas de observação oceânica em escala de bacia
- Ciclo de carbono: novas metodologias para cálculo de fontes e sumidouros, incluindo observações satelitárias
- Paleoclimas do Quaternário no Brasil, incentivar a criação de redes
- Estudos de Processos (apoio principal pelo Programa FAPESP e possível apoio do projeto ao GEF, cooperação internacional)
- Papel da biologia no ciclo oceânico de carbono na plataforma do Atlântico Ocidental
- Incerteza do papel dos aerossóis no ciclo hidrológico
- Interação da radiação solar com o sistema terrestre
- Ciclos biogeoquímicos no oceano e nos ecossistemas terrestres
- Atividade solar e o clima terrestre
- Funcionalidade dos ecossistemas e agro-ecossistemas em resposta à variabilidade e mudanças climáticas
- Melhoria no entendimento dos processos de acoplamento da biosfera-atmosfera
- Estudos do efeitos de deposição de aerossóis nos ecossistemas terrestre e marinhos.
- Interação estratosfera-troposfera
- Influência da química da atmosfera no tempo de residência de GEE
- Estudos de química e dinâmica de ozônio troposférico e estratosférico.
- Modelagem do Sistema Terrestre (apoio do Programa FAPESP e órgãos federais (MCT, FINEP, MMA), cooperação internacional)
- Modelo Integrado do Sistema Terrestre: desenvolvimento de uma rede de pesquisa brasileira
- Validação de sub-modelos componentes do Sistema Terrestre
- Modelagem da criosfera
- Acoplamento dos vários componentes do sistema terrestre
- Mudanças abruptas do sistema climático e de ecossistemas sob estresses múltiplos
- Cenários Futuros Climáticos e Sócio-Econômicos (apoio do Programa FAPESP, MCT, FINEP, possível projeto ao GEF)
- Cenários de mudanças climáticas para o Estado de São Paulo até 2200
- Simulação e projeção de extremos climáticos no futuro
- Cenários sócio-econômicos futuros

ANNEX III – Apêndice da Contribuição de Autoria de Carlos Clemente Cerri e Carlos Eduardo P. Cerri

1998/11456-3
INFLUENCIA DE FATORES NUTRICIONAIS, CLIMATICOS E FENOLOGICOS NA SINTESE DE TANINOS EM LEGUMINOSAS FORRAGEIRAS.
OSCAR FONTAO DE LIMA FILHO
Início: 1/1/1999; Término: 11/30/2000
Área do conhecimento: AGRONOMIA E VETERINARIA
CENTRO ENERGIA NUCLEAR AGRICULTURA/USP, UNIVERSIDADE DE SAO PAULO
$60.270,00

1992/02281-9
O DESENVOLVIMENTO DE TECNICAS ANALITICAS NUCLEARES APLICADAS AO ESTUDO DE QUEIMADAS DA FLORESTA AMAZONICA.
FABIO GERAB
PAULO EDUARDO ARTAXO NETTO
Início: 9/1/1992; Término: 3/20/1996
Área do conhecimento: FISICA
INST FISICA/USP, UNIVERSIDADE DE SAO PAULO
$28.997,01

1996/12624-1
CLIMATE IMPACTS OF FRIAGENS IN FORESTED AND DEDORESTED AREAS OF AMAZONIA.
JOSE ANTONIO MARENGO ORSINI
Início: 4/7/1997; Término: 4/11/1997
Área do conhecimento: GEOCIENCIAS
INST NACIONAL PESQUISAS ESPACIAIS/MCT, MINISTERIO DA CIENCIA E TECNOLOGIA
$ 0,00

1996/06765-1
RECUPERACAO DE PASTAGENS DEGRADADAS ATRAVES DA UTILIZACAO DE MANEJO DA FERTILIDADE DO SOLO E DA FISIOLOGIA DAS PLANTAS.
ANDRE LUIS STRAPASSON
MOACYR CORSI
Início: 1/1/1997; Término: 12/31/1997
Área do conhecimento: AGRONOMIA E VETERINARIA
ESC SUPERIOR AGRICULTURA LUIZ DE QUEIROZ/USP, UNIVERSIDADE DE SAO PAULO
$ 0,00

