Transition to Global Sustainability:

The Contribution of Brazilian Science

Edited by

Carlos Eduardo Rocha-Miranda

Academia Brasileira de Ciências

TRANSITION TO GLOBAL SUSTAINABILITY:

THE CONTRIBUTION OF BRAZILIAN SCIENCE

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CARLOS EDUARDO ROCHA-MIRANDA

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FOREWORD

As a result of the planning for the Year 2000 Conference in Tokyo during the meeting of the IAP Sustainability Transition Coordinating Committee (STCC) Committee on the 12th of September 1997 in Rio de Janeiro, the Board of the Academia Brasileira de Ciências decided to invite Brazilian scientists to present position papers on subjects concerned with transition to sustainability in the next millenium. Besides addressing the main theme, the contributions would have to be the result of Brazilian research work, either experimental or theoretical. The Board, after due consideration to areas of Brazilian expertise, nomminated a group of scientists to search for contributions that conformed with the above criteria on the following core issues:

AGRICULTURE - José Gallizia Tundisi

AMAZONIA - José Gallizia Tundisi

CLIMATIC CHANGES - Umberto Giuseppe Cordani

EDUCATION - Simon Schwartzman & Luiz Bevilacqua

ENERGY - Luiz Bevilacqua

EXPLORING BIODIVERSITY - Sérgio Henrique Ferreira

HEALTH - Eloi Garcia

INLAND WATERS & OCEANS - José Gallizia Tundisi

POVERTY - Simon Schwartzman

SUSTAINABILITY - Luiz Bevilacqua

Two meetings were agreed upon, a preliminary one at the end of 1998 to evaluate the contribution and a final and formal one to be held at a Seminar on the days following the reception of the new Fellows on the 28th of April, 1999. At this meeting, the scientific community would appreciate the presentations and be encouraged to provide its contribution.

At the formal presentations, on April 29th and 30th of 1999, seventeen papers that met the established criteria were presented in a workshop at the Academia Brasileira de Ciências entitled "The Brazilian Science and the Transition to Sustainability". Summaries of the talks delivered by the main authors to the Academicians and the public at the April meeting are given below.

Education and poverty are the subjects of the three initial papers, coordinated by Simon Schwartzman. For Maria Helena Guimarães de Castro (INEP), who opened the seminar with the talk entitled "Education for the 21st Century: the Challenge of Quality and Equity", it is the successful response to the challenge posed by education that will ensure sustainability for Brazil in the third millenium. The paper by Ricardo Paes de Barros (IPEA), "Education and Equitable Economic Development", analyses the interplay in Brazil of education, economic growth and inequality, while that by Sonia Maria R. da Rocha (IPEA), "Sustainable Development and the Poverty Reduction Goal" places in perspective the relationship between poverty and the concept of sustainability.

The **health** core issue of the main theme is the subject of the next two papers. Luiz Hildebrando Pereira da Silva (CEPEM) and "Emergent Diseases", describing some of the reasons for the emergence of new pathologies, as well as the reappearance of old ones, with recommendations as to what can be done by the Public Health Service to keep them at bay. Eloi Garcia (FIOCRUZ) on his talk on "Health and Environment" proposed measures that could lead to the necessary integration of health and environmental agencies as required by a sustainable development.

One of the papers dealing with the core issue on energy receives a theoretical treatment in the paper entitled "Energy and Sustainability" by José Goldemberg (USP), delivered at the seminar by José Roberto Moreira (USP), where different energy sources are examined with an eye on sustainability. In addition it is dealt with in an applied study of the energy production from sugar cane vis a vis the main theme by Isaias C. Macedo (COPERSUCAR) in "Energy Production From Biomass Sustainability: The Sugar Cane Agro-Industry In Brazil".

Distinct aspects for sustainability are analysed by two papers on **climate change**. The first one by José D. G. Miguez (MCT), "Responsibility and Climate Change" analyses the ethical aspects of the policies adopted by different countries to deal with the change, while that by Pedro Leite da Silva Dias (USP), "Climate Change: Specific Research Issues in the Tropical Area for Developing Countries", treats of the effects of this variable on the changes of the biosphere and the carbon balance and surface processes in the tropics.

The thoughts of a pharmacologist on the **preservation of biodiversity** are expressed by Sérgio Henrique Ferreira (USP) in "Biodiversity, Sustainability and Drug Development", illustrated by his own experiences.

Three papers place in perspective particular points of **tropical agriculture**. The work presented by Ernesto Paterniani (ESALQ), "Sustainable Agriculture in the Tropics" reviews the development of agriculture, in particular that of agriculture in different tropical regions, and the achievements in Brazil with the improvement of fertility of "cerrado" soils. The two other papers, "The Role of Biological Nitrogen Fixation to Bio-Energy Programmes in the Tropics", presented at the seminar by Johanna Döbereiner (EMBRAPA), and "The Role of Biological Nitrogen Fixation in Land Reclamation, Agroecology and Sustainability of Tropical Agriculture", presented by Avílio Antonio Franco (EMBRAPA), describe some of the contributions performed at EMBRAPA on biological nitrogen fixation for the maintenance of soil fertility and the use of biofuels to avoid the pollution occasioned by chemical fertilizers.

The problems of **inland waters and oceans** were the subjects of the talks of José Galizia Tundisi (IIE) and Luiz Roberto Tommasi (USP). The first work, entitled "Water for Sustainable Development: the Brazilian Perspective" is divided into three parts. Part I describes the Brazilian freshwater ecosystems, Part II discusses the various uses of water to satisfy basic human needs and Part III discusses the economic and social aspects of water management. The second work, entitled "The Sustainable Development of the Coastal Marine Brazilian Areas" reviews some of the recent meetings and legislations referring to coastal regions and makes recommendations for review of the pertinent legislation in developing countries with an eye on sustainability.

Eneas Salati (FBDS) delivered the talk on **Amazonia**, entitled "Perspectives for Sustainable Management of the Renewable Natural Resources of the Amazon Forest", where he distinguishes the nature of the scientific contributions before and after the nineteen seventies, as the result of the anthropic influence. He then describes the factors that hinder the sustainable use of the natural resources of the region and proposes the implementation of projects in search for solutions to circumvent this problem.

The last talk was delivered by Roberto Bartholo Jr. (UnB) on "Science and the Ethics to Sustainability". This paper contributes to the much needed phylosophical framework for conceptual problems related with **sustainability**. The author brought forth arguments to make the point that sustainable development should not be self-commanded nor oriented solely by market forces but rather be at the service of Life.

The present collection of papers represents the revised version of the talks delivered at the workshop, incorporating in some cases contributions gleaned from the participants. They are here published to bear witness to the Brazilian scientific efforts towards the global problem of sustainable development in the third millenium and as reference papers for theTokyo 2000 IAP Conference.

The opinions expressed by these position papers are the responsability of the authors. The revised texts were reproduced from electronic media as sent by the authors.

EDUARDO MOACYR KRIEGER
PRESIDENT OF THE BRAZILIAN
ACADEMY OF SCIENCES

CARLOS EDUARDO ROCHA-MIRANDA
EDITOR

List of Acronyms

CENBIO - Centro Nacional de Referência em Biomassa

CEPEM - Centro de Pesquisa em Medicina Tropical

COPERSUCAR - Centro de Tecnologia COPERSUCAR

COPPE - Coordenação dos Programas de Pós-Graduação em Engenharia

EMBRAPA - Empresa Brasileira de Pesquisa Agropecuária

ESALQ - Escola Superior Agrícola Luiz de Queiroz

FBDS - Fundação Brasileira para o Desenvolvimento Sustentável

FIOCRUZ - Fundação Oswaldo Cruz

FUNDESPA - Fundação de Estudos e Pesquisas Aquáticas

IIE - Instituto Internacional de Ecologia

INEP - Instituto Nacional de Estudos e Pesquisas Educacionais

IPEA - Instituto de Pesquisa Econômica Aplicada

MCT - Ministério da Ciência e Tecnologia

UERJ - Universidade do Estado do Rio de Janeiro

UnB - Universidade de Brasília

USP - Universidade de São Paulo

UFF - Universidade Federal Fluminense

Education for the 21st Century: The Challenge of Quality and Equity

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I - Introduction*

In the present context of globalisation of economic, political and cultural relations and the increased pace of change in the technology base and the means of production, education has become a strategic vector for sustainable and equitable development. In fact, the idea is generally accepted today that education has become the greatest comparative advantage of countries and companies when challenged by international competitiveness. In addition, level of schooling is one of the main factors that decide the individual's employability.

While education alone certainly does not create employment, it is however essential to keep the worker in a job and to help his/her social entry into the sphere of production. And, to this end, it is not sufficient just to ensure the expansion of the educational system. It is necessary to generate an improvement in the quality of the teaching that is offered, without which it will be impossible to meet the demand for increasingly qualified human resources to accompany the changes presently under way. Thus, the satisfactory performance of the education system will be one of the decisive factors in the self-sustaining development of Brazil in the foreseeable future.

This premise, which is applicable equally to other countries in Latin America, implies a new focus for the challenges and dilemmas of developing societies, which have to give a high degree of priority to investment in training the social and human capital which, according to Kliksberg (1998), "is currently deemed to be fundamental to the productivity and competitiveness of nations"[1]. When it comes to working in this area, education takes on a key role as part of the policies aimed at decreasing levels of social inequity and encouraging improved distribution of income, thus helping to overcome the main impediments to sustainable economic growth in the region.

This topic has been the subject of recent research that has investigated the relationship between the performance of the educational system and the economic performance of developing countries. An attempt has been made to show that those that have achieved a rapid increase in the average level of schooling among their population, as is the case of Korea, have had greater economic success and taken greater steps to reducing indices of poverty and inequity.

The list of recipes for policies that have been recommended to developing countries by international organisations, based on the primacy of economic reform and reforms of the State, which dominated the 80s, eventually gave way to a new agenda for the 90s that prioritises reduction of inequity and to this end revives the role of social policies. Behind this change lies the recognition that macro-economic re-structuring processes result in an increase in concentration of income and consequently in an increase in social exclusion and poverty. More than just a paradox, these perverse effects of liberalising reforms represent, from the point of view of social equity, a serious obstacle to economic stability and to the consolidation of democracy in the region.

It is within this context that education emerges as a central element in a new development strategy, linking the quest for economic efficiency to the encouragement

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The writer wishes to thank the specialist team at INEP, especially Paulino Motter, for help in preparing this paper.

[1] "*Inequidad en América Latina: un tema clave*" "*Inequity in Latin America: a key theme*". Supporting document at the conference, given by the author at the International Seminar on Educational Management - Trends and Perspectives, organised by the National Council of Secretaries of Education (Conselho Nacional de Secretários de Educação - CONSED) held in Rio de Janeiro from the 17th to 20th August, 1998.

of equity and citizenship. To achieve this goal - a pre-requisite for productive and autonomous entry into the globalised economy - Brazil will have to overcome a challenge: to successfully conclude its drive for universal basic education and, at the same time, raise the quality of teaching offered by public sector schools, which today account for 92% of enrolments in primary education and 81% of enrolments at secondary level. The educational changes implemented in the 90s by the three levels of government that share responsibility for maintaining and developing public sector education, attempt to employ strategies to overcome the history of backwardness the country has accumulated in this area.

This paper attempts to identify some of the principle obstacles that Brazil will have to overcome in order for its educational system to reach the levels of efficiency, equity and quality demanded by society that will be able to guarantee support for the nation's sustainable development plan in the 21st century. To this end a brief analysis is presented of the educational system, highlighting the major changes that have taken place in the last ten years and the difficulties that are being faced. Next, the paper discusses the new focus of educational policies in the 90s, which are based on the quest for quality and the fostering of equity. Following this, a survey is made of the efficacy of educational evaluation as an inducement to making efforts to improve quality, and the main results of the National System for Evaluation of Basic Education (Sistema Nacional de Avaliação da Educação Básica - SAEB) are described. Finally we examine the perspectives for defining national standards, suggesting some possible responses to this problem, which today occupies the international debate on strategies for improving the quality of teaching.

The central argument that this paper attempts to develop may be described in the following terms: if there is a virtuous circle involving education, equity and sustained development, the effectiveness of this process increasingly depends on expansion of the teaching on offer, together with quality. This is because one can only be a complete citizen - actively participating in the worlds of society, work and politics - if one can develop the basic competences demanded by his/her presence in the society of knowledge, which include: the ability to solve problems; autonomy in discovering information; the ability to make choices and take decisions. Creating citizens with this profile will be the major challenge for education in the next century.

II - A Brief Balance Sheet of Educational Indicators in the 90s

Analysing the situation of education in Brazil - a task which is made easier today by the availability of a wide-ranging and up-to-date stock of quantitative and qualitative information provided by educational censuses and national evaluation systems[2] - provides two paradoxically contradictory interpretations. The first, deliberately optimistic, emphasises the positive aspects that stand out in the present educational scene, such as the notable increase in enrolments at all levels, a phenomenon that

[2] Since 1995 the Ministry of Education has been making a great effort to institute a consistent system of educational information, recognising the importance of such an instrument to aid the efficient management of programmes and policies in this area. The advances made in this period are well-known, starting with the complete re-structuring of the National Institute for Educational Studies and Research (Instituto Nacional de Estudos e Pesquisas Educacionais - INEP), which is responsible for the development and implementation of policy of the different levels of government.

accompanies a trend towards improving efficiency indicators in the system, especially in primary education.

This evidence allows us to conclude that education in Brazil has advanced considerably in recent years. The second way of interpreting the indicators, from a comparative point of view, shows aspects of the educational system that are still unsatisfactory, such as continuing high levels of repetition, dropout and mis-match of age to grade and the low level of student achievement indicated by the Nation System for Evaluation of Basic Education (SAEB).

This apparent contradiction is resolved when we look more closely at the evolution of the main educational indicators of the 90s. In fact, if the Brazilian educational system achieved reasonable standards from the point of view of expansion, bringing the country closer to the goal of universal primary education, the same cannot be said in regard to the indicators of quality and equity, which are still far from the levels society demands and which are necessary for national development. Here is the dilemma that Brazil faces in the sphere of education and to which the government has turned its attention.

Universalisation of primary education and the expansion of secondary education

During the last thirty years the priorities of the nation's educational efforts have been directed towards universalising access to primary education, an aim which has nearly been reached. Thus the state will formally achieve the requirement established by the 1998 Constitution, which stated the obligatory nature of this level of education and the duty of the public system to ensure its availability. Indeed, the rate of net schooling in the 7-14 age-group jumped from 67% in 1970, to 95.8% in 1998[3]. The growth in enrolment increased in the 90s in response to more defined and focused policies of universalisation of provision that were carried out by a partnership between the three levels of government. In this way Brazil managed to anticipate five years early the aim it had committed itself to in the Education for All Ten-Year Plan, which aimed to raise educational provision for the school-age population to at least 94% by the year 2003[4].

The success of this effort to universalise primary education, which is greatly affected by the existence of deep regional inequalities in the conditions of provision, has created the phenomenon of accelerated increase in the educational system. Brazil has today, adding together all the levels and types of basic education, about 51 million pupils. If we add to these the enrolments of higher and post-graduate education, this population rises to 53 million enrolments, equivalent to a little less than one third of the country's total population. Nevertheless, in spite of increased access, which is proved by the concentration of about 36 million enrolments in primary education, Brazil's education system still remains quite funnel-shaped, since a very small

[3] Three indicators are used to measure the scope of educational coverage. **Rate of Net Schooling**, which shows the percentage of 7-14-year-olds enrolled in primary education in relation to the total number of the age-group; **Rate of Provision**, which shows the percentage of 7-14-year-olds whose needs are provided for by the school system, regardless of the level of teaching; **Rate of Overall Schooling**, which shows the relationship between the total enrolments at primary level, regardless of pupil age-group, and the total number of 7-14-year-olds.

[4] This plan states the commitments taken on by Brazil as a signatory of the 1990 Jomtien Declaration.

proportion of each age cohort manages to complete its basic education, which includes secondary education, and an even smaller proportion enters higher education.

Distribution of Enrolment by School Level and Participation in the State System – Brazil – 1998

Level/Type of Education	Total Enrolment	State System	% State System
Pre-School	4,110,448	3,121,368	75.9
Literacy Classes	807,171	550,837	68.2
Primary Education 1st to 4th grades	21,377,130	19,562,110	91.5
Primary Education 5th to à 8th grades	14,461,242	12,878,010	89.1
Secondary Education	6,967,905	5,740,611	82.4
Special Education (1)	293,153	137,201	46.8
Education of Young People and Adults	2,881,231	2,516,690	87.3
Higher Education	2,125,958	804,729	37.8
TOTAL	53,024,238	45,311,556	85.5

Source: INEP/MEC

Note (1) The number of pupils with special needs who receive special education in special schools or in special classes within conventional schools, does not include those pupils with special needs who are integrated into conventional classes.

This situation is illustrated when we see that only about 30.4% of 15-17-year-olds are enrolled in secondary education, which suggests that the recent large growth in the number of enrolments at this level was achieved by the inclusion of older learners. A part of this clientele is made up of young people and adults who are returning to school to complete their basic education, thus meeting a need that is being imposed by the labour market[5]. This pupil profile is also reflected in the high rate of mis-match of age to grade which produces the apparent paradox between the accelerated increase in enrolment and a rate of overall schooling among 15-17-year-olds that remains very low. Since only one in every four young Brazilians reaches secondary education at an age considered to be suitable, this level of education has a great potential for increase in future years[6].

The gradual improvement in the efficiency of primary education is already producing positive results at other levels of education, especially in relation to secondary education, which has shown higher rates of enrolment increase in the most recent period. This shows that the strategy adopted by the Ministry of Education (MEC) in the last four years, giving priority to primary education, is helping to stimulate development of the educational system as a whole. In this way Brazil is repeating, some years later, the successful experiments of other countries in which the change

[5] The 1998 School Census shows that 54.8% of enrolments in secondary education are concentrated in night school courses. This percentage, which was 56.1% in 1996, show slight signs of falling. The restriction of availability of places in day schools has contributed to the fact of Secondary Education being mainly an evening activity. In primary education, night school classes make up 11.6% of total enrolments, a phenomenon associated with the mis-match of age to grade.

[6] In spite of only about 25% of 15-17-year-olds being enrolled in secondary education, when we look at enrolments of this age group in primary education the rate of school provision is 66.9%. To calculate these rates enrolment data taken from the 1996 School Census and data from the 1996 IBGE national census were used.

in population's educational profile was initially instigated by a rapid universalisation of primary education, followed by an effort to expand the other levels of teaching[7]

It is important to note that this growth in enrolment in primary education has also been accompanied by a gradual improvement in the efficiency of the system, as is shown by the declining trend in rates of repetition, dropout and mis-match of age to grade. Clearly these rates are still quite high. The main evidence of improvement is the considerable growth of enrolment in the final grades and the corresponding rise in the number of those completing school. In fact, the development of enrolment rates in the 1989-1998 period shows that while the national average enrolment in 1st to 4th grades grew by 13.4%, enrolment in 5th to 8th grades showed an impressive expansion of 66.1%. Thus the relative size of enrolment in the first four grades within total primary school enrolments fell from 68.4% to 59.6%, while enrolments in the four final grades increased their share from 31.6% to 40.4%.