2005/50970-0

DINAMICA DE CARBONO NO AGROSSISTEMA CANA-DE-ACUCAR: MODELAGEM MATEMATICA E IMPLICACOES AMBIENTAIS.
CARLOS CLEMENTE CERRI
Início: 7/1/2005; Término: 6/30/2007
Área do conhecimento: BIOLOGIA
CENTRO ENERGIA NUCLEAR AGRICULTURA/USP, UNIVERSIDADE DE SAO PAULO
$ 0,00
2004/11617-0
SIMULACAO REGIONAL DA VARIABILIDADE CLIMATICA INTERANUAL NO NORDESTE BRASILEIRO.
JONATHAN MOTA DA SILVA
ADILSON WAGNER GANDU
Início: 5/1/2005; Término: 4/30/2007
Área do conhecimento: GEOCIENCIAS
INST ASTRONOMIA GEOFISICA CIENCIAS ATMOSFERICAS/USP, UNIVERSIDADE DE SAO PAULO
$26.400,00

2004/01230-0
CONVERSAO DO CERRADO PARA FINS AGRICOLAS NA AMAZONIA E SEU IMPACTO NAS MUDANCAS CLIMATICAS.
CARLOS CLEMENTE CERRI
Início: 10/1/2004; Término: 9/30/2006
Área do conhecimento: AGRONOMIA E VETERINARIA
CENTRO ENERGIA NUCLEAR AGRICULTURA/USP, UNIVERSIDADE DE SAO PAULO
$52.500,00

2004/00415-7
MODELOS PARA A PREVISAO DE RESPOSTAS PRODUTIVAS E QUALITATIVAS DE PANICUM MAXIMUM JACQ. BASEADOS EM VARIAVEIS CLIMATICAS.
CARLOS GUILHERME SILVEIRA PEDREIRA
Início: 9/1/2004; Término: 2/28/2006
Área do conhecimento: AGRONOMIA E VETERINARIA
ESC SUPERIOR AGRICULTURA LUIZ DE QUEIROZ/USP, UNIVERSIDADE DE SAO PAULO
$114.437,50

2004/06698-0
DETERMINACAO DA EMISSAO DE CO2 DO SOLO APOS ESCARIFICACAO DE AREAS AGRICOLAS.
LUIS GUSTAVO TEIXEIRA
NEWTON LA SCALA JUNIOR
Início: 9/1/2004; Término: 8/31/2005
Área do conhecimento: AGRONOMIA E VETERINARIA
FAC CIENCIAS AGRARIAS VETERINARIAS JABOTICABAL/UNESP, UNIVERSIDADE ESTADUAL
PAULISTA JULIO DE MESQUITA FILHO

$3.960,00

2003/09973-0
EVENTOS EXTREMOS DE PRECIPITACAO NO SUL DO BRASIL ASSOCIADO AO JATO DE BAIXOS NIVEIS.
FABIANA VICTORIA WEYKAMP
TERCIO AMBRIZZI
Início: 3/1/2004; Término: 2/28/2006
Área do conhecimento: GEOCIENCIAS
INST ASTRONOMIA GEOFISICA CIENCIAS ATMOSFERICAS/USP, UNIVERSIDADE DE SAO PAULO
$26.400,00

2003/10006-4
ENTENDIMENTO E RISCOS DA FUNCIONALIDADE HIDRICA NOS ECOTONOS DA ILHA DO BANANAL.
RICARDO ACOSTA
HUMBERTO RIBEIRO DA ROCHA
Início: 3/1/2004; Término: 2/28/2006
Área do conhecimento: GEOCIENCIAS
INST ASTRONOMIA GEOFISICA CIENCIAS ATMOSFERICAS/USP, UNIVERSIDADE DE SAO PAULO
$26.400,00

2003/04582-2
DECOMPOSICAO DE RESIDUOS CULTURAIS E EMISSAO DE GASES DO EFEITO ESTUFA EM SISTEMAS DE MANEJO DO SOLO EM PONTA GROSSA(PR).
MARIANA ADDISON PAVEI
MARISA DE CASSIA PICCOLO
Início: 9/1/2003; Término: 8/31/2005
Área do conhecimento: AGRONOMIA E VETERINARIA
CENTRO ENERGIA NUCLEAR AGRICULTURA/USP, UNIVERSIDADE DE SAO PAULO
$26.400,00