But it is from the regional point of view that we can see the major changes in the profile of enrolment in primary education. The South and Southeast regions, obviously at a more advanced stage of socio-economic and educational development, have shown over the last ten years a negative growth in enrolment in the 1st to 4th grades, accompanied by an accelerated expansion of enrolment in the final grades. This phenomenon, apart from reflecting a change in demographic dynamics, is directly related to the founding of the 'basic cycle', to the struggle against repetition and, more recently, to results obtained by the accelerated learning classes and other initiatives that have led to the considerable fall in repetition rates, in this way greatly evening out progress through school. In this way the South and Southeast regions are already showing almost equal numbers of enrolments in the first four grades (52.1% in the Southeast and 53.4% in the South) and enrolments in the last four grades (47.9% in the Southeast and 46.6% in the South), a situation which will probably consolidate itself in the near future.

This situation is reversed in the rest of the country, in spite of there having been a consistent expansion in enrolment at all grades in primary education between 1989 and 1998. The Northeast and Northern regions have the greatest rates of increase in enrolment in the early grades - 39,1% and 35.8% - which reflect the effort to universalise primary education. The enrolment increase in these regions was also greater in the final four grades. In spite of this improvement, almost 70% of total enrolment at primary level is still concentrated in the first four grades. We note, therefore, when comparing the profile of enrolment distribution between the early grades and the final grades, that the Northeast and Northern regions have an accumulated shortfall of ten years in relation to the South and Southeast regions. The Centre-West region, in its turn, has a very similar structure to the Southern and Southeastern profiles, a picture that is distorted by the presence of the Federal District. The three states in the region - Mato Grosso, Mato Grosso do Sul and Goiás - have profiles more in line with those of the Northern and Northeastern regions.

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[7] "Analyses relating to the role of education in the economic success of Southeast Asian countries has emphasised equally the speed with which that region's educational system was able to expand, and the fact that this expansion concentrated on the lowest educational levels, passing on to the higher levels when the possibility of expanding the lower levels was exhausted. Such a manner of expansion has been felt essential for the ability of those economies to combine economic growth with low levels of equity that are often becoming lower". Cf. *Report on human development in Brazil 1996* - Rio de Janeiro: IPEA; Brasília, D.F.: PNUD, 1996, p. 35.

Primary Education - Initial Enrolment by Grade - Brazil anr Regions 1989-1998

Region/Year	Total	1st to 4th grades (*)	%	5th to 8th grades	%
Brazil					
1989	27.557.542	18.851.075	68,4	8.706.467	31,6
1991	29.203.724	19.383.791	66,4	9.819.933	33,6
1996	33.131.270	20.027.240	60,4	13.104.030	39,6
1997	34.229.388	20.568.128	60,1	13.661.260	39,9
1998	35.838.372	21.377.130	59,6	14.461.242	40,4
Growth % 89/98	30,0	13,4		66,1	
North					
1989	2.155.068	1.645.834	76,4	509.234	23,6
1991	2.246.339	1.671.491	74,4	574.848	25,6
1996	2.820.531	1.954.909	69,3	865.622	30,7
1997	3.011.865	2.087.265	69,3	924.600	30,7
1998	3.208.587	2.235.750	69,7	972.837	30,3
Growth % 89/98	48,9	35,8		91,0	
Northeast					
1989	8.105.453	6.036.485	74,5	2.068.968	25,5
1991	8.650.474	6.314.964	73,0	2.335.510	27,0
1996	10.475.469	7.245.010	69,2	3.230.459	30,8
1997	11.184.186	7.707.699	68,9	3.476.487	31,1
1998	12.261.780	8.399.253	68,5	3.862.527	31,5
Growth % 89/98	51,3	39,1		86,7	
Southeast					
1989	11.300.227	7.271.258	64,3	4.028.969	35,7
1991	11.965.480	7.417.955	62,0	4.547.525	38,0
1996	12.958.674	7.014.934	54,1	5.943.740	45,9
1997	13.020.903	6.933.486	53,2	6.087.417	46,8
1998	13.248.533	6.908.570	52,1	6.399.963	47,9
Growth % 89/98	17,2	-5,0		57,4	
South					
1989	3.992.351	2.574.270	64,5	1.418.081	35,5
1991	4.201.369	2.613.396	62,2	1.587.973	37,8
1996	4.475.774	2.458.130	54,9	2.017.644	45,1
1997	4.512.267	2.446.789	54,2	2.065.478	45,8
1998	4.553.460	2.429.921	53,4	2.123.539	46,6
Growth % 89/98	14,1	-5,6		49,7	
Centre-West					
1989	2.004.443	1.323.228	66,0	681.215	34,0
1991	2.140.062	1.365.985	63,8	774.077	36,2
1996	2.400.822	1.354.257	56,4	1.046.565	43,6
1997	2.500.167	1.392.889	55,7	1.107.278	44,3
1998	2.566.012	1.403.636	54,7	1.162.376	45,3
Growth % 89/98	28,0	6,1		70,6	

Source: MEC/INEP/SEEC
Notes(1) Includes non-graded students

The substantial growth in absolute terms of primary education enrolment observed in the 90s had a favourable impact on the increase in the rate of net schooling among 7-14-year-olds. According to the 1998 School Census only three states in the Northeastern region show net schooling rates among 7-14-year-olds, of below 90% - Piauí (85.9%), Alagoas (87.6%) and Maranhão (89.7%). On the other hand, all the Southern and Southeastern states had already reached net schooling rates above 97%, notably the Federal District, which had the best score in the country (98.2%).[8]

[8] This result indicates the success of policies to combat truancy, such as the School Grant Programme which guarantees a monthly financial grant equal to a minimum salary to low-income families who undertake to keep children under 14 years of age, in school.

School Provision Rates for 7-14-year-olds and Rates of Net and Overall Schooling in Primary Education Brazil and Regions - 1998

Brazil and Regions	Rate of Provision	Rate of Schooling	
		Net	Overall
Brazil	96.5	95.8	127.6
North	95.3	91.9	138.0
Northeast	94.4	92.0	139.5
Southeast	97.9	97.6	127.4
South	98.1	97.1	118.6
Centre-West	96.2	94.3	140.7

Source:MEC/INEP/SEEC

Notes:

(1) The estimates refer to data from the School Census

(2) The rates of Primary Education are preliminary, and subject to alteration

(3) Rate of Provision - identifies the percentage of the school-age population that attends school, regardless of level of schooling

(4) Rate of Net Schooling - identifies the segment of the population in the 7-14-year-old age range enrolled in Primary Education

(5) Rate of Overall Schooling - identifies if the availability of enrolments in Primary Education is sufficient to meet the demand of the 7-14-year-old age range. It evaluates the amount of enrolments in Primary Education as a function of the potential demand in the 7-14-year-old age range.

The quality deficit in primary education

It is clear that the present challenge in primary education is no longer in terms of democratisation of access but rather in offering an education that meets minimum standards of quality. The systematic monitoring of the educational system - carried out annually by means of the School Census and every two years by the SAEB - has shown that the teaching networks' capacity for providing schooling is now sufficient to guarantee a place to all children from 7 to 14 years of age, although there are still deficits in certain specific regions of the country. Thus the main objective has progressed to promoting permanence of learning for pupils, that is, to guarantee them the conditions for achieving educational success. To this end a set of actions has become necessary, ranging from improving the physical plant of the school system[9] to a complete uprooting of the deep-seated culture of grade repetition. The guarantee of an adequate level of quality requires the introduction of a school day of at least five hours and adopting policies for training and improving the teaching body.

The false premise that it is good for the under-achieving pupil to repeat the same grade to reinforce the content of that grade has contributed to one of the main

[9] This situation was highlighted in research carried out recently by INEP concerning the infrastructure of public and private schools in the whole country. It was found, for example, that in the Northeast, 8.4% of primary school pupils attend schools that do not have running water. In the North, 18.1% of pupils, and 9.3% of those in the Northeast, attend schools that have no sewage system. Also, a large number of pupils study in institutions that have no electricity: 19.6% in the North and 14.6% in the Northeast. Cf. *Caracterização física das escolas.* INEP. Brasília, 1999, p.85.

anomalies of the Brazilian educational system: the high levels of age-to-grade mis-match. This happens because pupils take, on average, about 11 years to complete the eight grades of compulsory schooling. There are in primary education alone, 8.5 million pupils aged 15 or over who should be in secondary education. This excess of enrolments, which gives an overall rate of schooling of 127.6%, increases the cost of the educational system by about 30%. The most drastic consequence, however, is for the learners themselves with the mis-match of age to grade, since it has been shown that this situation affects self-esteem and has a negative effect on their performance, often resulting in them dropping out of school completely[10]

The identification of causes: repetition and dropping out, and the recognition of the severe consequences of age-to-grade mis-match: cost increase, drop in performance levels and school failure, are causing the educational system to create accelerated learning programmes and to initiate other plans with a view to regulating school throughput. Age-to-grade mis-match, which was 66% in 1994, fell to 46.7% in 1998. In spite of this reduction there are about 16.7 million pupils - from a total of 35.8 million enrolments at the this level - who are at least one year behind in their school careers. The fall in the rate of age-to-grade mis-match has been most noticeable in the first four grades, a trend that is definitely linked to the launch of the 'basic cycle' which eliminated the problem of end-of-year failure. This policy has still not produced the same effects in the final grades, which continue to have a history of higher mis-match levels, especially in the 5^{th} grade (54.3%).

Thus, although some recent improvements are significant, the general picture still requires redoubled efforts in the school systems to combat the causes of age-to-grade mis-match and at the same time, to create the opportunities of speeding up the learning of the huge number of pupils who are out of step in their school careers. From a regional point of view we notice again the situation Northeastern and Northern regions, where rates are well above the national average: 64.2% and 61.3% respectively. By contrast, in the Southern and Southeastern regions the rates are much lower: 25.8% and 34.2% respectively. The Centre-West region, with a mis-match rate of 45.5%, is much closer to the national average.

With the accelerated learning classes there is a falling trend in the rates of age-to-grade mis-match, which shows, on the one hand, the positive results of the programmes that are being carried out, and on the other, the effect of improving the main performance indicators in primary education[11]. The pass rate rose from70.6% in 1995, to 77.5% in 1997. During the same period the failure rate dropped from 15.7% to 11.4% and the dropout rate fell from 13.6% to 11.1%.

[10] The findings of the National System for Evaluation of Primary Education (Sistema Nacional de Avaliação da Educação Básica - SAEB) and of the Evaluation of Secondary School Leavers (Avaliação dos Concluintes do Ensino Médio - ACEM) show that the performance levels of pupils falls in proportion to an increase in age-to-grade mis-match.

[11] According to the 1998 Educational Census, enrolment in school throughput correction - the so-called 'accelerated learning classes' - reach 1.2 million pupils from 1^{st} to 8^{th} grade throughout the country.

Primary Education - Rate of Age-to-Grade Mis-match - Brazil and Regions 1991-1998

Region/Year	Grades (%)							
	Total	1st Grade	2nd Grade	3rd Grade	4th Grade	5th Grade	6th Grade	7th Grade
Brazil								
1991	64.1	59.5	62.6	63.3	62.7	70.2	68.6	67.4
1996(1)	47.0	40.0	44.1	46.4	46.6	55.6	53. 2	49.2
1998(1)	46.6	38.2	43.9	44.5	45.7	54.3	52.5	52.0
North								
1991	79.0	72.5	81.0	81.6	81.4	84.3	83.1	81.8
1996(1)	62.3	54.7	63.1	65.0	64.9	69.1	67.5	60.7
1998(1)	61.3	51.2	62.3	64.5	64.9	69.7	67.4	65.7
Northeast								
1991	80.6	75.7	82.9	82.6	81.6	84.5	82.9	82.6
1996(1)	65.7	58.4	66.9	68.0	67.3	72.8	70.2	67.1
1998(1)	64.1	54.1	65.0	67.7	66.2	72.2	69.2	70.2
Southeast								
1991	54.7	39.6	49.0	53.8	54.1	64.5	63.5	61.6
1996(1)	34.8	16.7	26.5	32.1	34.4	47.4	46.1	42.9
1998(1)	34.2	14.7	22.6	25.6	34.3	43.9	45.5	45.4
South								
1991	43.8	33.3	38.1	40.0	44.3	52.5	53.0	52.6
1996(1)	2.72	12.8	20.0	23.8	26.7	38.2	38.1	34.7
1998(1)	25.8	10.5	17.6	21.4	24. 0	35. 8	33. 1	32. 2
Centre-West								
1991	65.9	55.0	63.1	65.0	65.5	73.9	72.9	72.1
1996(1)	47.1	30.0	40.0	44.9	47.4	60.6	58.9	55.6
1998(1)	45.5	25.1	36.3	42.2	43.4	56.7	58. 0	57. 5

Source: MEC/INEP/SEEC

Note (1) Note the recommended age for each grade/level of schooling, that is, 7 years for 1st grade of primary education, 8 years for 2nd grade, and so on.

Primary Education - Rates of Passing, Failure and Dropout Brazil and Regions - 1995-1997

Brazil/ Regions	Pass			Fail			Dropout		
	1995	1996	1997	1995	1996	1997	1995	1996	1997
Brazil	70.6	73.5	77.7	15.7	14.2	11.4	13.6	12.3	10.9
North	58.9	62.9	66.2	17.9	19.0	16.7	23.2	18.1	17.1
Northeast	60.3	63.6	68.1	18.9	17.6	15.5	20.7	18. 8	16.4
Southeast	79.7	82.5	87.5	13.0	10.1	6.6	7.1	7.4	5.9
South	76.7	77.7	82.2	15.2	14.9	11.5	8.1	7.4	6.3
Centre-West	68.5	70.9	74.0	14.9	14.8	12.5	16.6	14.2	13.5

Source: MEC/INEEP/SEEC

Note: 1 - The non-graded student does not appear in the figures of this indicator

This positive development in performance rates - brought about by the systematic fall in failure and dropout rates and by the increased pass rate - has resulted in a systematic increase in the number of pupils completing primary education. The accumulated increase in the last four years has been 34.4%, while enrolments only increased 12.2% in the same period. In 1997 the number of school graduates passed the two million mark for the first time. This tendency, which should continue in the coming years, is already bringing strong pressure to bear on the growth of enrolment at secondary level. In the period between 1989-1998 the number of pupils passing through this level of education doubled, going from 3.5 million to about 7 million. The number of graduates also doubled, going from 658,000 in 1990 to 1.3 million in 1997.

The accelerated expansion of secondary education in the 90s repeated even more dramatically the phenomenon that was seen in the 70s and 80s in primary education. But the similarities go beyond the speed of the process of increase in enrolment. Democratisation of access to secondary school has also been accompanied by a lowering of the quality of education. We can see also a great concentration of supply of places in the public sector, which now accounts for 80.9% of enrolments. The participation of the private sector in secondary education enrolment fell from 46.5% in 1980 to 19.1% in 1998. During this same period private sector enrolments also suffered a drop in absolute terms, dropping from 1.3 million to 1.2 million pupils. It will, therefore, fall to the public sector to bear the load of absorbing growth in demand and to ensure the progressive universalisation of secondary education as laid down in the Constitution.

However, the challenge is not restricted to expansion of provision. Equally complex and urgent is the reform of secondary education, requirements for which were established in the new Law of Guidelines and Foundations of National Education (Law No. 9,493/96) and the guidelines set down by the National Council for Education (Conselho Nacional de Educação). This task involves solving the problem of lack of teachers qualified in core subjects - chemistry, physics, mathematics and biology - the up-grading of under-equipped schools and the gradual introduction of curriculum reform. As a result of this process of system re-organisation, it is hoped that secondary schools will be able to carry out their task of preparing citizens who are able to fit into society and the world of work. Since this level of schooling has become more elite, it has begun to receive a more varied clientele, a fact that is already being reflected in performance indicators.

As has already been pointed out, secondary education also reveals high levels of age-to-grade mis-match, repeating the same picture found in primary education. This happens because the majority of pupils enter secondary school with a mis-match accumulated through the eight grades of compulsory education. Nevertheless, the rate of age-to-grade mis-match is coming down, falling from 71.5% in 1995 to 53.9% in 1998. This trend is in line with the improvement in the indicators of transition from primary education. The problem is most acute in the regions of the North (73.2%) and Northeast (69.5%), in contrast with the rates in the regions of the South (39.1%) and Southwest (48.4%). The performance rates in secondary education have also improved in recent years. The pass rate jumped from 68.2% in 1995 to 78.8% in 1997. In the same period the failure rate fell from 10.1% to 7.5% and the dropout rate from 21.6% to 13.7%.

Secondary Education - Rate of Age-to-Grade Mis-match Brazil and Regions - 1996-1998

Brazil/Region	Overall Total	Grade		
		1st Grade	2nd Grade	3rd Grade
Brazil				
1996	55.2	57.7	54.6	51.0
1998	53.9	56.4	52.8	51.3
North				
1996	74.8	77.2	73.2	71.8
1998	73.2	75.6	71.9	70.0
Northeast				
1996	69.6	72.6	68.8	64.7
1998	69.5	72.3	68.4	66.0
Southeast				
1996	50.0	52.2	49.8	46.3
1998	48.4	49.7	48.0	47.1
South				
1996	41.4	43.3	41.4	37.6
1998	39.1	41.6	36.6	36.2
Centre-West				
1996	58.9	62.4	57.5	53.4
1998	57.7	60.8	55.9	53.9

Source: MEC/INEEP/SEEC

Secondary Education - Rates of Passing, Failure and Dropout Brazil and Regions - 1995-1997

Brazil/Regions	Pass			Fail			Dropout		
	1995	1996	1997	1995	1996	1997	1995	1996	1997
Brazil	67.7	73.2	78.8	10.3	9.7	7.5	22.0	17.1	14.0
North	56.3	66.9	66.3	10.9	11.0	7.9	32.7	22.1	24.5
Northeast	63.2	70.1	74.4	10.1	8.6	7.5	26.7	21.3	17.9
Southeast	71.3	76. 7	82.8	9.2	9. 0	6. 3	1 9.5	14.4	11.0
South	69.6	71.6	80.0	13.0	12.5	10.0	17.4	15.9	12.6
Centre-West	64.2	67.2	73.7	12.2	11.2	10.1	23.6	21.6	17.0

Source: MEC/INEEP/SEEC

Note: 1 The non-graded pupil does not appear in the figures of this indicator

Growth in demand for higher education

The efficiency gains in primary and secondary education, although still far from desired levels, are already starting to produce positive effects in the system of higher education. The selective and excluding nature of primary school, which is responsible for the high rates of repetition and truancy, are the greatest obstacle to expanding the higher levels of education. Nevertheless, while educational policies are showing themselves capable of encouraging both the universalisation and the improvement of rates of transfer from primary education, a synergy is created that activates all the other levels of teaching. This effect is, obviously, a long-term one, but already we can see an increase in productivity in the Brazilian educational system that directly benefits secondary and higher education.

Among the indicators that best show this change we note especially the speed at which enrolments at these levels are increasing. This trend has been most striking at secondary level, as has already been mentioned. In higher education the pace of enrolment growth has increased in the last four years after a long period of relative stagnation. In fact, between 1980 and 1993 there was an increase of 217,000 enrolments, which represents a modest annual increase of 15.78% in 14 years. In 1998 the number of students in higher education rose to 2.1 million, a rise of 464,000 enrolments in comparison to 1994, a 27.9% growth over the last four years. With this performance, after secondary education, higher education was the area of greatest relative growth in this period.