2003/01727-0
CLASSIFICACAO E MONITORAMENTO DA COBERTURA VEGETAL E USO DA TERRA UTILIZANDO DADOS DO SENSOR MODIS.
YOSIO EDEMIR SHIMABUKURO
Início: 7/1/2003; Término: 6/30/2005
Área do conhecimento: AGRONOMIA E VETERINARIA
INST NACIONAL PESQUISAS ESPACIAIS/MCT, MINISTERIO DA CIENCIA E TECNOLOGIA
$31.375,00

2001/06395-0
O IMPACTO DAS MUDANCAS GLOBAIS NA PRODUTIVIDADE DA SOJA: COMPARACAO ENTRE OS

RESULTADOS EXPERIMENTAIS E SIMULADOS.
DURVAL DOURADO NETO
Início: 9/1/2001; Término: 2/28/2003
Área do conhecimento: AGRONOMIA E VETERINARIA
ESC SUPERIOR AGRICULTURA LUIZ DE QUEIROZ/USP, UNIVERSIDADE DE SAO PAULO
$5.019,00

1999/03353-2
MUDANCAS GLOBAIS E TAXA DE CRESCIMENTO DAS ESPECIES ARBOREAS DA AMAZONIA.
SIMONE APARECIDA VIEIRA
LUIZ ANTONIO MARTINELLI
Início: 11/1/1999; Término: 5/31/2003
Área do conhecimento: BIOLOGIA
CENTRO ENERGIA NUCLEAR AGRICULTURA/USP, UNIVERSIDADE DE SAO PAULO
$93.639,00

1998/13281-6
EFEITOS DA COLHEITA SEM QUEIMA DA CANA-DE-ACUCAR SOBRE A DINAMICA DO CARBONO E PROPRIEDADES DO SOLO.
EDGAR FERNANDO DE LUCA
CARLOS CLEMENTE CERRI
Início: 4/1/1999; Término: 2/28/2002
Área do conhecimento: AGRONOMIA E VETERINARIA
CENTRO ENERGIA NUCLEAR AGRICULTURA/USP, UNIVERSIDADE DE SAO PAULO
$75.220,50

1998/06639-1
EFEITOS HIDROLOGICOS E CLIMATICOS DE PLANTIOS FLORESTAIS EM AREAS DE CERRADO.
SILVIO DIAS PEREIRA NETO
ARTHUR MATTOS
Início: 10/1/1998; Término: 9/30/2002
Área do conhecimento: ENGENHARIA
ESC ENGENHARIA SAO CARLOS/USP, UNIVERSIDADE DE SAO PAULO
$100.739,54

2004/12610-9
CONVERSAO DO CERRADO PARA FINS AGRICOLAS NA AMAZONIA E SEU IMPACTO NAS MUDANCAS CLIMATICAS.
JOAO LUIS NUNES CARVALHO
CARLOS CLEMENTE CERRI
Início: 3/1/2005; Término: 2/28/2007
Área do conhecimento: AGRONOMIA E VETERINARIA
CENTRO ENERGIA NUCLEAR AGRICULTURA/USP, UNIVERSIDADE DE SAO PAULO
$ 0,00

2003/14147-1
A RELACAO ENTRE VARIABILIDADE E TENDENCIA CLIMATICA E A PRODUCAO DA SOJA NO ESTADO DE SAO PAULO.
ADRIANA ROSA BIERAS
MARIA JURACI ZANI DOS SANTOS
Início: 3/1/2004; Término: 2/28/2007
Área do conhecimento: GEOCIENCIAS
INST GEOCIENCIAS CIENCIAS EXATAS RIO CLARO/UNESP, UNIVERSIDADE ESTADUAL PAULISTA
JULIO DE MESQUITA FILHO
$ 0,00