This tendency towards a greater rate of expansion in higher education will probably continue during the next ten years, responding to a demand that will also remain acute. It is important to note that in spite of greater enrolment growth over the last four years, the number of places offered at university entrance examinations is still growing more slowly than the number of secondary school graduates. As a result this relationship, which was 1.2 graduates for each place in 1990, rose to 2:1 in 1997. This shortfall will increase in the coming years since, as has already been seen, enrolment at secondary level has been showing an annual growth of over 10% and is increasing rapidly.

Compared to countries with similar wage levels and at a similar stage of development or even less developed countries, Brazil has a very unfavourable situation with regard to access to higher education, with an overall schooling rate of 13%[12]. This rate is three times less than that of Argentina (39%) and twice as low as Chile's (27%). In this respect Brazil is also clearly at a disadvantage with regard to Bolivia (23%). Another parameter for international comparison used by the Organisation for Economic Co-operation and Development (OECD) is the net rate of schooling within the 18-21-year-old age group. In Brazil this rate is only 6.1%, 22.4% in Argentina and 11.3% in Uruguay, as opposed to an average of 23.3% in OECD countries[13].

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[12] The Overall Schooling Rate when referring to higher education, shows the relationship between the total number of enrolments, independent of the students' age group and the total number of the population within the 20-24-year-old age group.
[13] *Education at a Glance*. Annual Report published by the OECD.

Development of Enrolment in Higher Education by Administrative Organ Brazil 1980-1998

Year	Total	Federal	State	Municipal	Private
1980	1,377,286	316,715	109,252	66,265	885,054
1985	1,367,609	326,522	146,816	83,342	810,929
1990	1,540,080	308,867	194,417	75,341	961,455
1991	1,565,056	320,135	202,315	83,286	959,320
1992	1,535,788	325,884	210,133	93,645	906,126
1993	1,594,668	344,387	216,535	92,594	941,152
1994	1,661,034	363,543	231,936	94,971	970,584
1995	1,759,703	367,531	239,215	93,794	1,059,163
1996	1,868,529	388,987	243,101	103,339	1,133,102
1997	1,945,615	395,833	253,678	109,671	1,186,433
1998	2,125,958	408,640	274,934	121,155	1,321,229
94/98 (%)	28.0	12.4	18.5	27.6	36.1

Source: INEP/MEC

It is clear, therefore, that Brazil's ability to provide higher education is much less than that of other countries. The size of the system has also become inadequate to attend to the needs of the country's process of social and economic development. The new thrust in expansion in secondary teaching and the increasing selectivity of the labour market - which is demanding a workforce of high professional quality - tend to exercise an ever-increasing pressure on higher education, demanding an increase in places, diversification of courses, flexibility of curricula, improvement in teaching quality and partnerships with the production sector. These are the great challenges that higher education has to face in order to cope with the socio-economic and technological changes of the end of the 20th century.

Notwithstanding all the problems that have been described, the balance sheet of the last ten years is a positive one for Brazilian education, showing a leap forward in terms of quality of primary education, improved school throughput, reduced rates of repetition and truancy, increased pass rates and numbers of pupils graduating. In secondary education also we see a promising picture, especially in the rapid growth of enrolments and the steady improvement of transfer indicators. Higher education, which went through a period of stagnation in the 80s, has begun to grow again now that it is under pressure from the numbers of secondary school graduates.

In this context a new worry has emerged that is central to the educational policy debate: quality improvement and the search for equity. Knowing what how learners learn, which schools are the most effective and why they have better performance; discussion of the new profile of the teacher and the organisational pattern of the school; creating mechanisms that guarantee equalisation of the conditions of provision of state education and that encourage school success: these are the new themes that have begun to occupy the agenda of educational policies in the 90s.

III - The new focus of educational policies in the 90s

The 1990s represent a new stage in the design of educational policies in Brazil. Three factors have been decisive in bringing about this change in the profile of government actions in the area of education. First, a reasonable degree of agreement has been reached in diagnosing the causes behind the lack of effectiveness of the school systems. Second, a great convergence of the actions developed by different levels of government has evolved, above all in regard to primary education. Third, society has started to give greater value to education, organising itself to demand better quality teaching in state schools.

With different rhythms and emphases, respecting local and regional differences, we can claim that Brazil has now passed the stage of giving exclusive priority to a policy of increasing access to school and therefore of prioritising investment in physical plant[14]. The quest for quality and the promotion of greater equity in the system have come to occupy a major role in the new agenda of policies of primary education.

These new guidelines are linked to the main policies and programmes implemented by the federal government since 1995 and have also come to direct the plans of states and municipalities in the area of education. A common axis of the actions of the three levels of government, is seen in a strong emphasis on decentralisation of educational management, directed towards promoting and strengthening school autonomy.

Recent institutional reforms in the educational sphere - consolidated by means of Constitutional Amendment No. 14 of 12th September, 1996; by creating the Fund for Maintenance and Development of Primary Education and of Teacher Status (FUNDEF); by the passing of the new Law of Guidelines and Foundations of National Education (Law No. 9,394/96) and by the re-organisation and re-defining of the terms of reference of the National Council for Education (CNE) - have reinforced the role of the federal government in co-ordinating national policies at the same time as they have re-defined the responsibilities of the states and municipalities in offering educational services[15]. In addition, mechanisms were created to encourage the partnership and co-operation of the three spheres of government around a common theme: the improvement of the quality of learning and the quest for the effective school.

The leadership of the federal government in the field of policies of promoting equity and quality in the educational system was only taken on with any degree of boldness in the 90s and has consolidated itself in the last four years. At the same time the emergence of the states and municipalities as important actors in the process of formulating and implementing national policies in basic education - a phenomenon which is integral to the development and the re-democratisation of the country - has

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[14] It is evident, however, that the problem of physical plant is far from being satisfactorily solved, since the unacceptable state of buildings and of infra-structure of the great majority of state schools in the country is a fact that cannot be ignored in establishing policies for improving the quality of teaching. Cf. *Physical Characteristics of Schools (Caracterização física das escolas)* INEP/MEC: Brasília, 1998.

[15] In accordance with the new formulation given Constitutional Amendment No. 14 to Art. 211 of the Federal Constitution, the municipalities must participate principally in primary and infant education, leaving the states and the Federal District to concentrate on secondary education. It lays down also that the states and municipalities must establish means of co-operation to ensure the universalisation of compulsory education. The Union, for its part, is required to exercise, in terms of education, "a re-distributive and supplementary role, so as to guarantee equity of educational opportunities and minimum standard of quality of teaching by means of technical and financial assistance to the States, the Federal District and the Municipalities".

contributed to MEC itself taking on a new role, concentrating on activating and monitoring these policies[16].

This new approach still includes a strong emphasis on developing national systems of evaluation and educational indicators, reaching into all levels of teaching. Thus the federal government has ceased to directly carry out initiatives - especially in the area of basic education - and has adopted as major intervention strategies in the educational system, the decentralisation of its programmes and co-operation with the states and municipalities.

The state and municipal teaching systems in their turn, have started to promote new teaching methods including within their priorities the development of management and implementation of evaluation instruments. In the management area, among the major improvements we note particularly the introduction of new means of selecting heads, combining elective methods with selection criteria based on the qualifications and professional competence of candidates, which has led to the strengthening of the administrative and pedagogic autonomy of the school. This practice has also encouraged planning and the participation of parents and teachers in school management, strengthening the link between school and community. Thus the school has come to take a greater responsibility for its own results.

In the area of evaluation we see an important cultural change among the directors and managers of school systems, who have come to recognise external evaluation procedures applied to the schools as an indispensable tool for monitoring policies. This new position has not only led to state and municipal educational groups participating in nation-wide evaluation projects, especially that of the National System for Evaluation of Basic Education (SAEB), but also to the efforts that many teaching groups have undertaken to create their own evaluation systems[17]. The emphasis on management and evaluation stands out as the central component of the reforms carried out by state and municipal educational systems that have proved to be the most successful in the 90s.

Principal federal government policies in the period 1995-1998

While recognising the role of the states and municipalities in the provision of basic education, the federal government has directed national policies towards promoting improvement of quality and equity, the following initiatives being the most important since 1995:

Policies of decentralisation, promotion of equity and strengthening the state schools

- the creation and implementation of FUNDEF, which establishes greater equity in the distribution of educational resources - thus guaranteeing suitable conditions

[16] The National Council of Secretaries of Education (Conselho Nacional de Secretários de Educação - CONSED), a forum organised by the secretaries of education of the states and the Federal District, and the National Union of Municipal Directors of Education (União Nacional de Dirigentes de Educação - UNDIME), have been important partners of the federal government in promoting national policies of basic education.

[17] Some states are further ahead in developing evaluation mechanisms to monitor the performance of their system and to subsidise their educational policies. This is the case of São Paulo, Minas Gerais and Paraná.

for improving teachers' salaries and re-establishing the social prestige of the profession - and which ensures an annual minimum investment per pupil, fixed at R$315.00 in 1999, to be made up by the federal government in those states where this sum per capita is not attained[18];

- the Money in School Programme, following the policy of decentralisation, enables the automatic transfer of money from the resources of the federal quota of the Education-Salary to state schools, which guarantees greater efficiency in its application as well as strengthening the school's financial autonomy and encouraging the organisation and participation of the community in creating the educational project and school management[19];
- the spread and decentralisation of the National School Meals Programme (PNAE), ensuring the regularity of tax revenue transfers to the states and municipalities and greater accountability in applying the resources;
- financing initiatives focusing on the poorest regions in the country that have the greatest needs in the educational area, by means of the Northeast Project and of "Fundescola", that support the development of primary education[20], and of the Literacy Solidarity Programme, which serves municipalities with the greatest levels of illiteracy, offering the chance of schooling to young people and adults;
- the development of a modern and efficient system of educational information that reaches all levels of teaching and produces quantitative and qualitative indicators to support government action in different areas of educational management[21]

Policies for improving the quality of basic education

- improvement and consolidation of the National System for Evaluation of Basic Education (SAEB) that provides qualitative data on the effectiveness of primary

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[18] Constitutional Amendment No 14, which instituted this fund, states that the states and municipalities should assign to primary education over the next ten years, at least 60% of the resources linked to education. That is, 15% of all state and municipal revenue, including those coming from inter-government dealings, should be devoted to compulsory education. FUNDEF is made up, in each area of the Federation, of 15% of resources: of the State Participation Fund (Fundo de Participação dos Estados - FPE); of the Municipality Participation Fund (Fundo de Participação dos Municipios - FPM); of that part of the Industrial Products Tax (Imposto sobre Produtos Industrializados - IPI) going to the states and the Federal District; of that part of the Tax on the Circulation of Goods and Services (Imposto sobre Circulação de Mercadorias e Serviços - ICMS) going to the Federal District, the states and the municipalities; financial compensation paid by central government to states and the municipalities for exemption of exports - Complementary Law No. 87, of 1996. These resources are divided between the state and its municipalities according to the number of enrolments in the respective primary educational systems. From what each one receives, at least 60%, must be directed to paying teachers who do not have classrooms.

[19] Started in 1995, this programme has transferred more than R$ 1 billion to about 137,000 schools in the last four years, benefiting on average 29 million pupils per year. The money can be applied to the following ends: maintenance, conservation and minor repairs in the school building; acquisition of consumables necessary for running the school; professional qualification and training of staff and acquisition of teaching materials.

[20] These two programmes are partly financed by the World Bank (BIRD). The Northeast Basic Education Programme (Projeto de Educação Básica para o Nordeste), which will end this year, has in the last six years, invested about R$800 million in the nine states in the region. The School Consolidation Fund (Fundo de Fortalecimento da Escola), which began to be implemented in 1998, anticipates spending US$1.3 billion in the next six years. The first stage will concentrate on the North and Centre-West regions. From 1999 the programme will be extended to the Northeast region.

[21] This initiative was consolidated by the re-structuring of INEP in 1995. With the change, carried out by means of Law No. 2,448 of 14th March, 1997, INEP was strengthened and received new powers aimed at carrying out educational censuses and at implementing national evaluation systems. The information produced by these initiatives is widely disseminated, both by means of traditional publications and by new electronic methods, especially the page INEP maintains on the Internet (www.inep.gov.br).

and secondary school systems - given as a measure of pupil performance - and which identifies a group of factors that combine in the learning process, thus supporting policies of improving teaching quality;

- pedagogical evaluation of the quality of school textbooks and the preparation and distribution of the *Guide to Evaluating the Textbook* which helps the teacher's choice by confronting serious questions such as the reproduction of theoretical errors and discriminatory and prejudiced points of view;
- the discussion, formulation and diffusion of references and standards of quality by means of the National Curriculum Parameters (Parâmetros Curriculares Nacionais - PCNs) for primary education; through the Curriculum Proposal for Educating Young People and Adults; through the Curriculum Reference Book for Infant Education and the Education of Indigenous Peoples, which bring to teaching systems and to schools support that encourages the renovation and up-dating of curricula;
- the elaboration and diffusion of References for Teacher Training, focusing on training teachers for infant schools and the early years of primary school, directing content to the new professional identity demanded by the LDB and offering support in decision-making on the part of managers of education systems and training institutions;
- the Accelerated Learning Programme, which encourages and supports efforts of teaching systems to even out the passage through the educational process, tackling one of the main obstacles to improving the quality of education, the high level of age-to-grade mis-match, the principal causes of which are repetition and truancy;
- the TV-School Programme, which allows teachers in the state primary school system to gain in-service training and up-dating of skills, as well as distributing videos that can be used to support classroom activities;
- the National Programme of Information Technology in Schools (Proinfo), which aims to give public schools access to new technologies and which encourages in-service teacher training programmes by means of a network of Educational Technology Nuclei (NTEs), carried out in partnership with state secretaries of education;
- launching the reform of Further Education Programme which, by becoming separate from secondary education, was able to increase the supply of places, flexibility of curricula and diversification of courses in order to fit them to the new demands of the labour market;
- drawing up and approving secondary education reform, defining curricular requirements in line with the new demands of the information society and of the world of work and establishing the necessary requisites to allow this level of education to expand with quality and to fulfil the role of completing the educational process allocated to it by the new LDB;
- introducing the National Secondary School Examination (ENEM), with the aim of evaluating pupil performance at the end of primary education, assessing the development of basic abilities and the practices of citizenship and giving guidance for the direction of further choices, both in relation to the labour market and to continued studies;
- the permanent attempt to achieve social mobilisation and to build strategic partnerships through the "Wake up Brazil! It's time for school!" programme, the

"Every Child in School" programme and other activating proposals that have helped to speed up changes.

Policies for expanding and improving higher education

- the re-organisation of the higher education system (Decree No 2,306/97), based on the principles laid down by the Law of Guidelines and Foundations of National Education, introducing among others, the following changes: institutional diversity, crating new legal structures in University Centres and Integrated Faculties; encouraging the expansion of student places, granting greater freedom to create new courses to non-university institutions which are outstanding for their quality of secondary education according to periodic evaluations; the guarantee of the right of students to be informed of the conditions and performance of institutions, making it obligatory to publish an annual general prospectus showing courses offered, profile of the teaching body and the infra-structure available (laboratories, libraries, etc.);
- consolidating the evaluation system for higher education - through the founding of the National Course Examination (ENC), otherwise known as the "Provão" ("Big Exam"), and by strengthening the Higher Education Secretariat's commissions of specialists to investigate the state of supply - setting up transparent mechanisms to evaluate undergraduate teaching throughout the country and supplying new parameters for re-accrediting institutions and approving courses;
- developing the new Guidelines and Foundations for Undergraduate Curricula - by means of a wide-ranging process of debates begun in the first half of 1998, which involved higher education institutions, academic bodies and professional organisations[22] - directed towards the following objectives: expanding and improving courses on offer; widening and integration different areas of knowledge; creating flexibility in curricula; working against dropping out and increasing the ability of the learner to take decisions in designing his/her academic curriculum;
- creating the Teaching Stimulus Bonus (GED) - which meant pay rises between 20% and 50%, based on qualifications, teaching hours, academic production and teaching performance - a benefit that was offered to all the teachers in federal higher education institutions (IFES) as an encouragement to improving teaching at undergraduate level and an appreciation of the principles of academic dedication and merit;
- incentives to improving teaching through continuing normal programmes of support for teaching qualifications for higher education (Social Demand, PICDT and Scholarships Abroad), extending the Capes scholarship programme[23] and adopting the policy of filling posts in IFES made available by early retirements, by means of the authorising of 8,871 public examinations between January and April, 1998, thus allowing a renewal of 21% of the total number of active teachers and an increase in the proportion of doctoral level staff from 22% to 29% in the faculties of these institutions, with the proportion of master's level staff remaining

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[22] More than 800 suggestions were received which are being analysed and incorporated into the proposal that will be sent by MEC to the National Education Council.

[23] The number of scholarships at master's doctoral and post-doctoral levels granted by Capes increased from 16,902 in 1994 to 19,764 in 1997; during the same period the number of scholarships abroad grew from 1,535 to 1,996.

unchanged and the numbers of specialists reduced (22% to 18%), as was that of graduates (18% to 15%);

- making more investments in the repair and improvement of IFES infra-structure, enabling the up-dating of library stocks at undergraduate level, installing information networks and acquiring equipment for undergraduate laboratories and university hospitals;
- defining criteria for the process of choosing university managers and the composition of committees (Law No. 9,192/95), making the process more accountable and democratic, strengthening the role of the faculty and reserving to the latter a proportion not less than 70% in any of the stages of making up candidate lists;
- reformulating the post-graduate evaluation system, working towards improving and expanding it with quite impressive results both in relation to numbers of courses - which grew from 1,713 to 2,014 between 1994 and 1997 - and to the number of completions per year - with an increase in the numbers of qualified students from 7,627 masters' degrees and 2,081 doctorates in 1994, to 11,920 masters' degrees and 3,620 doctorates in 1997[24]

Also included as one of the highest priorities in the agenda of higher education policies, is the definition of the legal landmark that will allow the implementation of complete autonomy, encompassing administrative and financial areas of the federal universities. The search for consensus in this debate, which involved very complex questions, is crucial to eliminating one of the greatest obstacles to developing the public university system. As a counterbalance to autonomy, mechanisms must be created to permit society to demand greater efficiency, transparency and social responsibility from the IFES. Freedom from the bonds that immobilise the management of budget and personnel in the public sector, is vital to allow the public universities to increase their offer of places, to avoid having spare capacity and improving student/teacher and student administrator relations, until they achieve the standards of the best international systems, without sacrificing quality in the mean while.

MEC's guidelines for higher education in the next four years[25], have as their most urgent plans in the short and medium term, the adoption of the following measures: implementation of the new process of re-accreditation of teaching institutions, based on the results of the evaluations and on the system of quality indicators set up on the foundation of data up-dated annually by the Higher Education Census, impose the new curricular structure, making curricula more flexible and diversifying subjects offered, including the creation of sequenced courses as set out in the LDB; re-organising and amplifying the educational credit programme, linking it to the process of evaluating private institutions, combining criteria of income and educational performance in order to benefit 15% of students in higher education institutions; to stimulate distance learning and the use of technology in teaching in order to increase opportunities in higher education without prejudicing the quality of learning.

[24] The readiness of Capes to link the granting of scholarships to course results, measured in terms of the qualification of masters' degrees and doctorates, had a great effect on the increase in the number of passes recorded in this period.

[25] *Avança, Brasil: proposta do governo* Fernando Henrique Cardoso - Brasília. 1998 pp. 125-130

The redistributing impact of FUNDEF

The main educational reform instituted in Brazil in the 90s is the Fund for Maintenance and Development of Primary Education and Teacher Status (FUNDEF), created by Constitutional Amendment No. 14 in 1996 and inaugurated on the 1st January, 1998. This policy deserves, by reason of its importance, to be highlighted as an example of the new focus of pubic education policies since it touches on three crucial variables for improving this level of teaching:

- it connects the decentralisation of primary education and the division of duties between states and municipalities, to the redistribution of resources based on the number of pupils served by the respective education systems;
- it guarantees a minimum cost per pupil as a means of reducing regional and inter-state inequalities, providing greater equity in distributing public resources associated with the development of primary education;
- it establishes the provision of at least 60% of resources for paying the salaries of serving teachers, it encourages the adoption of career plans and stimulates investment in teacher training.

Until the creation of FUNDEF there was no correspondence between the share of tax receipts between states and municipalities and the division of educational costs, especially with regard to the supply of compulsory primary education. Thus there was no incentive for the "collaborative regime" recommended by the Constitution and encouraged by the LDB. This situation produced two serious consequences: on the one hand it favoured non-observance of the constitutional obligation to "apply at least 25% of tax receipts, including those accruing from transfer, to maintaining and developing teaching"[26]; on the other hand it established notable differences between the state and municipal educational systems, in defiance of the principle of equity in providing a basic service to the people.

In practice, there were found to be situations of rich municipalities with few pupils in their system, since the state schools supplied the provision and, at the other extreme, poor municipalities with many pupils and insufficient resources to guarantee the provision of compulsory education with the minimum levels of quality. FUNDEF attacks one of the principal roots of inequity in the Brazilian education system, which is the unsatisfactory distribution of resources. This distortion contributes to crystallising regional inequities and the contrasts between public systems of primary education, both state and municipal - which are responsible for attending to 32.4 million pupils, according to the 1998 School Census.

During its first year of operation FUNDEF re-distributed the impressive sum of R$ 13.3 billion[27]. The states, which in 1998 had been in charge of 59.3% of enrolments in public primary education, kept R$ 5.1 billion of these resources (61.6%) while the municipalities, which provided for 40.7% of pupils, received R$ 5.1 billion

[26] Art. 212 of the Federal Constitution

[27] The resources that make up FUNDEF, as set out in Constitutional Amendment No. 14, come from 15% of the following sources: Tax on the Circulation of Goods and Services (ICMS); State Participation Fund (FPE); Municipal Participation Fund (FPM); Tax on Industrialised Products, proportional to exports (IPIexp); and the financial compensation to states for exemption of exports, in accordance with Complementary Law No. 87/96 (the Kandir Law). Also making up part of the increased re-distribution by FUNDEF were the resources supplied by central government - which came to R$ 524.2 million - to make up the shortfall in those states which could not achieve the minimum cost per pupil of R$ 315.00 - Pará, Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco and Piauí.

(38.4%). According estimates for 1999, the municipalities' share of the division of the Fund's cake should rise by 43%, a reflection of the accelerated process of municipalisation of primary education. It is noticeable therefore, that FUNDEF has ensured quite a balanced division of resources between the states and the municipalities, correcting the previous distortion.

The municipal systems were the main beneficiaries, receiving a significant increase in resources that permitted an impressive improvement in cost per pupil/year in relation to the previous situation. Of the 5,506 municipalities in Brazil, 2,703 received additional resources, totalling about R$ 2 billion. This group of municipalities is responsible for the education of 10.9 million pupils. It is important to note that within the total of Brazilian municipalities there were 2,159 (39%) that lacked sufficient resources to give primary education the R$ 3215.00 cost per pupil/year that the FUNDEF legislation had fixed as the national baseline. In an even more penurious condition were 921 municipalities whose *per capita* value was less than R$ 150.00 per pupil/year. With the resources injected by FUNDEF into the education systems of these 2,159 municipalities the pupil/year value showed an average increase of 129%.

Financial Effects of FUNDEF in Municipalities with a Pupil/Year Cost Less than R$315,00 – 1998

Pupil/Year Cost (*)	Municipalities		Pupils/97		Pupil/Year Cost (R$)		Gross Additional Receipts (R$ million)	Variation	
	Nº	%	Nº	%	Before FUNDEF (A)	With FUNDEF (B)		In Cost Per Pupil (B-A)	% (B/A)
Up to 100	308	5.6	1,740,209	14.0	77.84	324.91	429.9	247.07	317
>100<=150	613	11.1	2,192,551	17.6	124.25	335.46	463.1	211.21	170
>150<=200	474	8.6	2,006,045	16.1	178.44	437.09	518.8	258.64	145
>200<=250	370	6.7	1,193,002	9.7	225.78	389.31	195.1	163.54	72
>250<=315 (**)	394	7.1	1,125,758	9.0	281.36	405.74	140.0	124.38	44
SUB-TOTAL	2,159	39.2	8,257,565	66.4	163.72	375.29	1,746,9	211.57	129
OTHER MUNIC.	3,347	60.8	4,178,963	33.6					
OVERALL TOTAL	5,506	100.0	12,436,528	100.0					

Sources: Resources: MEC/SAEDE Figures; Municipalities: IBGE; Pupils: School Census

(*) Calculated for each municipality by dividing the value of FUNDEF's contribution (15% from FPM, FPE, ICMS, IPIexp, e LC 87/96), by the total number of pupils in primary education (value prior to FUNDEF effects).

(**) The minimum national cost per pupil/year in 1998 was R$ 315.00

The redistributive impact of the Fund was felt more in the municipalities of the Northeast and Northern regions where the greatest needs in the area of education were found. There was also found to be a significant supply of resources to a group of municipalities in eight metropolitan regions in the country, excluding state capitals, in which provision offered by the respective state systems was significant[28]. Thus,

[28] FUNDEF provided financial assistance to the municipal education systems of the metropolitan areas of Fortaleza (CE), Belém (PA), Vitória (ES), Recife (PE), Curitiba (PR), Rio de Janeiro (RJ), Natal (RN) and Porto Alegre (RS). In the metropolitan areas of Belo Horizonte and São Paulo, the Funds effect was lessened by the supply of enrolments from the respective state systems, with resources being transferred from the municipalities to the state government.

this reform brought the greatest benefit to the poorest areas of the country, which have the greatest number of children out of school and the worst quality indicators in primary education.

The improvement in the profile of resource distribution brought about by FUNDEF has also been seen in increased teacher salaries, as a direct result of the obligation imposed on the states and municipalities to direct at least 60% of resources to this end. According to research carried out by MEC, teachers' pay rose nationally on average 12.9% between December 1997 and August 1998, taking into account state and municipal education systems and all levels of training al all working days. When we dissect the data by administrative authority we see that average salary rises were greatest in the municipal systems (18.4%) in comparison to the state systems (7.7%). From the regional point of view the greatest average rise was in the municipal systems of the Northeast (49.6%).

Another important change brought about by FUNDEF was the improvement in the profile of teaching in public primary education. Between 1997 and 1998 the number of unqualified teachers in various categories fell considerably. In fact last year there was a drop of 26% in the number of teachers who had not completed primary education and a 38% fall in those who had secondary level training in teaching. At the same time there was a rise in the number of teachers with higher levels of education - with secondary level in teaching and fully trained. This tendency, which had already been registered in the latest School Censuses, was speeded up when FUNDEF was founded, and was one of the latter's most striking successes.

Finally, it is worth noting that the Fund had a positive effect on the growth of enrolment in primary education[29]. The criterion of redistribution of resources - based on the number of learners provided for by the state and municipal systems - stimulated, by itself, the effort of those education systems to enrol all children of school age. In this way the total enrolments in public primary education showed an increase of 6% from 1997 to 1998. In absolute terms the number of students grew from 30.5 million in 1997 to 32.4 million in 1998. Enrolments increased more noticeably in the Northeast (12.1%) and the Northern (7.7%) regions, which had shown the greatest deficits in coverage in compulsory education.

Another phenomenon associated with the actions begun by FUNDEF has been the accelerated municipalisation of primary education. Between 1997 and 1998 enrolments in municipal systems leaped 21.5%, going from 12.4 million pupils to 15.1 million. In the same period enrolment in state systems fell by 4.6%, with student numbers falling from 18.1 million to 17.3 million. The greatest rates of growth in municipal network growth were registered in the Northern (40.2%) and Northeastern (22.1%) regions. This performance reflects both the process of municipalisation of schools, which is found more in those regions, and the effort to enrol more pupils. By encouraging the municipalities to take on a greater commitment to primary education, it was hoped that FUNDEF would induce a revival in the process of decentralisation, which had stagnated in the 90s after vigorous activity in the 80s.

[29] This result was brought about by the "Every Child in School" Programme, launched by MEC in the second half of 1997 with the aim of co-ordinating the efforts of the three levels of government and mobilising society to guarantee universal school attendance in the 7-14 age-group. This campaign reached its climax in National Enrolment Week, from the 7th to 14th February, 1998 and which resulted in about 700,000 enrolments.

New Perspectives for Brazilian education

Taken as a whole, the results attained by FUNDEF in its first year of operation suggest that this reform has achieved its main objectives. From the point of view of redistribution, it has resulted in a clear improvement both in terms of ensuring greater equity and in terms of guaranteeing more transparency and efficiency in management of educational resources[30]. There has also been a positive result in the raising of teachers' pay levels and in the increase of expenses on teacher training, school transport, repair and enlarging of schools and the acquisition of teaching equipment and materials. It can thus be seen that FUNDEF has begun a new stage in the process of development in primary education, providing solutions to some of its major dilemmas. Given its ten-year life-span, the initial results of this reform will be broadened and consolidated in the coming years, with encouraging prospects for primary education.

All these actions converge on the main strategic objective: building a public education system that is democratic and has quality, capable of supporting the country's sustainable development in the 21st century. The advances to this end were quite significant in the 90s, drawing up a new scenario for Brazilian education, as we have seen from the indicators presented and analysed in the previous section. However, we must also recognise that what was inherited from the past still exerts a great pressure, above all in the face of pent-up demands resulting from the omissions of the State for many years. For Brazil to overcome the accumulated delay and at the same time to get in step with the modern world, requires a high level of public investment in primary education and the continuity of the policies that have been implemented.

The positive balance of national policies on primary education in the last ten years is mainly due to the level of co-operation achieved between the federal government, the states and the municipalities. Another important factor that has contributed to give the reforms a high profile has been the growing importance of educational topics in the media, which has created greater participation on the part of society in the debate on pubic policies and on the performance of teaching institutions. The up-to-date publication of indicators and results of national evaluations has helped to the attention of the media and to capture the interest of public opinion[31]. In the next section we shall discuss the impact of evaluations on the education systems and their validity as a means of encouraging policies of improving the quality of education.

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[30] FUNDEF's resources are managed in an exclusive bank account, which enables their control by councils, legislative assemblies and national auditors. In addition, Law No. 9,424/96 requires there to be instituted in each type of government a Council for Regulation and Social Control concerned with the sharing, transfer and application of the Fund's resources. Research carried out by MEC in August, 1998 indicated that 80.6% of municipalities had already created and installed this council.

[31] The space given by the press to covering educational topics showed an increase of more than 300% in the first half of 1998 in relation to the same period in the previous year, according to the Research paper ANDI - Childhood in the Media. Thus, for the first time the subject has reached first place in the topics most touched on since this study began to be carried out in June, 1996. The research, done by the News Agency for Children's Rights (Agência de Notícias dos Direitos da Infância - ANDI), in partnership with the Ayrton Senna Institute and UNICEF, studied 51 newspapers from all regions of the country and eight magazines with nation-wide circulations.

IV - Evaluation as an inducement to improving the quality of education

In the 90s, especially in the last four years, educational evaluation has taken a very important position in the public policy agenda of Brazilian education, accompanying a trend that other countries have been following since the 70s. There exists today a united and high level of agreement among managers, educationists and other specialists on the relevance of evaluation systems to direct educational reform and above all, to encourage policies for improving the quality of teaching. For this reason there has been an increasing preoccupation with improving the mechanisms of monitoring the performance of education systems focusing on pupils' learning and on the various factors associated with school output.

The agreement concerning the strategic importance of looking more deeply into the levels of quality in education as well as the variables that affect the results of the educational process, have caused educational evaluation to be chosen by different groups, as a priority area for multilateral co-operation for educational development. With the support of international associations and organisations, various projects that promote international comparative studies have flourished, with the aim of generating information to support government decisions on educational policy[32].

This co-operation has tended to spread within the hemisphere since the implementation of the Action Plan in Education that was approved by the last meeting of heads of state at the Summit of the Americas, held in Santiago, Chile, in 1998. At the suggestion of Brazil, the document included the proposal to develop an inter-American educational evaluation project, with the aim of promoting and strengthening national evaluation systems, facilitating the exchange of experiences and generating the standards that will permit comparison of pupil performance[33].

The development of national evaluation systems

In the last four years MEC has put a great emphasis on educational evaluation policy, taking on the responsibility demanded by the LDB of "safeguarding the national system of evaluating school output at primary, secondary and higher levels, in co-operation with the teaching systems, aiming at a definition of priorities and the improvement of teaching quality"[34]. The progress achieved in this area are worth noting, especially the following: consolidation of the National System for Evaluation of Basic Education (SAEB); introduction of the National Examination for Secondary Education (ENEM) and of the National Course Examination (ENC); and finally, re-structuring of the post-graduate evaluation system.

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[32] In 1997 Brazil participated in the First Comparative International Study carried out by the Latin American Laboratory for Evaluation and Quality in Education, linked to the Regional Office for Education for Latin America and the Caribbean (OREALC/UNESCO). This study, in which 13 of the region's countries took part, aimed to evaluate the levels of learning in language and mathematics and the factors associated with them, of 3rd and 4th grade primary school pupils. Another, ongoing, project in which Brazil is taking part, it the International Student Evaluation Programme (PISA), co-ordinated by the Organisation for Economic Co-operation and Development (OECD). This project, involving about 30 countries, aims to evaluate the performance of 15-year-old pupils and to produce indicators on the effectiveness of educational systems. Three batteries of tests will be applied at three-yearly intervals, the first in the year 2000.

[33] The recent bilateral co-operation agreements in the area of education signed by Brazil with the USA and Great Britain also pinpoint evaluation as one of the main areas of interest for the development of partnerships and technical co-operation.

[34] Cf. Art. 9, section VI, of Law No. 9,394 of the 24th December, 1996

The SAEB is a large-scale evaluation, carried out on a basis of sampling, applied to pupils at the end of primary education (4th and 8th grades) and of secondary education (3rd grade). As well as measuring academic performance the SAEB also provides information about pupils' socio-economic and cultural profiles, as well as about their study habits. Another important group of variables is produced by means of giving questionnaires to teachers (concerning teaching profile and practice) and headteachers (concerning the profile and practices of school management). The rest of this wide-ranging survey is made up of data on the equipment available and the physical nature and state of repair of the schools. This information, which covers the main elements of the teaching and learning process, gives an idea of the performance attained by pupils and identifies the factors associated with it.

The ENEM, the initiative that completes the set of evaluation instruments created by MEC, to introduce and direct the efforts of improving the quality of education at the different levels of teaching[35], works in conjunction with the new proposal National Curricular Guidelines for Secondary Education, approved by the National Council for Education through Resolution No. 15/98. Its main aim is to evaluate pupil performance at the end of basic schooling[36].

We are dealing, therefore, with an advanced proposal, both in its transdisciplinary nature and in its emphasis on the "exit profile" of secondary school leavers, thus strengthening the final phase of this level of education. While the SAEB aims to evaluate teaching systems, the ENEM contributes an evaluation of individual performance, providing guidance for continued study or for entry into the labour market. For this reason the ENEM is voluntary and its target population are those finishing and leaving secondary school.

Set up in 1996, the "Provão" (Big Exam) has already evaluated ten undergraduate courses - Law, Administration, Civil Engineering, Chemical Engineering, Mechanical Engineering, Veterinary Medicine, Dentistry, Language/literature, Mathematics and Journalism - and has initiated a lively debate on the shortcomings of higher education in the country and stimulated the relevant institutions to invest in the qualification of teaching staff and improving their physical assets in an attempt to raise the level of the courses on offer. This examination is legally compulsory for all students who are finishing the annually evaluated undergraduate courses.

In spite of its prominence, the "Provão" is not the only external evaluation instrument used by MEC to assess higher education courses and institutions, as required by Law No. 9,131/95. The undergraduate evaluation system embraces a complex battery of indicators that include the results of evaluations and data collected by the Higher Education Census. In addition, MEC has been carrying out, through its commissions of specialists in the Secretariat for Higher Education (SESU), an *in loco* evaluation of the situation of places being offered at undergraduate level[37].

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[35] ENEM was first applied on 30th August, 1998 in184 municipalities in Brazil, including all the state capitals, and involving 115,221 candidates.

[36] National Institute for Educational Studies and Research. *National Secondary Education Examination: Basic Document. 1998.*

[37] These commissions of subject specialists have focused their visits on courses that have not been evaluated by the "Provão", specifically with the aim of identifying the shortcomings that hamper average student output. The commissions analyse the faculty's teaching qualifications, the organisation of teaching and learning and the physical assets. They have already visited 811 courses. The results of these investigations will also be incorporated into the system of indicators that will serve to direct the process of re-accreditation of institutions and approval of courses.

The evaluation system at post-graduate level is more traditional and is lodged among the mechanisms developed by MEC to evaluate different levels of teaching. This evaluative practice has been one of the main reasons why Brazil has been able to create a diversified system at post-graduate level, which is internationally recognised for the high standards it has reached. In spite of being respected, the post-graduate evaluation model had begun to lose, over time, its ability to discriminate between programmes in relation to the classification scales used. As a large proportion of the courses were given grades of A and B, it was not possible to identify which programmes really had levels of academic excellence comparable to international norms. For this reason, this system was subjected to an external evaluation carried out by international specialists with the active participation of the Brazilian academic community. Based on this diagnosis, Capes led a process of reformulating the post-graduate system, introducing a new scale of classification, based on more rigorous criteria. In practice this meant adjusting the system to a new phase of development in post-graduate work.

Although they may be rather new, above all when compared with the traditions in other countries in this area, Brazil's developing national evaluation systems are innovatory in several aspects, both methodological and institutional. They represent, therefore, important steps in improving the information available concerning the learning of students at the different levels of teaching and above all, steps in the introduction of a culture of evaluation at the several stages of education. The impact in the media of the results achieved by these evaluations has furthermore contributed to introduce a concern with improving educational quality into the public agenda.

The large-scale evaluation systems such as the SAEB help in the search for answers to some of the main questions met by decision-makers in education policies, enabling them to identify priorities and alternatives in order to increase the efficiency of initiatives and to optimise investment in this area. In this way, these research results try to discover what learners are actually learning, to indicate what we should expect learners to learn in the school careers in the light of the curricula proposed, and to identify which are the factors in school or outside it that help or limit the acquisition of the hoped-for competences.

We see, therefore, that evaluation systems can fulfil an important role when they manage to establish a close connection between the effort of education networks to provide quality education. Among the reasons that justify the emphasis that is being given to carrying out periodical studies on student learning and the associated factors that affect it, we may highlight the following[38]:

- international competitiveness in the economic field and the impact of technological change on production have come to demand that people achieve better and higher levels of schooling;
- the quality of teaching (taking into account its elements of equity, efficiency and excellence) is an aim sought by the majority of countries and which can be permanently evaluated and monitored from a base of objective data;
- the increasing autonomy and decentralisation of teaching systems has necessitated the creation of national evaluation systems that permit the comparison of results

[38] The Latin American Laboratory for Educational Evaluation and Quality: *Structure, methodology and implementation of research into associated factors in the First International Comparative Study.* Document presented at the 6th National Co-ordinators' Meeting - Havana, Cuba, 17th -19th March, 1999.

against minimum quality standards and guiding policies to correct regional inequalities;

- regional integration in terms of Mercosul, together with globalisation, require greater educational uniformity to ensure Brazil's independent and competitive entry;
- the growth in public expenditure on education and the mobilisation of society to demand greater accountability in administrative areas as well as in schools, have made it necessary to bear in mind other educational indicators in addition to school output.