2003/09237-1
A INFLUENCIA DAS SUBSTANCIAS HUMICAS NO SEQUESTRO DE CARBONO.
ORLANDO PAULINO DA SILVA
ENY MARIA VIEIRA
Início: 1/1/2004; Término: 12/31/2006
Área do conhecimento: ENGENHARIA
INST QUIMICA SAO CARLOS/USP, UNIVERSIDADE DE SAO PAULO
$ 0,00

003/04912-2
TAXA E EXTENSAO DA DIGESTAO DO MILHO E POLPA CITRICA ASSOCIADOS AO FARELO DE GIRASSOL E UREIA E SUA CONTRIBUICAO NA PRODUCAO DE GASES NO RUMEN DE BOVINOS.
NIVIA ARAUJO FONTES
JANE MARIA BERTOCCO EZEQUIEL
Início: 9/1/2003; Término: 8/31/2005
Área do conhecimento: AGRONOMIA E VETERINARIA
FAC CIENCIAS AGRARIAS VETERINARIAS JABOTICABAL/UNESP, UNIVERSIDADE ESTADUAL
PAULISTA JULIO DE MESQUITA FILHO
$ 0,00

2001/12518-7
BANCO DE DADOS PARA O ZONEAMENTO AGROCLIMATICO DO CAFE EM SAO PAULO.
LUDMILA ALEXANDRA DOS SANTOS SARRAIPA
MARCIO DE MORISSON VALERIANO
Início: 11/1/2001; Término: 10/31/2003
Área do conhecimento: GEOCIENCIAS
INST AGRONOMICO CAMPINAS/SAGRSP, SECR EST AGRICULTURA E ABASTECIMENTO DE SAO
PAULO
$ 0,00

2001/07579-7
FLUXO DE GASES DO EFEITO ESTUFA EM SISTEMAS DE RECUPERACAO DE PASTAGENS DEGRADADAS NA AMAZONIA.
CAIO CESAR PASSIANOTO
BRIGITTE JOSEFINE FEIGL
Início: 7/1/2001; Término: 6/30/2005
Área do conhecimento: AGRONOMIA E VETERINARIA
CENTRO ENERGIA NUCLEAR AGRICULTURA/USP, UNIVERSIDADE DE SAO PAULO
$ 0,00

2001/01062-2
ANALISE DA VARIABILIDADE DA TEMPERATURA NO ESTADO DE SAO PAULO NO PERIODO DE 1887 A 2000.
ANGELA CRISTINA SILVA
JOAO LIMA SANT ANNA NETO
Início: 4/1/2001; Término: 3/31/2002
Área do conhecimento: GEOCIENCIAS
FAC CIENCIAS TECNOLOGIA PRESIDENTE PRUDENTE/UNESP, UNIVERSIDADE ESTADUAL
PAULISTA JULIO DE MESQUITA FILHO
$ 0,00

2001/01170-0
ANALISE DA VARIABILIDADE DA CHUVA DO ESTADO DE SAO PAULO NO PERIODO DE 1887 A 2000.
ANDERSON ANTONIO DA SILVA
JOAO LIMA SANT ANNA NETO
Início: 3/1/2001; Término: 2/28/2002
Área do conhecimento: GEOCIENCIAS
FAC CIENCIAS TECNOLOGIA PRESIDENTE PRUDENTE/UNESP, UNIVERSIDADE ESTADUAL
PAULISTA JULIO DE MESQUITA FILHO
$ 0,00

1997/11275-6
EFEITO DE MUDANCAS GLOBAIS SOBRE A ESTABILIDADE E INVASIBILIDADE DE COMUNIDADES DE PLANTAS.
GISLENE MARIA DA SILVA GANADE
Início: 1/1/1998; Término: 12/31/1998
Área do conhecimento: BIOLOGIA
INST BIOLOGIA/UNICAMP, UNIVERSIDADE ESTADUAL DE CAMPINAS
$ 0,00

1996/12377-4
MODELAGEM E SIMULACAO DO FLUXO E UTILIZACAO DE NUTRIENTES PELOS RUMINANTES NO CONTROLE DA POLUICAO AMBIENTAL COM AGRICULTURA SUSTENTAVEL.

LUIS ORLINDO TEDESCHI
Início: 8/1/1997; Término: 7/31/1998
Área do conhecimento: AGRONOMIA E VETERINARIA
PESSOA FISICA, PESSOAS FISICAS
$ 0,00

ANNEX IV – Resumo do Grupo III – Mitigação Através de Projetos de Redução de Emissão e Alterações Tecnológicas no Agronegócio e na Indústria do Workshop FAPESP realizado em 24/11/2005

O Grupo entende que para os projetos de pesquisas relacionados á mitigação, a serem apoiados pela FAPESP, os seguintes pontos merecem especial atenção:

1. Muitos projetos e/ou tecnologias não possuem atualmente aplicabilidade, ou seja, viabilidade econômica. Isto não significa que não devem ser feitas pesquisas em relação a estes projetos e/ou tecnologias. Na verdade estes é que precisam de mais pesquisa com o objetivo de torná-los viáveis;
2. Muitas pesquisas que já estão em andamento poderiam ser facilmente adaptadas para estudar as possibilidades de mitigação. Seria necessária apenas uma integração maior;
3. As pesquisas sobre as possibilidades de mitigação deverão trabalhar em diferentes escalas;
4. A medição e o monitoramento são fundamentais dentro deste tipo de pesquisa, porém ela não deve se restringir a apenas às metodologias de medição e monitoramento;
5. Seria necessária a criação de uma base de dados unificada para as diferentes linhas de pesquisas;
6. As novas linhas de pesquisa não podem ser confundidas com os projetos comerciais de mitigação;
7. Seria desejável criar sinergias destas pesquisas com a Inovação Tecnológica em Pequenas Empresas (PIPE);
8. As formas de avaliação deste tipo de pesquisa deveriam ser feitas não pelo número de artigos publicados somente, mas através da medição da transferência da tecnologia para o setor privado e/ou sociedade (incubadoras de empresas nas universidades poderia ser um dos parâmetros para a medição). Outra forma de avaliação seria o impacto sobre políticas públicas;
9. Um prazo mínimo de cinco anos seria necessário para este tipo de pesquisa.

O Grupo acredita que vários projetos temáticos poderiam ser propostos para a FAPESP. Estes projetos devem ter o caráter integrador, uma vez que várias pesquisas estão co-relacionadas entre si e preferencialmente serem desenvolvidos em parceira com empresas privadas. Alguns projetos que poderiam vir a ser propostos são:

1) Identificação das vantagens comparativas para a mitigação no Brasil e o estabelecimento de políticas públicas

2) Conscientização de consumidores/investidores e impactos financeiros nas empresas das mudanças climáticas

3) Seqüestro geológico:
   I. Uso atual das tecnologias
   II. Uso de novas tecnologias (Ex: nanotecnologia)

4) Uso da terra, mudança do uso da terra e florestas:

- III. Políticas públicas para a recuperação de mata ciliar
- IV. Uso de biosólidos e seu balanço energético
- V. Biomassa e células de hidrogênio
- VI. Biomassa e combustíveis vegetais
- VII. Produtos madeireiros e o ciclo do carbono
- VIII. Fito-remediação de solos
- IX. Redução do desmatamento através do pagamento por serviços ambientais
- X. Indutores exógenos do desmatamento da Amazônia
- XI. Zoneamento ecológico-econômico

5) Potencial de mitigação em culturas/manejo agropecuárias e florestais:

- XII. Ruminantes
- XIII. Papel e celulose
- XIV. Setor sucro-alcooleiro
- XV. Aumento da eficiência das culturas quanto ao ciclo biogeo-químico
- XVI. Uso de derivados em substituição a derivados de petróleo

6) Energia:

- XVII. A expansão e a utilização do gás Natural
- XVIII. Cenários futuros na produção e uso da energia
- XIX. Eficiência Energética
- XX. Células de Hidrogênio
- XXI. Planejamento integrado de recursos energéticos

7) Setor urbano:

- XXII. Potencialidades de mitigação na construção civil
- XXIII. Caracterização e gestão de resíduos sólidos e efluentes domésticos