The National System for Evaluation of Basic Education (SAEB)

Within this challenging context, Brazil proposed to develop in the 90s a national evaluation system capable of producing information on the performance of basic education in the whole country, encompassing the different conditions found in state and municipal teaching systems. Out of this proposal came the SAEB, whose aim is to evaluate the effectiveness of teaching systems, with a focus on quality, efficiency and equity. It is applied to country-wide sample of pupils representing each one of the 27 units comprising the Bazilian federation[39]. Participation is still voluntary, which shows that education system managers recognise the importance of this tool to monitor educational policies.

Since its creation, the SAEB's general characteristics both in terms of objectives, structure and conception, have remained constant. However, after 1995 important methodological changes were introduced, mainly with the aim of establishing subject-specific proficiency scales throughout the three grades being evaluated, which enabled pupils' performance to be arranged in a continuum. This is realised by applying common items to the three grades and adjusting the scales for each subject between the grades in order to obtain a common scale.

Main results and trends identified by SAEB/97

The results of SAEB/97, confirming trends found in previous studies, show low effectiveness in teaching and learning in the three subjects evaluated - Portuguese language, mathematics and sciences. In addition, they show that the gap between what is planned by the curricula and the actual performance of pupils increases after the last grades of primary education and during secondary education. Thus, it is seen that basic education in Brazil has the following characteristics:

A **variation in teaching systems** - average proficiency of pupils shows severe inequalities on both a regional and within-state basis; the variation is considerable within each state and within an individual education system, reflecting the profound inequalities that exist in the supply of education; we also see great differences between the average proficiency levels of urban and rural areas, with the latter being lower in

[39] In SAEB/97 167,196 pupils participated, representing 5,659 year-groups from 1,933 public and private schools. In addition, 13,267 teachers and 2,302 head teachers took part. In 1999 the SAEB sample will be increased to include 300,000 pupils, 20,000 teachers and 6,000 head teachers.

the whole country[40]; this picture suggests that the education system acts as a mechanism to reinforce inequity, since the poorest regions have lower rates of performance, signifying that they offer less effective opportunities for learning than those offered to pupils in more developed regions, who demonstrate higher levels of performance.

B **the gap between the planned curriculum and pupil performance** - the results obtained confirm the low level of effectiveness of the planned or intended curriculum, showing that the latter is not being learned in a satisfactory manner, since only a small number of pupils demonstrate performances close to those aimed at by the intention of the curriculum; this gap may be occurring because of the differences that exist between the planned curriculum and what is actually taught, which suggests that the planned curriculum has not yet appeared in the classrooms;

C **age-to-grade mis-match has a negative effect on pupil achievement** - confirming the results of previous studies, SAEB/97 showed a marked fall in average ability in proportion to the widening of the gap between the pupil's age and that considered to be ideal for the grade s/he is in, a finding which was true in all the grades and all the subject areas studied;

D **association between pupil performance and qualification level of teachers** - SAEB/97 shows that average pupil performance is greater when the teacher's level of education increases; most surprising of all, however, was to find that the average proficiency of pupils who have teachers of degree level but without teaching training, surpasses the average level of pupils whose teachers have a teaching degree, a phenomenon found to be constant in all the grades and subject areas studied;

E **parents' level of education influences pupil performance** - there is found to be a tendency towards higher levels of proficiency in pupils in proportion to the rise in education level of the father and mother in all grades and subject, in the three teaching systems; these results reflect, to a large degree, the link that exists between the family's socio-economic conditions and pupils' ability.

The link between the teacher's level of education and pupil performance pointed out by the SAEB shows once more the importance of policies of initial and in-service teacher training in regard to improving the teaching-learning process. It is important to note that the gains in pupil output continue to rise in harmony with the teacher's level of education, in all the grades and subjects that were evaluated, up to higher education level.

Another relevant link appears when the level of teacher education is connected to the length of teaching experience and contrasted with the performance of pupils. It is found, for example, that pupils whose teachers had university education, had more than ten years of experience and attended in-service courses in their subjects in 1977, had the best results in all subjects, mainly in primary education. When we compare the results of this group with those of pupils whose teachers did not have university education, had less than ten years' experience and had not attended in-service courses in 1977, greater proficiency was found in all subjects, mainly in Portuguese Language, where the differences reached 22%, 24% and 18% in the 4th

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[40] Regional differences are so acute that, in the 4th grade of primary education, in mathematics and Portuguese language, pupils from the country areas in the Southern region achieved better results than those of urban areas in the North.

and 8th grades of primary education and the 3rd grade of secondary education, respectively.

It is clear, however, that although the level of teacher education and his/her teaching experience have a positive influence on pupil performance, continued training - by means of in-service courses - is an important factor.

In relation to pupil profile, results of other studies are confirmed by the finding that the variable that seems to have the greatest influence on the average proficiency attained, is age. This analysis considers the ideal are for 4th and 8th grades of primary education and 3rd grade of secondary school, to be 10, 14 and 17 years, respectively. We find that as the difference in pupils' age and the ideal age for his/her grade, increases, so the learner's performance in mathematics and Portuguese language and sciences (biology, physics and chemistry) decreases. This is confirmation that the fall in average proficiency seems to be associated with the increase in the age-to-grade mis-match in all the subjects evaluated.

Average proficiency of pupils in relation to education level of teacher, by grade and subject matter - Brazil, 1997

	4th grade			8th grade			3rd grade				
Education level	M	L	S	M	L	S	M	L	C	P	B
Up to Secondary Education in Teaching	181	158	176	228	212	231	293	282	281	286	264
Secondary Education - other subjects	187	165	177	235	242	239	303	263	295	295	283
Higher - Teaching Degree	194	170	187	248	248	251	303	290	292	287	294
Higher - other subjects	208	180	195	254	260	255	313	308	321	306	301
Post-Graduate	196	179	193	269	256	252	322	299	323	328	323

Source: MEC/INEP/DAEB

Legend: M: Mathematics; L: Portuguese language S: Sciences; C: Chemistry; P:Physics; B: Biology.

Average proficiency levels of pupils in relation to education level of teacher, length of teaching experience and attendance at professional courses in1997, by grade and subject matter, Brazil, 1997

Education level of teacher	Length of teaching experience	Courses in 1997?	4th grade			8th grade			3rd grade				
			M	L	S	M	L	S	M	L	C	P	B
Below University	≤10	Yes	180	153	174	237	222	245	309	276	297	284	276
		No	173	149	172	224	210	235	285	251	292	272	285
	>10	Yes	188	171	181	248	241	230	312	299	302	352	-
		No	177	152	175	239	231	223	321	264	270	312	301
University Level	≤10	Yes	191	170	185	248	245	253	304	289	299	297	299
		No	181	167	186	243	246	248	299	293	292	306	290
	>10	Yes	203	181	194	257	260	258	313	296	295	308	322
		No	193	159	185	254	249	245	309	297	320	316	296

Source: MEC/INEP/DAEB

Legend. M: Mathematics; L: Portuguesa Language; S: Sciencies; C:Chemistry; P:Physics; B: Biologia.

Since SAEB/95, results have shown that pupils who go through a grade at an age greater than that considered ideal, have a greater chance of showing reduced performance. Some of the theories that explain this situation say that the fact of pupils learning at an appropriate grade-age gives them several psychological, emotional, physical and pedagogical advantages. The most important pedagogical aspect is the teacher's use of teaching methods and materials that are suitable to the ideal age and therefore unsuitable for pupils who are mis-matched to their grade/age.

This last aspect has to be discussed at length by those who work in teacher training and who design and produce teaching materials. It seems to be common sense that teacher training, the production and selection of teaching materials, should be compatible with and suitable for the conditions the pupils experience, since the Brazilian education system has one of the greatest rates of age-to-grade mis-matches in the world, as was shown earlier.

Comparison of results of SAEB/95 and SAEB/97

Comparison of the SAEB results of the years 1995 and 1997 show for the first time in Brazil, the possibility of evaluating the progress that has taken place with regard to pupil learning in the different teaching systems. It is clear that, as international experience has shown, the period of two years is too short to show significant differences in pupil performance. Nevertheless, some significant trends were identified.

Before looking into them, however, two methodological clarifications and one reservation must be made. The procedure used to construct the unified scale - which permits this comparison of SAEB/95 and SAEB/97 results - was that of joint calculation of the statistical parameters of all the test items used in these two levels of schooling, by means of a process known as 'calibration'. This allowed the production of a single scale for the subjects of Portuguese language and mathematics combining the results of both years[41].

The second aspect that has to be taken into account is that as the statistical programme that was used is different from that used to analyse results specific to SAEB/97 - shown in the previous table - measures of proficiency obtained for the two levels of education that are being compared (1995 and 1997), analysed below, have different absolute values from the results of SAEB/97. However, the two groups of results show extremely similar behaviour, suggesting that the trends observed in both cases were the same.

It is worth pointing out finally, that these comparisons demand caution, since some changes in defining the sample population of pupils in SAEB/97 in relation to SAEB/95, were introduced. In 1997 pupils in multi-graded year groups and state school pupils were excluded, as well as pupils in rural schools in the Northern region and 3rd grade secondary pupils enrolled in further education courses. As a result of these exclusions, variations in average proficiency levels may be due to the changes in the nature of the samples and not to real performance changes.

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[41] The data were analysed on the basis of Response-to-Item Theory by means of dedicated software. In this study the calibration was done using Bilog-MG statistical software (Zimowski, Murski, Mislevy and Bock, 1996). It is necessary, however, to point out that as the Response to Item Theory involves probabilistic estimating models, it is customary for small variations to occur in the calibration results, which are due to the estimation variations inherent to the model used.

Having made these observations, two positive trends based on the comparison between the SAEB/97 results and those of SAEB/95 can be highlighted: on the one hand, an improvement was found in the performance of pupils from the Northeastern region and in some states that have pushed forward their educational reforms in recent years - such as Paraná, Minas Gerais, Santa Catarina and Rio Grande do Sul; on the other hand, the relative stability of proficiency levels in the other states of Brazil show that the rapid expansion of primary and secondary education in recent times has not been carried out at the expense of quality[42]

Ranking of regions of the federation in relation to variation in average proficiency in mathematics - 1995-1997

Grade	Variation in averages between 1995 e 1997		
	Fall in average (statistically significant diminution)	Stability (no significant statistical difference)	Increase in average (statisticlly significant increase)
4th primary	RR, DF	BR, N, NE, SE, S, CO RO, AC, AM, PA, AP, TO, MA, PI, CE, RN, PB, PE, AL, SE, BA, MG, ES, RJ, SP, PR, SC, RS, MS, MT, GO	
8th primary	RR, SP, DF	BR, N, SE, S, CO RO, AC, AM, PA, AP, TO, MA, PI, CE, RN, PB, PE, AL, SE, BA, MG, ES, RJ, PR, RS, MT, GO	NE SC, MS
3rd secondary		BR, N, SE, CO RO, AC, AM, RR, PA, AP, TO, MA, PB, AL, SE, ES, RJ, SP, PR, MT, GO, DF	NE, S PI, CE, RN, PE, BA, MG, SC, RS, MS

Source: MEC/INEP/DAEB

Ranking of regions of the federation in relation to variation in average proficiency in Portuguese language - 1995-1997

Grade	Variation in averages between 1995 e 1997		
	da Fall in average (statistically significant diminution)	Stability (no significant statistical difference)	Increase in average (statisticlly significant increase)
4th primary	CO RJ, GO, DF	BR, N, NE, SE, S RO, AC, AM, RR, PA, AP, TO, MA, PI, CE, RN, PB, PE, AL, SE, BA, ES, SP, PR, RS, MS, MT	MG
8th primary	BR, SE ES, SP	N, S, CO AC, AM, RR, PA, AP, TO, MA, PI, CE, RN, PB, PE, AL, SE, BA, MG, RJ, PR, SC, RS, MS, MT, GO, DF	NE RO
3rd secondary	BR, SE SP	N, S, CO RO, AC, AM, RR, PA, AP, TO, MA, CE, RN, PB, AL, SE, BA, ES, RJ, PR, SC, RS, MS, MT, GO, DF	NE PI, PE, MG

Source: MEC/INEP/DAEB

[42] Cláudio de Moura Castro. "O Ensino melhorou ou travou?" (Has teaching got better or stalled?) Veja magazine, 27/01/99, p.20.

The effect of the SAEB on educational policies and initiatives

One of the proofs of the SAEB's effect as a permanent mechanism for improving teaching and of the importance of its results in assisting the formulation of policies has been the rapid expansion of accelerated learning programmes, which attack one of the main causes associated with low attainment of pupils, which is the age-to-grade mis-match. In fact, the strong correlation shown by SAEB/95 and confirmed by SAEB/97 between the average level of proficiency of pupils and their ages, has brought about a reaction in the education systems, which include adopting measures to bring down the repetition and dropout rates - the main causes of this mis-match - and to bring held-back students into line with their normal rate of passing through school. In 1998 accelerated learning classes were provided for 1.2 million pupils, which is evidence of the spread of this policy through the country.

The SAEB results also form a valuable aid in directing the implementation of the National Curriculum Parameters (Parâmetros Curriculares Nacionais - PCNs) and curriculum reform in secondary school, since they allow the identification of the major deficiencies in pupil learning. As has been shown already, the SAEB has already shown the low level of effectiveness of the curricula. "This gap may exist due to the current differences between the planned curriculum and that which is actually taught, meaning that the specified curriculum has still not reached the classroom. Or, equally, it may also be attributed to the high level of expectation found in the planned curriculum, which makes it difficult for pupils to fulfil its requirements."[43]

One of the distortions that the new curricular Guidelines are trying to eliminate is precisely the encyclopaedic nature of the curricula, which has had a negative effect on pupil learning. The reforms instigated by MEC, in accordance with the new LDB, bring changes to the official curricula so as to reduce the emphasis on content that is unnecessary for general training in basic education and to encourage a teaching approach that concentrates more on problem-solving and developing general competences and abilities. In addition, the PCNs emphasise cross-curricular themes such as ethics and multi-culturalness, suggesting that these might be approached in an inter- and trans-disciplinary way so as to form an integral part of education for the exercise of citizenship.

This connection between the SAEB and the PCNs has already been developed in the realm of the TV School - a MEC distance education programme that serves state primary schools with more than 100 pupils, offering teachers the chance for further training and support for classroom activities. Within this same area of interest, some states have begun to use the SAEB results to plan in-service and teacher training programmes - as in Paraná, Pernambuco, Rio de Janeiro, Goiás, Maranhão, Rio Grande do Norte and Minas Gerais. This interaction is most important in producing a multiplier effect, causing the SAEB results to bring about changes in teaching practices and improvements in the teaching-learning process, thus accomplishing their main role. The co-operation also helps to spread and consolidate an evaluation culture in Brazil.

[43] INEP. *SAEB 97: Primeiros Resultados* (*SAEB 97: Initial Results*). Brasília, 1999. p. 49.

V - The new debate on the use of standards in education

The development of standards in education is a relatively new idea in the educational debate and for this reason has aroused a growing interest and generated an intense debate among specialists and managers in education systems. The current axis of this debate is found in two main themes: the question of equity and of the effect on teaching. Underlying the arguments presented by the participants in the debate are different concepts concerning standards and different concepts concerning the role they can achieve as a tool to promote quality improvement in education.

The theme of equity is a central problem in public policy, especially in the area of education. As has been exhaustively demonstrated, Brazil's education system has a great deficit in terms of guaranteeing the minimum conditions of equity, both from the point of view of access and of quality of the teaching offered by the public schools. This aspect has been very much emphasised since national evaluations began to be carried out, the results of which shoed the enormous imbalances that existed between states and the teaching systems. Therefore, simply thinking about establishing minimum standards - which would go on to impinge upon the performance of teaching systems - leads us inevitable to a discussion of the problem of equity.

Two distinct views have crystallised in this debate. The first maintains that standards do not favour equity, since they discriminate negatively both in socio-economic and in cultural terms. It is said also that these differences hamper the use of common evaluation tests and that adopting these standards will lead to a tendency towards homogeneity and against diversity. The second view, on the other hand, defends the validity of establishing standards precisely because they allow the problem of inequity to be confronted in the most informed way by educational policies. It is argued also that the social factor cannot be used as a justification for the impossibility of attaining quality standards, which would condemn the socially excluded to a second-class education.

These controversial views intensify the present international debate about the development of standards in education. Meanwhile the positions tend to converge towards a recognition of the need to define what all pupils are expected to develop in terms of abilities, basic competences and mastery of topics, throughout their school careers. The idea of standards gains strength precisely because it starts from the premise that it is possible to define the desired levels of proficiency that should have been reached at the end of each stage of school. These would be the patterns of quality to be sought by the teaching systems.

Paradoxically, although education has been identified as one of the main mechanisms for social mobility, the education system continues to reinforce inequalities by not succeeding in promoting access from the less favoured sectors to the more favoured sectors of learning. The evaluation systems - by allowing the cross-referencing of socio-economic and cultural variables with the results of tests applied to pupils - show in which subjects and content areas the differences are found, thus directing the design of specific actions. For this reason it is also important that these results are widely broadcast so that schools, teachers and parents may know what shortcomings have been identified and, with that knowledge, may develop the actions necessary to introduce improvements.

The role of standards in introducing equity policies

The applicability of standards in education demands, of necessity, an emphasis on equity policies that lead toward an ideal situation in which each pupil has access to the same opportunities for learning. In the mean time, as these conditions do not exist as a point of departure, it is necessary that the definition of standards bear in mind regional differences and the socio-economic and educational factors that affect pupils' learning. As well as this, it is necessary to create methods to evaluate pupil performance in relation to the standards that allow a measure of the value added by the school, which presupposes a knowledge of the pupil's level at entry to school. Thus, instead of discriminating, standards can become a powerful instrument to bring about an improvement in the quality of education, thus accomplishing, in the final instance, its main function.

The second theme that has been put forward in this debate is the effect of standards on learning. The critical arguments occupy a level similar to that of equity. In sum they manifest a fear that establishing patterns will tend to concentrate the teaching process solely on subjects for which they have been designed. In this way there will be a reduction in the curriculum since schools will be encouraged to give priority only to subjects identified as the objects of standards and evaluation. The question is posed whether adopting minimum standards might lower even more the average attainment levels of pupils. On the other hand, the choice of adopting desired standards of excellence will tend to generate frustration among those who do not manage to reach them, encouraging repetition and dropping out.

These critical aspects need to be duly considered when designing standards and when using them jointly with evaluation procedures. What has been seen from the basis of current experience is that standards exercise a benevolent influence insofar as they are used to establish references for developing curricula, textbooks, teaching materials and teaching methods. Thus they direct actions towards equity of opportunity and come to be used as a target for the school's pedagogical programme. Finally, they encourage social control and the participation of groups interested in education.

The role given to standards is that of showing clearly the result that can be expected from the teaching-learning process and in which the education systems and the schools are involved. Thus, the process offers parameters of comparability and, what is more important, it supplies the elements necessary to demand accountability from the various educational agents. Casassus (1997), on examining the scope of standards as a means of raising the quality of education, identified four dimensions that come to be included in establishing standards[44]. The first refers to the *prescribed*, that is, the pedagogical aims that make up the basic element of standards; the second refers to what would be *desirable*, indicating levels of excellence in relation to what is expected of education; the third refers to what can be *observable*, that is, what has actually been achieved and is assessed in evaluations; the fourth shows what makes the former results *feasible*, that is, the conditions and production factors needed in order to attain the desired standards.

The first step to formulating standards is to answer a recurring question in the educational debate: what do we expect students to learn and what do we expect teachers to teach? The challenge, then, is to establish "in a clear and public manner what are the conceptual and practical competences that we expect pupils to achieve"[45]

[44] *Estándares en educacion: conceptos fundamentales (Standards in Education: fundamental concepts)* J. Casassus. UNESCO, 1997.
[45] Idem.

and the indicators that will permit their measurement. On a more general level, standards must relate to curriculum objectives and to the results all learners are required to attain. There are, therefore, basic standards. The emergence of the theme of quality has raised expectations about what is expected of education, leading to discussion on desirable profiles, the aims of the different levels of education and the demands that schools should attend to in order to achieve those aims. This debate takes place on the level of the *desirable*, which may be translated in terms of standards of excellence. That is, ideal standards "attainable by some, although not necessarily all, as is the case with basic standards". Their function is to establish a goal to be achieved.

In both interpretations of standards - basic or of excellence - we must be absolutely clear in defining the competences to be attained. And, in order for them to be effective, they must be expressed in such a way as to be observable, measured and evaluated. Therefore, in order to have any meaning, standards must be operationalisable, allowing indicators to be developed by means of which the level of progress in acquiring competences and abilities may be evaluated. In this way, standards can accomplish the role of providing information that gives an account of the responsibility of responsibility of the teaching systems and the schools themselves for the result of the teaching-learning process.

However, for *feasible* standards to be established, it is also necessary to define strategies to ensure the conditions that will allow schools to achieve them. To this end we must fix minimum standards concerning physical infra-structure and the elements of production, not only material ones - textbooks, equipment, etc. - but also managerial ones - administrative autonomy, opportunity for learning, etc.

These are the substantive aspects involved in the international debate on standards. When applied to the situation of the Brazilian national education system, with its well-known variation in levels, this debate brings in other equally relevant questions: how can we think about national standards when we see that in the public schools even basic infra-structure is not always present? How can we link standards to teacher training policy? What should be the level of performance desirable among students at the end of basic education? What are the competences necessary for citizenship and entry into the world of work?

VI - Some brief final observations

The balance of the 90s in the educational area, sketched in this study, shows that there was a very positive change in the state of education in the country. We can note, among the main improvements:

- the marked fall in levels of illiteracy, above all in the youngest age groups;
- the notable growth in enrolment at all levels of education, especially the advance in universalising primary education and the rapid expansion of secondary education;
- the adoption of policies aimed at improving teaching quality;
- the gradual improvement in transition rates in primary and secondary education, with a concomitant fall in rates of repetition, dropout and truancy;

- the improvement in the level of qualification of teachers, linked to a policy of boosting the status of the teaching profession;
- the emphasis on accelerated learning programmes to correct imbalances in rates of student throughput in schools;
- the development of curricular parameters and terms of reference for infant education, further education, education of indigenous peoples, primary education, secondary education and teacher training;
- the decentralisation of educational responsibilities, based on installing a mechanism for re-distributing resources (FUNDEF);
- improving the status of schools and encouraging community participation in school management;
- institutionalising national educational evaluation systems encompassing all levels of teaching;
- re-organising the Educational Statistics System to assist in diagnosis and formulation of education policies in the various administrative organs.

These changes met to form a new constitutional landmark, consolidated by Constitutional Amendment No. 14, of 1996, and by the new Law of Guidelines and Foundations for National Education - Law No. 9,394/96. The decentralisation of basic education policies stimulated by this new educational legislation, is based in the founding of national evaluation systems and the creation of mechanisms to reinforce social control. In this way federal government actions aimed at promoting greater equity in public education become more consistent; among these actions are: definition of curricular terms of reference and parameters for the different levels of education; guaranteeing a minimum cost per pupil/year by means of FUNDEF; defining minimum standards for schools - with reference to physical conditions and production factors; and the discussion, occasioned by the SAEB results, about establishing standards to be attained by all the nation's schools.

In spite of these noticeable improvements however - which have been accompanied by an increased capacity for management in education systems - the challenges that have to be confronted in the next ten years are very great and will require redoubled efforts at the three levels of government and from society in order for Brazil to overcome accumulated historic shortfalls in the sphere of education and to finally achieve a stage of development coherent with the means and resources at its disposal. Given the present educational situation, together with the change in the demographic profile, the next ten years will see the following trends:

- a gradual slowing-down of demand in the early grades of primary education, accompanied by a marked growth in enrolment in the final grades, a phenomenon that is already being observed in the more developed regions of the country;
- an explosion of demand for secondary education, putting pressure on the expansion of places in state education systems and requiring increased investment in the broadening and improvement of schools, teacher training and the maintenance and development of this level of education;
- a rapid expansion of higher education, accompanied by diversification of courses and flexibility of the curricula;
- increased pressure for public expenditure on education to be increased at the three levels of government;

- the inflexibility of public budgets will demand a reconsideration of the financial profile of the three levels of education based on criteria of equity and of the priority given to social demands for basic education.

This situation indicates that the country's main challenge in the next ten years will be to eliminate the quality deficit found in all levels of teaching - most seriously in the public primary education system - thus responding to growing public pressure and to the demands imposed by the technological changes that have characterised the last quarter of the 20th century. The real size of this challenge is revealed when it is linked to the urgent task of completing the process of universalising basic education and expanding provision for the other levels of teaching, democratising educational opportunities and satisfying present demand.

Current educational policies appear to present a suitable strategy for providing a simultaneous expansion of the system and a raising of the standard of quality in education. The coming years will show Brazil's ability to gradually improve the indicators of equity and efficiency in its educational system. The main advantage is that the country already has instruments of international standard - such as the Educational Census, SAEB, ENEM and the "Provão" - to monitor this effort and adjust its policies in order to achieve these aims.

Education and Equitable Economic Development

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I – Introduction

A fast continuous process of educational expansion is a fundamental condition for equitable and sustainable socioeconomic development. In fact, on one hand, educational expansion is essential for improvements in labor productivity leading to economic growth, higher wages and less poverty. On the other, education expansion is essential to improve equity and mobility, since education is a non-transferable asset, which is much easier to distribute than land and most other physical assets. In addition, education is a reproducible asset that can be and usually is publicly provided to the poor. In short, education expansion is essential to foster economic growth and to reduce inequality and poverty.

Nevertheless, the impact of education expansion goes beyond its direct influence on equity and economic growth. For instance, education has also an important direct impact on population growth, parental care and political participation. Through these channels education can further improve efficiency, reduce poverty and facilitate social mobility.

The goal of this paper is twofold. First, it seeks to provide some empirical evidence on the importance of a continuous process of educational expansion for equitable and sustainable socioeconomic development. Second, it provides an evaluation of the Brazilian educational performance and seeks to identify the major impediments for faster educational expansion in the country.

The paper is organized in six sections. The next section investigates the overall connection between educational expansion and socioeconomic development. Section 3 then takes a deeper look at the important connection between educational expansion and income inequality. Section 4 shows evidence of the Brazilian educational performance over the past decades. Section 5 attempts to identify some of the main impediments against the expansion of the Brazilian educational system. In section 6 we summarize our main findings and present some final remarks.

II – The Impact of Education on Social and Economic Development

Education and Development

The contribution of education for an equitable economic development can be evaluated by the impact of schooling on a series of socioeconomic indicators. Table 1 presents estimates of the impact that an extra year of schooling of the population would have on economic growth, population growth, mortality, longevity and schooling respectively.[1] The estimates in this table[2] show that additional schooling has important consequences on the rate of economic and population growth and on the next generation's mortality rate and level of schooling.

In terms of economic growth, Table 1 reveals that a single extra year of schooling can increase the rate of economic growth by 0.35 percentage points. This table also reveals that an extra year of schooling would increase the annual growth rate of exports and wages in manufacturing.

[1] The estimates given in this table are partially obtained from Behrman (1993). There is a further discussed content of this table in Barros and Mendonça (1998a).
[2] See, in particular, a the first row of this table.

Table 1: The impact of changes in schooling on social and economic indicators

Socio-economic indicators	Investing one extra year in education (1)	(1) x 2.5 years of schooling (2)	Brazil (currente rate) (3)	South Korea (current rate) (4)	Gap Korea-Brazil (5)	Brazil (%) (2)/(3)	Brazil/ Korea-Brazil (%) (2)/(5)
Economic growth							
Annual growth rate per capita income	0.35	0.88	3.3	7.1	3.8	27.0	23.0
Annual growth rate per capita industrial wage	0.85	2.13	4.0	10.0	6.0	53.0	35.0
Annual growth rate of exports	0.70	1.75	4.0	12.8	8.8	44.0	20.0
Population growth							
Annual growth rate of population	-0.26	-0.65	2.4	2.0	-0.4	-27.0	163.0
Annual growth rate of total fertility	-0.24	-1.00	3.2	1.8	-1.4	-31.0	71.0
Gross annual growth rate of births per 1000 inhabitants	-2.40	-6.00	27.0	16.0	-11.0	-22.0	55.0
Mortality and Longevity							
Infant mortality rate (by 1000 live births), female	-8.90	-22.25	57.0	17.0	-40.0	-39.0	56.0
Under 5 mortality (by 1000 live births), female	-11.80	-29.25	62.0	17.0	-45.0	-48.0	66.0
Under 5 mortality (by 1000 live births), male	-13.40	-33.50	75.0	24.0	-51.0	-45.0	66.0
Life expectancy at birth, female	2.00	5.00	69.0	73.0	4.0	7.0	125.0
Life expectancy at birth, male	2.00	5.00	63.0	67.0	4.0	8.0	125.0
Schooling							
Gross enrollment rate-secundary level	5.20	13.00	39.0	86.0	47.0	33.0	28.0
Female illiteracy rate	6.80	17.00	80.0	97.5	17.5	21.0	97.0
Male illiteracy rate	5.40	13.50	81.0	97.5	16.5	17.0	82.0

Source: Based on Behrman, Jere J. "Human resources in Latin America and the Caribbean"- 1993.

Once the importance of additional schooling on economic growth has been reported we can go further in our analysis by simulating the impacts of an educational policy that increases the average schooling level of the Brazilian population to eight completed grades. Since the current average schooling in the population of 25 years old and over is close to 5.5 grades, to reach 8.0 grades the average schooling must increase by 2.5 grades. Using the information presented in Table 1, we find that this increase in schooling would further per capita income growth by 0.9 percentage points. Such increase in schooling would also increase the annual growth rate of exports by 1.8 percentage points and increase the growth rate of wages in manufacturing by 2.1 percentage points. These changes would represent an increase between 27% and 53% in the current rate of growth of these variables. By comparing South Korean and Brazilian per capita income growth rates we can see that increasing the Brazilian schooling level by 2.5 grades would eliminate one quarter of the gap in the per capita income growth between these two countries.

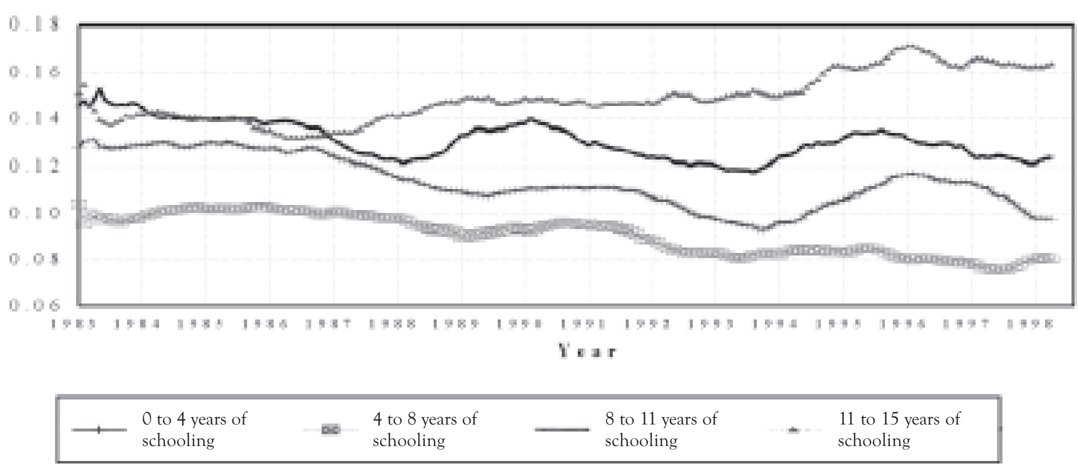
The impact of extra schooling on population growth is also very important. An extra year of schooling would reduce the annual population growth rate by 0.26 percentage points. As a consequence, the proposed increase in average schooling from 5.5 to 8.0 would reduce population growth by 0.65 percentage points, which is the equivalent of a 27% drop in the current growth rate of the population. It would be more than sufficient to eliminate the whole difference in population growth between Brazil and South Korea.

Table 1 also reveals a sizeable impact on infant mortality. An additional year of schooling of parents would reduce infant mortality by 9 deaths per 1000 live births. Given the current level of infant mortality in Brazil, an increase in average schooling from 5.5 to 8.0 would reduce infant mortality by 39%. It would also reduce the gap in infant mortality between Brazil and South Korea by 56%.

Finally, Table 1 shows evidence that extra schooling of the adult population has a strong effect on the educational attainment of the next generation. In fact, a single extra year of schooling of the adult population would increase the secondary school enrollment rate of the following generation by 5.2 percentage points. As a result, if the average schooling of the Brazilian adult population were 8.0 instead of 5.5, the enrollment rate in secondary education of the next generation would be 33% higher and the gap between Brazil and South Korea 28% lower.

There is plenty of further available evidence on the impact of education on per capita income and the level of wages. For instance, the estimates by Lau, Jamison, Liu and Riukin (1996), using Brazilian cross-section panel information, show that an extra year of schooling of the labor force would increase per capita income by 20%. The evidence of the impact of schooling on wages is of a similar magnitude. For instance, Barros and Mendonça (1998a) show that each year of college education would increase wages in São Paulo, on average, by 16% (see Figure 1). The impact on wages of the other educational levels is less. The impact of an extra year of secondary education is close to 12%, while the impact of an extra year of primary education is close to 9%.

FIGURE 1: WAGE DIFFERENTIALS BY EDUCATIONAL LEVEL
SÃO PAULO



Source: Monthly Employment Survey (IBGE).

Although the impact of education on economic growth is certainly very strong, the evidence connecting educational expansion and poverty reduction reveals much slighter effects. In fact, by estimating the impact of one extra year of schooling on poverty we found that it is equal to the effect on poverty of a 6% increase in per capita income (Table 2). This result may seem contradictory to some of the evidence presented earlier that an extra year of schooling would increase wages by 10% to 20%. However, the two pieces of evidence are actually consistent with each other. To reconcile these two facts two factors must be taken into consideration. First, it must be noted that the major increase in wages occurs in the final year of each educational cycle. The impact of an extra year of schooling that does not bring an education cycle to conclusion is somewhat less. Since only a very small fraction of the population is one year behind completing primary or secondary education, the extra year of schooling given to each member of the labor force is probably a non-completion year that has a much smaller effect on wages. Secondly, the effect on poverty also tends to be less because the poor tend to have only primary education, if any at all, and the impact of primary education on income tends to be much less than the effect of secondary and college education.

Table 2: The impact of changes on the unemployment rate, the economic growth and the schooling of the Brazilian population

Variables	Proportion of poors 1995	1996	1997
Baseline*	33.7	33.4	33.3
Unemployment rate	6.1	7.0	7.9
Unemployment			
No unemployment	30.6	29.9	29.6
Constant unemployment rate of 4%	32.6	31.9	31.5
3% annual growth rate of GDP per capita, with no decrease of the unemployment rate			
01 year	33.0	32.7	32.9
02 years	32.1	31.9	32.5
03 years	31.6	31.5	31.9
04 years	31.1	31.2	31.3
05 years	30.7	30.7	30.9
06 years	30.3	30.0	30.3
07 years	30.1	29.5	30.1
08 years	28.1	28.5	28.6
09 years	27.8	28.3	28.3
10 years	27.5	27.9	28.0
15 years	25.9	25.8	25.6
Education			
One year more of schooling for all	31.9	31.9	32.1
Two years more of schooling for all	30.7	30.8	31.1

Source: Based on Pesquisa Nacional por Amostra de Domicílios (PNAD).

Note: The results of this line are based on a poverty line such that 1/3 of population were under the line, that is, 1/3 of population were classified as poor.*

Education and Inequality

As we have shown above, the impacts of formal schooling on growth rates are positive and significant for the socioeconomic indicators analyzed. However, to recognize the relevance of the Brazilian educational gap we need to identify how important are the differences in schooling between Brazil and the industrialized countries in explaining the corresponding gap in per capita income. Barros and Mendonça (1994) investigated this question. They began by showing that current per capita income in Brazil (US$ 5,000) is one third of the corresponding value for industrialized countries (US$ 15,000). Next, they show that if the schooling level of the Brazilian labor force were to be equal to that of the industrialized countries, then the per capita income in Brazil would double. As a consequence, the Brazilian per capita income would increase from one to two thirds of the corresponding value for the industrialized countries. In short, half the large gap in per capita income between Brazil and the industrialized countries is explained by the lower educational attainment of the Brazilian population.

Education is also closely related to income inequality, since it is a major determining factor in labor productivity and, consequently, in the level of wages. Wage disparities have two basic sources. On one hand, they may reflect differences in productivity among workers, while on the other, may be the result of the differential payment of equally productive workers. The fraction of the wage disparities that derives from differences in productivity intrinsic to workers is perceived as that revealed by the labor market as contrary to that generated by the labor market. In the former case, the workers provide different services to the market that reveal these differences by attributing different prices to them. In its turn, the fraction of the wage disparities that results from the differences in the payment of equally productive workers can be considered generated by the labor market since, in this case, the labor market is treating differently workers who are providing similar services.

Table 3 presents a breakdown of the wage inequality according to its origin. Each row in this table indicates a potential source of inequality. Each entry indicates the amount of wage inequality that would decline if all wage disparities among categories of a certain dimension were eliminated. Hence, for instance, the row associated with education heterogeneity indicates how many percentage points wage inequality would decline if the average wage of all educational groups were the same. Similarly, the row associated to race indicates that wage inequality would decline by 1% if the average wage of whites and non-whites were the same..

TABLE 3: DECOMPOSITION OF WAGE INEQUALITY ACCORDING TO ITS MAIN SOURCES

Source	Contribution (%)			
Identifiable sources				60
Genenerated by the labor market			11	
Discrimination		4		
Race	1			
Gender	3			
Segmentation		7		
Formal x Informal	1			
Sectorial	5			
Regional	1			
Revealed by the labor market			49	
Differences in tenure	2			
Occupational heterogeneity	7			
Educational heterogeneity	40			
Non identifiable sources				40
Total				100

Source: prepared by the authors

This table reveals that it is possible to trace the origin of almost 60% of the overall degree of wage inequality. Moreover, this table reveals that wage disparities between educational groups is the main source of wage inequality. If these disparities were eliminated, wage inequality would decline by 40%, indicating that education accounts for two thirds of the wage inequality from known sources. Also, mainly due to the importance of education in generating inequality, this table shows that wage inequality is primarily revealed by the labor market with only a small fraction being actually generated by the labor market. In short, this table shows that differences in productivity derived from educational differences are the main source of wage inequality, indicating that wage inequality in Brazil is the result of heterogeneity among workers rather than the result of unequal treatment of equally productive workers.