8) Setor transporte

- XXIV. Biocombustíveis
- XXV. Eficiência energética na malha de transporte
- XXVI. Mitigação de gases de efeito estufa e suas sinergias com a poluição atmosférica

9) Quadro regulatório nacional e internacional da mitigação de gases de efeito estufa

Participantes:

	Nome	Instituição	Email
1	Marcelo T. Rocha	CEPEA - ESALQ/USP	matrocha@esalq.usp.br
2	Sergio Pacca		sapacca@gmail.com
3	Rauda Lúcio Mariani	INPE/UFF	rauda@dge.inpe.br
4	Magda Ap. Lima	EMBRAPA	magda@cnpma.embrapa.br
5	Luiz Carlos Estraviz Rodrigues	IPEF/ESALQ	lcer@esalq.usp.br
6	Maria Paulete P.M. Jorge	INPE/CPTEC	paulete@cptec.inpr.br
7	Claudio B.B. Leite	IPT	cbbleite@ipt.br
8	Marcio A. R. Nahuz	IPT	mnahuz@ipt.br
9	Laiete Soto Messian	IPT	laiete@ipt.br
10	Adibe Luiz Abdalla	CENA/USP	abdalla@cena.usp.br
11	Osvaldo Stella Martins	CENBIO/USP	omartins@iee.usp.br
12	Ricardo Esparta	IEE/USP	esparta@iee.usp.br
13	Marco Antonio Conejero	FEARP/USP	marcoa@usp.br
14	Pedro Leite da Silva Dias	IAG/USP	pldsdias@master.iag.usp.br
15	Marco Fujihara	PWC	marco.fujihara@br.pwc.com
16	João Wagner S. Alves	CETESB	joaoa@cetesb.sp.gov.br
17	Paulo Kanayama	EP/USP	paulo.kanayama@poli.usp.br
18	Dione Z. A. Pradella	CETESB	dionep@cetesb.sp.gov.br

Lista de pesquisas em andamento:

- CENA:
  - Técnicas nucleares e correlatas para avaliação de plantas taniníferas na alimentação de ruminantes (FAPESP 2002/10575-6);
  - Evaluation of tanniniferous forages as alternative of mitigation of methane emission by ruminant (IAEA – RC 12663);
  - Avaliação dos teores de taninos e produção de gases *in vitro* em silagens de sorgo granífero com feijão guandu;
  - Impacto ambiental das perdas fecais de nutrientes pelos animais domésticos: análise quantitativa do fluxo de fósforo através de modelos matemáticos (FAPESP 04/14532-5).
- IPT:
  - Tecnologias de Seqüestro Geológico de Carbono no Contexto das Mudanças Climáticas Globais: estado-da-arte e estudo de caso no “reservatório Itararé”, Estado de São Paulo;
  - Redução das Emissões de Metano em Processos de Fabricação de Carvão Vegetal (Carbonização de Madeira);
  - Desenvolvimento de Sistema de Combustão de Alcatrão Vegetal;
  - Desenvolvimento de Tecnologias de Gaseificação de Biomassa para Geração de Gás de Síntese e Energia Elétrica;
  - Desenvolvimento de Tecnologia de Hidrólise Enzimática de Bagaço e Palha de Cana de Açúcar;
  - Desenvolvimento de Tecnologias de Combustão Industrial mais Limpa
- IPEF/ESALQ:

- Brasil - *Eucalyptus* - Produtividade potencial (BEPP) - www.ipef.br/bepp
- Modelos de recuperação de áreas degradadas com espécies nativas em duas regiões do Brasil visando sequestro de C
- Estimativas das taxas de sequestro de carbono nas fisionomias da RPPN SESC-PANTANAL, em Poconé – MT
- Estimativa do sequestro de carbono em solos sob florestas de *Eucalyptus*
- Quantificação dos balanços de carbono, ágau e nutrientes, na escala do ecossitema, para uma rotação do eucalipto usando torre de fluxo: testar modelos ecofisiológicos e melhorar as práticas silviculturais (fase de proposta)

▪ Outras instituções com pesquisas em andamento:
  - Embrapa (AGROGASES)
  - CETESB
  - IEE
  - CENBIO