Table 3 shows that educational heterogeneity is an important determining factor in wage inequality in Brazil. This result on its own, however, does not imply that education is the main explanation for the well-known very high level of inequality in Brazil, since education may be an important determining factor in wage inequality in all countries. In other words, it remains to be established whether education, in addition to being an important determining factor in wage inequality, can also explain the excessive inequality in Brazil in relation to the rest of the world.

TABLE 4: THE EXCESS OF BRAZILIAN WAGE INEQUALITY: A COMPARISON BETWEEN BRAZIL AND THE UNITED STATES

Indicator	Brazil	United States	Gap Brazil-United States (%)
Total wage inequality*	1.10	0.64	72
Wage inequality among equally educated workers*	0.59	0.55	7
Wage inequality among workers with different educational level*	0.52	0.09	478
Contribution of education to wage inequality (%)	47	15	213
The impact of an additional year of education on wages (%)	16	10	61
Inequality in education **	20	10	102

Source: Based on Lam and Levison (1990).

Note: * *measured by the variance of logarithmics*

** *measured by the variance of schooling.*

To check this possibility we compare the relationship between education and inequality in Brazil with the corresponding one in the United States. This comparison is presented in Table 4. The first row of this table shows that the degree of wage inequality is 72% higher in Brazil. To investigate the extent to which this excessive inequality is related to education, we break down the wage inequality of both countries in two components; (a) wage inequality among equally educated workers and (b) wage inequality among workers with different educational levels. We should expect that the excessive inequality in Brazil would be entirely related to education, then the level of wage inequality among equally educated workers would be very similar in both countries, whereas the inequality among workers with different educational levels would be much higher in Brazil. The second and third rows of Table 4 confirm these expectations. These rows reveal that while the inequality among equally educated workers is just 7% higher in Brazil, the inequality among workers with different educational levels is almost 500% higher. In short, the educational heterogeneity of the Brazilian labor force is not just a major explanatory factor for the overall level of inequality in the country, but also a major explanation for the much higher level of inequality in the country when compared with the rest of the world.

III - EDUCATIONAL EXPANSION AND INCOME INEQUALITY

In the previous section we demonstrated that the educational heterogeneity of the labor force is a major explanation for the higher level of wage inequality in the country. In this section we investigate the mechanisms behind this connection and discuss which kind of educational policy would be more adequate for reducing income inequality.

The contribution of education to wage inequality is a function of two factors. On the one hand, it depends on the degree of inequality in education. The more heterogeneous the labor force the higher the level of income inequality. On the other, the level of wage inequality also depends on how the labor market translates educational differences into wage differences, that is, what is the monetary value the labor market attributes to an extra year of education. The higher the value the labor market attaches to education the higher the level of wage inequality for any given level of educational inequality.

A simple analogy here may prove useful. Imagine that wage inequality is the image of the educational inequality through a curved mirror. In this case, the image (wage inequality) would be taller the larger the original object (educational heterogeneity of the labor force) and the larger the curvature of the mirror (the value the labor market attaches to an extra year of schooling).

As already mentioned, Table 4 shows that the contribution of education to wage inequality is greater in Brazil than in the United States. In Brazil, inequality in wages would be 47% lower if all educational groups were to receive the same salary, while in the Unites States the inequality would drop a mere 15% if education had no effect on wages.

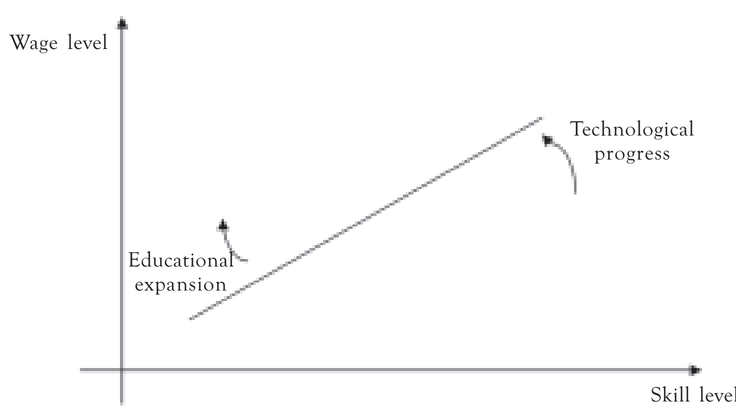
There are two possible reasons for the greater importance of education in Brazil. Either the level of educational heterogeneity (original object) is larger or the Brazilian labor market attaches more value to an extra year of education (the curvature of the mirror is greater). Table 4 reveals that both factors are central for wage inequality in explaining the importance of education. In fact, Table 4 shows that inequality in education in Brazil is 100% higher than in the United States, while the value of an extra year of education is 60% higher in Brazil.

Given that both factors explain the higher level of inequality, what are the policy implications? In principle, it would be favorable to reduce simultaneously the level of inequality in education and value of education in the labor market. These two factors are, however, linked in both a static and dynamic fashion. Changes in one of the factors tend to have important effects on the other.

The market value of education is particularly influenced by the distribution of education in the population. In fact, the market value of education is to a great extent a direct reflection of the relative scarcity of skilled workers. Hence, everything else constant, an increase in the proportion of workers with a higher education would reduce the market value of education, since it would reduce the scarcity of skilled workers in the labor force. As Tinbergen (1975) has clearly presented it, the market value of education is the result of a race between the education system and technological progress. On the one hand, as the educational system expands, the scarcity of skilled workers declines, inducing a concomitant decline in the market value of education. On the other hand, technological progress tends to be biased against unskilled workers and, as the technological progress that unravels the demand for skilled workers increases in relation to the demand for unskilled workers, there is an increase in relative scarcity of skilled workers. Consequently, there is an increase in the market value of education. This process is illustrated in Figure 2.

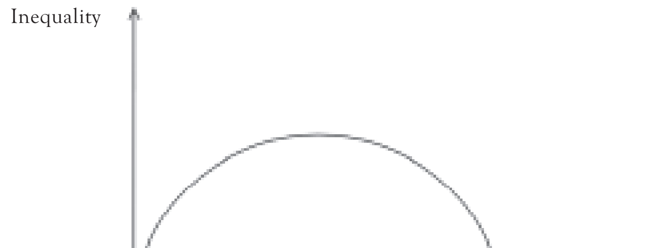
With respect to the evolution of educational heterogeneity, it is important to emphasize the natural inverse U-shaped relationship between the average and inequality in education (see Figure 3). On the one hand, when the average is very small, there is very little scope for inequality. Most workers are illiterate and the average and inequality in education are very small. On the other hand, there is a top limit for education, so when the average education is very high, most workers will have a college education and consequently inequality in education will again be lower. It is precisely when the level of education reaches intermediate values that there is considerable scope for educational heterogeneity. In this transitional case, while a significant fraction of the older population may still be illiterate, a substantial fraction of the younger population may already have college education. In other words, there is a natural tendency for countries with intermediate levels of education to have higher levels of educational heterogeneity.

Figure 2: The value of education in the labor market: the race between educational expansion and technological progress



In short, we have argued that increases in the level of education are an essential tool to reduce wage inequality since it would have the two following effects. On the one hand, increases in the level of education reduce the relative scarcity of skilled labor and, thereby, the market value of education. On the other hand, these increases would eventually reduce the inequality in education once the average level reaches the region of diminishing inequality (see Figure 3). If, in addition to increases in the average level of education, we could also reduce the inequality in education this would have an additional contribution to reducing the level of wage inequality.

Figure 3: Relationship between inequality and mean of schooling



It is worth mentioning, however, that a trade-off is present to the extent that attention to inequality in education would reduce the speed of the educational expansion. In this case, we must decide how much attention should be given to inequality and how much should be devoted to speeding up the educational expansion. To shed some light on the best way to solve this trade-off we present in Tables 5 and 6 the experience of South Korea and Colombia, two countries that have experienced sharp drops in wage inequality over the past decades.

These tables show that, from 1976 to 1986, wage inequality dropped 10 and 15 percentage points in South Korea and Colombia respectively from 1976 to 1985. In addition, these tables break down this drop in inequality into three components: (a) the contribution of reductions in inequality in education; (b) the contribution of reductions in the market value of education and (c) the contribution of non-educational factors.

TABLE 5: WAGE INEQUALITY: A COUNTER FACTUAL SIMULATION WITH KOREA IN 1976 AND 1986

Indicator	Theil index
Wage inequality in Korea in 1976	0.44
Wage inequality in Korea in 1976 if its educational inequality was equal to the one registered in 1986	0.47
Wage inequality in Korea in 1976 if its educational inequality was equal to the one registered in 1986 and if its labor market valued education as in 1986	0.35
Wage inequality in Korea in 1986	0.34

Source: prepared by the authors

TABLE 6: WAGE INEQUALITY: A COUNTER FACTUAL SIMULATION WITH COLOMBIA IN 1976 AND 1985

Indicator	Theil index
Wage inequality in Colombia in 1976	0.55
Wage inequality in Colombia in 1976 if its educational inequality was equal to the one registered in 1985	0.56
Wage inequality in Colombia in 1976 if its educational inequality was equal to the one registered in 1986 and if its labor market valued education as in 1985	0.51
Wage inequality in Colombia in 1985	0.40

Source: prepared by the authors

These tables offer at least three major facts. First, they show that education plays a very important role in both countries. Education was responsible for a drop in inequality of 9 percentage points in South Korea and 4 percentage points in Colombia. Other factors were important in Colombia but not at all in Korea. Secondly, and more importantly, these tables clearly indicate that reductions in educational inequality have not contributed to the significant drop in wage inequality in both countries. As a matter of fact, over the period, while wage inequality was declining the inequality in education increased in both countries. Lastly, these tables show that a sharp decline in the market value of education was a major factor leading to the drop in wage inequality for the period.

We should note, therefore, since this decline in the market value of education is the direct result of fast educational expansion in both countries, that these tables provide strong evidence that these countries solved the trade-off between educational expansion rate and reductions in inequality in education, clearly favoring the first. In other words, these countries opted for a fast process of educational expansion even at the expense of a moderate increase in the degree of inequality in education.

In short, the international experience indicates that probably the best strategy for Brazil would be to expand its educational system as fast as possible even if this may imply some moderate increase in the level of inequality in education. This seems to be the best policy to reduce wage inequality since the gains brought by the decline in the market value of education would more than compensate for some eventual increase in educational heterogeneity.

Given this evidence, the very high level of income inequality prevailing in the country is not surprising. Over the past decades Brazil has been hit by a process of fast technological progress but experiences a very sluggish educational expansion, and as a result the relative scarcity of skill labor increase, leading to a concomitant increase in the market value of education. In other words, over this period technology clearly won the Tinbergen race against the educational system. As a consequence the market value of education (the mirror's curvature) experienced a considerable increase to explain the unprecedented high levels of income inequality, which have been prevailing in the country since 1970.

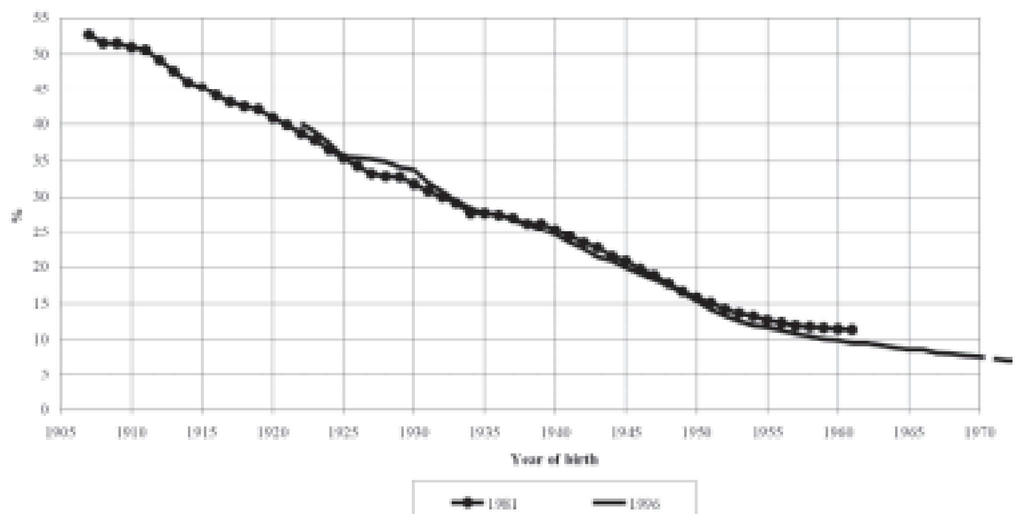
Moreover, since Brazil in 1970 was already a country with moderate levels of education it was, therefore, prone to high levels of inequality in education. The Brazilian experience can be described as that of a country (a) caught over the past decades in the middle of the educational spectrum where the level of the educational inequality (original object) is naturally high; and (b) expanding the educational system very slowly, leading to a growing scarcity of skilled labor and to an increase in the market value of education (curvature of the mirror). As a consequence, educational inequality remained high as the market value of education increased, leading to high and increasing levels of wage inequality. To escape this trap the Brazilian educational system must expand at a much faster rate than it has ever done. Only an unprecedented expansion of the educational system would lead to a substantial decline in wage inequality in the country.

IV - The Brazilian Educational Performance

In the previous sections we have sought to demonstrate the importance of acceleration in the expansion of the Brazilian educational system for the socioeconomic development of the country. In the following section, we investigate the main impediments to a fast expansion of the educational system. However, before we begin discussing these impediments we present below a brief assessment of the recent performance of the Brazilian educational system.

Figure 4 presents the evolution of the illiteracy rate by birth cohort. This figure reveals that from the beginning of the century to the mid-1950s the illiteracy rate dropped 8-9 percentage points per decade. After 1955, however, the decline of the illiteracy rate experienced a considerable slowing down, with the illiteracy rate declining only 3 percentage points per decade. As a consequence of this dramatic slowdown in the decline in the illiteracy rate, the eradication of illiteracy that would take just ten years at the previous speed is now expected to last at least two more decades. It is important to note that the dating in this analysis refers to the year of birth, which is 10 to 20 years before the person is actually exposed to the educational system. Thus, the slowdown of the decline in the illiteracy rate is likely to be associated to changes in the educational system that occur in the mid-sixties and have not been reversed since then.

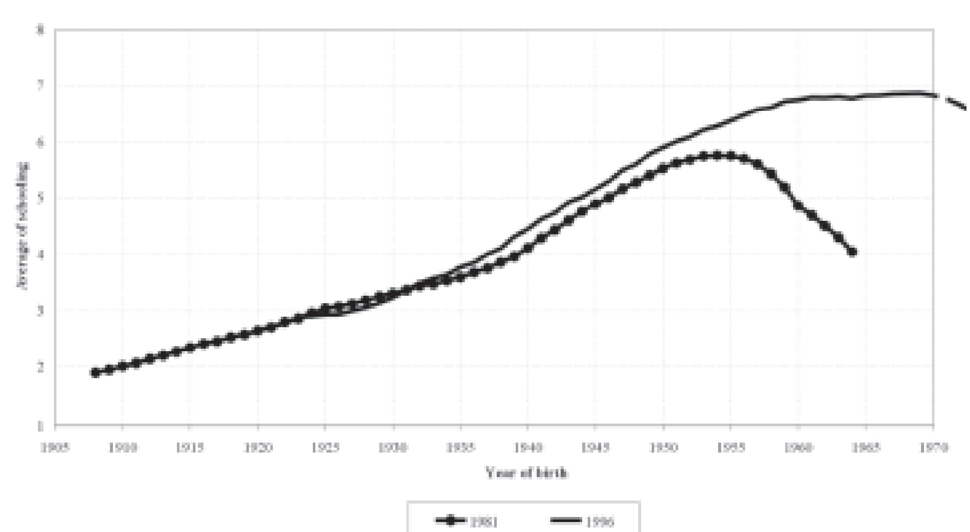
FIGURE 4: EVOLUTION OF ILITERARY RATE BY BIRTH COHORT



Source: Based on Censo Demográfico for years 1960, 1970, 1980 and Pesquisa Nacional por Amostra de Domicilios (PNAD) for years 1985, 1990 and 1995.

Figure 5 presents the evolution of average schooling of the adult population by birth cohort. This figure reveals that the average schooling was increasing at a rate of one extra year per decade at the beginning of the century. For those born in the 1940s, schooling was increasing at a rate of 1.5 extra years of schooling per decade. Since the mid-1950s, the educational expansion slowed down to less than 0.5 years of schooling per decade.

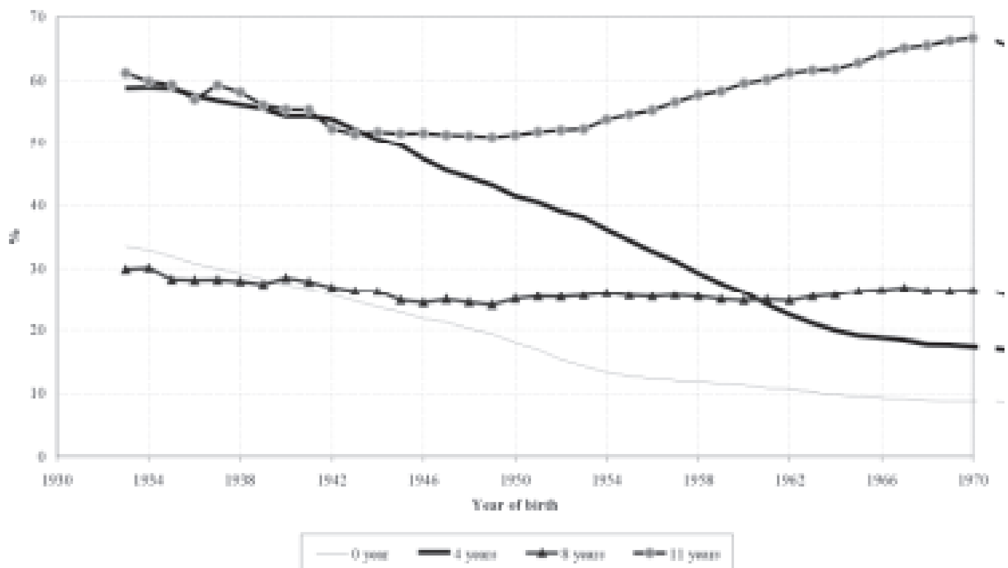
FIGURE 5: EVOLUTION OF SCHOOLING BY BIRTH COHORT



Source: Based on Censo Demográfico for years 1960, 1970, 1980 and Pesquisa Nacional por Amostra de Domicilios (PNAD) for years 1985, 1990 and 1995.

Figure 6 presents the retention rates at different education levels by birth cohort. On the positive side, this figure reveals that access to school has improved. It is evident by the considerable decline in the retention to the fourth grade – specially in the period between the 1930s and the beginning of 1960s – and the relative decline in the level of zero years. On the negative side, this figure shows no improvement at all in access to both secondary and college education. Actually access to college worsened over time, in particular for those groups born after 1950.

FIGURE 6: EVOLUTION OF RETENTION RATES BY BIRTH COHORT



Source: Based on Censo Demográfico for years 1960, 1970, 1980 and Pesquisa Nacional por Amostra de Domicilios (PNAD) for years 1985, 1990 and 1995.

In short, all evidence provided in these figures reveals a dramatic slowdown in the rate at which the Brazilian educational system has been expanding over the previous decades. This slowdown is of major concern given the still very low level of schooling of the Brazilian population.[3]

The evidence provided to date illustrates the decline in the rate of expansion of the Brazilian educational system. However, it is not very informative on whether the educational level and its rate of expansion are adequate, given the level of development already achieved by the country. To evaluate the performance of the Brazilian educational system we rely on a series of international comparisons.

Table 7 presents some comparisons between Brazil and Taiwan. This table reveals that, while in 1992 the average schooling of the 15-30 years age group in Brazil was 0.8 years of schooling more than the 50-65 years age group, in Taiwan the schooling difference between these two birth cohorts is a1.6 year of schooling. In other words, over the past 35 years the educational expansion in Taiwan was twice as fast as the educational expansion in Brazil. As a result, by 1992 the average education in Taiwan of the 15-30 years age group was almost twice the corresponding value for Brazil, that is, while in Brazil the average schooling of this age group was 6 years, in Taiwan the average schooling was more than 11 years.

3 It worth mention that it is still difficult to assess to what extent this slowdown has been reversed by the innovative educational policy that has marked the past five years.

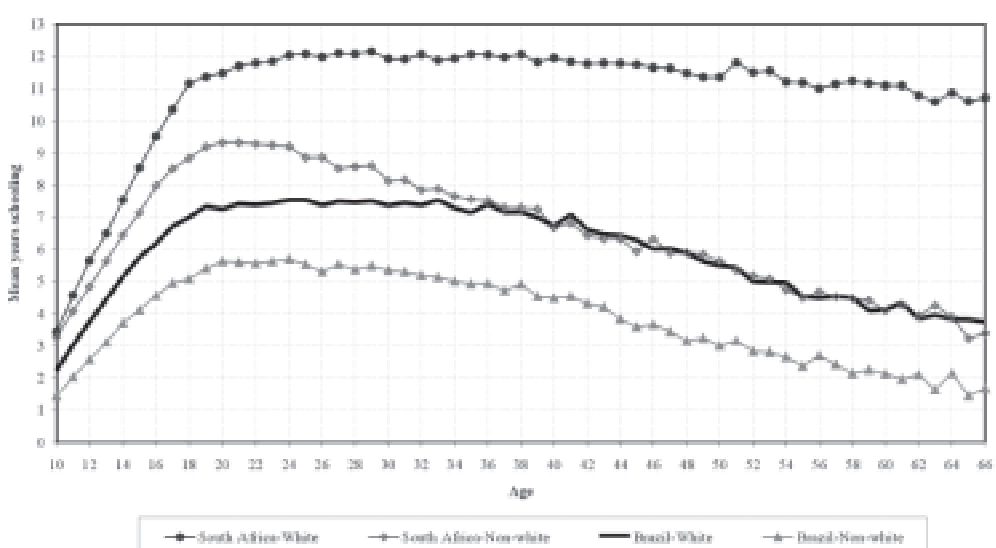
Table 7: Average schooling by year and age group and the progress per decade

		Brazil*			Taiwan**		
age group		1979 (a)	1992 (b)	((b)-(a))x10/13	1979 (a)	1992 (b)	((b)-(a))x10/13
1	15-30	4.9	6.0	0.9	9.6	11.3	1.3
2	30-50	3.8	5.6	1.4	6.9	9.6	2.1
3	50-65	2.6	3.4	0.6	5.1	5.6	0.4
(1-3)x10/35		0.6	0.8		1.3	1.6	

*Source: * Pesquisa Nacional por Amostra de Domicílios (PNAD) ** Bourguignon, Fournier and Gurgand (1998)*

Figure 7 gives a comparison between the educational attainment by age group in Brazil and South Africa broken down by race. This figure reveals that the educational attainment of whites in Brazil is historically very similar to the corresponding attainment of non-whites in South Africa. The performance of non-whites in Brazil is considerably worse than non-whites in South Africa and whites in Brazil. Even more problematic is the evidence that for the younger groups the educational level of the white population in Brazil is growing at a slower rate than that for non-whites in South Africa. As a result, the educational advantage of non-whites in South Africa in relation to whites in Brazil is increasing. In fact, for the younger birth cohort the educational attainment of whites in Brazil has remained essentially unchanged for at least a decade.

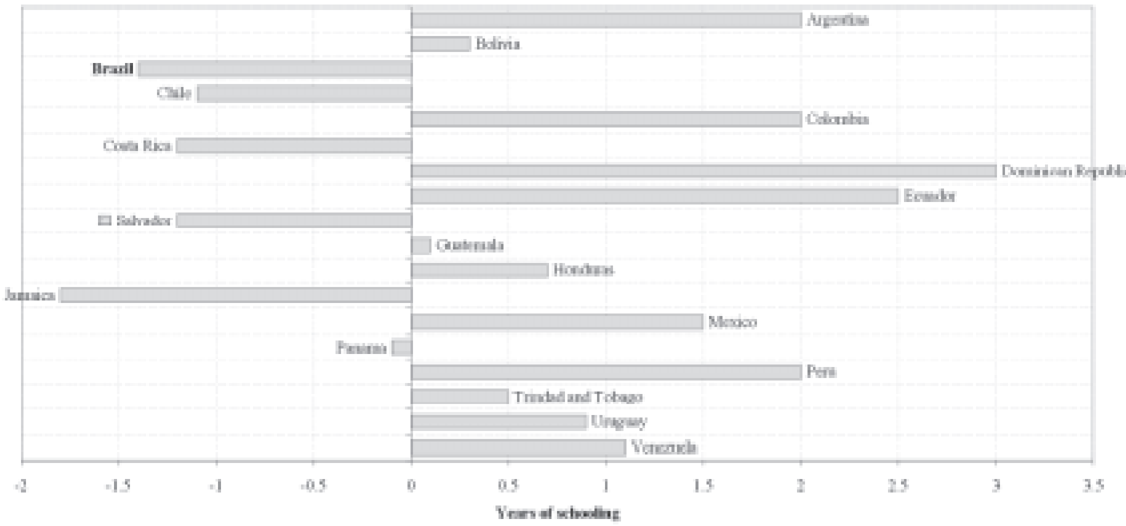
Figure 7: Mean years of schooling by age for whites and non-whites, South Africa, 1995 OHS and Brazil



Source: Based on Pesquisa Nacional por Amostra de Domicilios (PNAD) for year 1995.

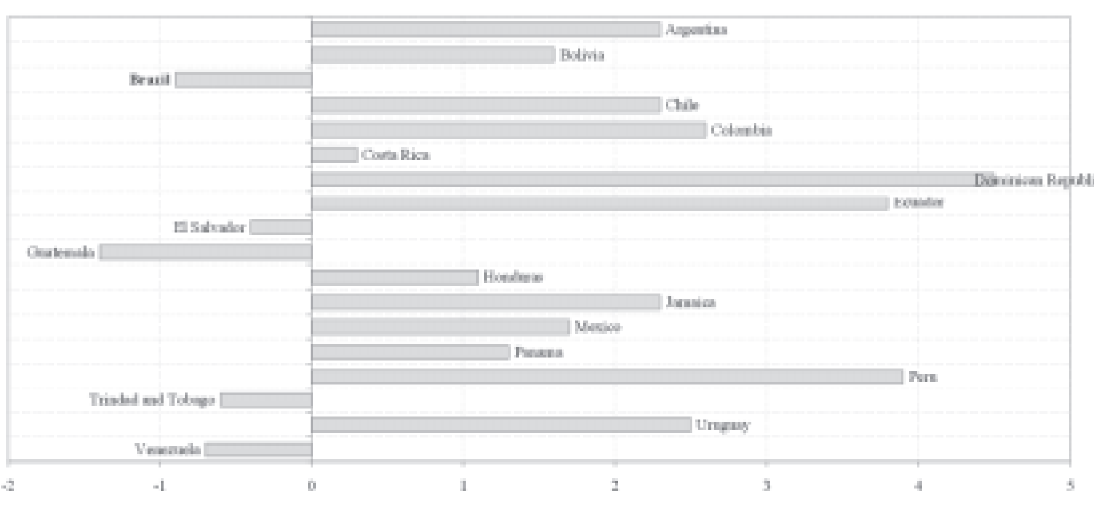
So far we have compared the educational attainment of the Brazilian population with that of other developing countries without any attempt to control the differences in economic development. Next, we give some estimates of the performance of the Brazilian educational system in relation to an international standard that takes into consideration the current level of development of the country. We compare both the current educational conditions in Brazil and its rate of expansion with the international standard.

Figure 8: Gap in school attainment relative to the international standard - 1965/87



Source: Behrman, Jere R. "Investing in Human Resources", in Economic and Social Progress in Latin America 1993 Report, Inter American Development Bank.

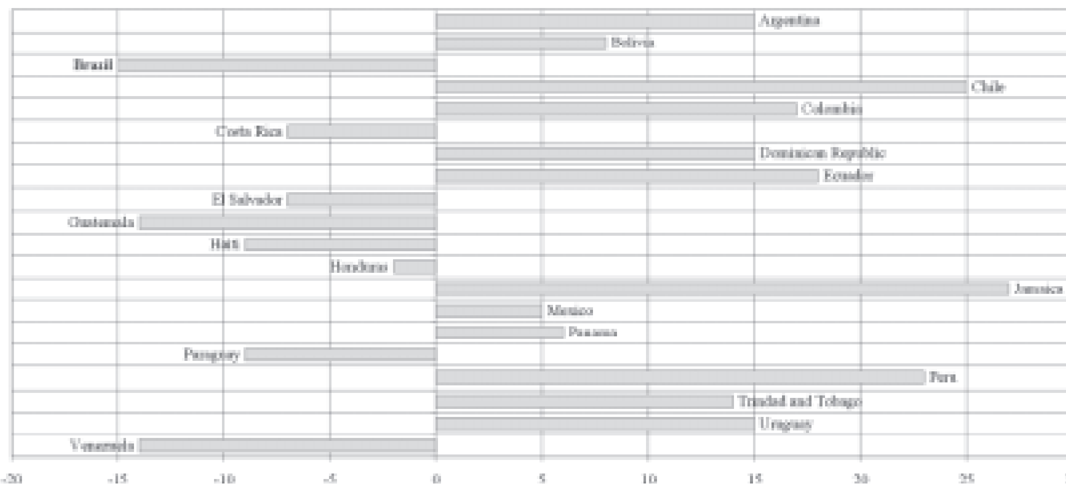
Figure 9: Gap in educational level relative to the international standard - 1987



Source: Behrman, Jere R. "Investing in Human Resources", in Economic and Social Progress in Latin America 1993 Report, Inter American Development Bank.

Figures 8, 9 and 10 compare the current situation in Brazil with the international standard. Figure 8 compares the expansion rate of the Brazilian educational system with the international standard. This figure shows that the Brazilian education system is expanding at a much slower rate than the corresponding international average. According to this figure the Brazilian educational system must increase its rate of expansion in one extra year of schooling per decade to reach the international standard. In addition, Figure 9 reveals that the average number of years of schooling in Brazil is almost one year less than the international standard. Since the educational system in Brazil used to expand at a rate of one year per decade, we can say that the Brazilian educational system is 10 years behind schedule. An analysis of this weak

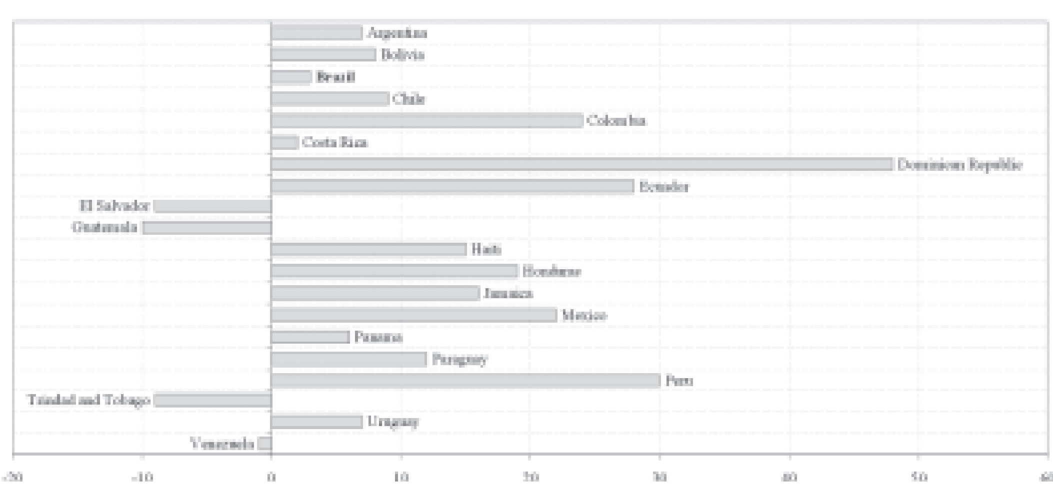
Figure 10: Secondary school enrollment compared with the international experience, 1987



Source: Behrman, Jere R. "Human Resources in Latin America and the Caribbean", Inter American Development Bank.

performance per educational level[4] indicates that most of the gap from the international standard is due to a very weak performance of secondary education. As a matter of fact, Figure 10 shows that the secondary school enrollment rate in Brazil is 15% below the international standard. Similar estimates for primary school and college (see Figures 11 and 12) indicate that at these levels Brazilian enrollment rates are very close to the international standard.

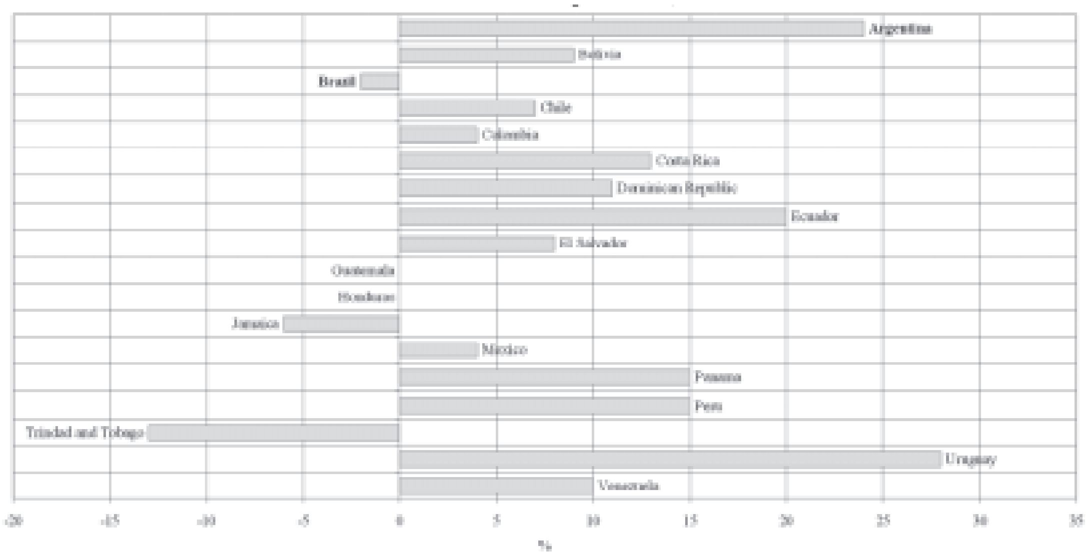
Figure 11: Primary school enrollment compared with the international experience, 1987



Source: Behrman, Jere R. "Human Resources in Latin America and the Caribbean", Inter American Development Bank.

[4] See Behrman (1993).

Figure 12: Tertiary school enrollment compared with the international experience, 1987



Source: Behrman, Jere R. "Human Resources in Latin America and the Caribbean", Inter American Development Bank.

V - Determining Factors in Educational Performance

Educational performance depends on families, schools and the labor market. Children can learn only if they go regularly to school. Although school can attract children, families play a decisive role in determining school attendance and how much effort and time children dedicate to studying related activities.

Investment and credit constraint

Although schooling can be thought of as a consumption activity to both parents and children, schooling is mainly an investment. During the schooling period, parents spend a considerable amount of time and money to educate their children. On the other hand, children spend a considerable amount of time in and incur substantial psychological costs in pursuing their own education. The main reason families and children spend all these resources on education is that better educated persons have better lives. Families expect that they will earn higher wages, have better chances to find jobs, become unemployed less often, be more healthy and live longer.

In other words, as with any other type of investment, the benefits of education lie in the future. In the short run, education is synonymous of time, monetary and psychological costs. These costs become even more important when families are poor, since they may not have the necessary resources to invest in their children's education. Even when public education of high quality is available the costs of education may still be heavy, since the main cost of education is the opportunity cost of the time children dedicate to schooling activities. Since children could be working instead of studying, one of the main costs of education is the income that families must forgo while their children are in school instead of being in the labor market. For poor families this cost may be high. Even if the benefits of education outweigh these costs, poor families may not have access to credit, making it impossible for them to pay these costs, that is, credit constraints may prevent poor families from pursuing profitable investments in their children's education.

Educational attainment: school availability, quality and efficiency

Moreover, children of poorly educated parents may be at a learning disadvantage because the environment at home may not be the best to stimulate learning and because poorly educated parents may have difficulties in helping children with their homework. For these reasons, we should expect a direct association between the educational attainment of children and the income and educational level of their parents. Several studies[5] confirm this close direct association between the educational attainment of children and the income and educational level of their parents. All of them show that parents' education is much more important than per capita family income in determining children's educational attainment (see, for instance, Tables 8 and 9).

For children to attend school, schools must be available in the community. In other words, school availability is an important determining factor of children's educational attainment. If schools are located far from the community and the number of vacancies are limited, it is natural that at least a fraction of children will not be attending school.

The quality of school is also an important determining factor of educational results. Since the attendance to better schools produces greater benefits or lower costs to students (for example, higher wages), better schools are more attractive to students. In fact, the main reason students give for dropping out of school is the low quality of the educational services being offered.

The quality of the educational services is traditionally measured by the quality of the input used in the educational process. This association, however, may not be valid. If schools are not being efficiently managed, high quality input does not necessarily translate into educational services of high quality. Hence, when the quality of schools is measured by the quality of its input it is important to consider management efficiency as an additional determining factor of educational attainment.

Several studies have estimated the impact of school availability, quality and efficiency on educational performance.[6] These studies have reached two important conclusions. First, they have demonstrated that school availability is definitely not a major explanation for the weak educational performance in Brazil. Secondly, they have shown that although the poor quality of the services being provided is a major problem, it does not seem to be as important as the low income and low educational level of parents.

To illustrate this result we present in Tables 8 and 9 estimates of the impact of school quality and availability and estimates of the impact of family background on educational performance. Table 8 presents estimates of the importance of family background and school availability and quality in explaining the gap in educational performance between three selected Northeast States and Rio Grande do Sul. In order to measure educational performance we use the grade-age gap (that is, the age of the children minus 7 minus the highest grade already completed). The results in this table reveal that regional differences in the education of parents are the main explanatory factor. This table also reveals that regional differences in family background are much more important in explaining regional differences in educational attainment than differences in school availability and quality (teacher's education).

[5] Barros and Lam (1993), Barros and Mendonça (1998a), Mello e Souza & Valle Silva (1996).
[6] See, for instance, Barros and Mendonça (1998b; 1996).

Table 8: Determinants of education performance in Brazil: age - grade gap Ceará, Bahia and Pernanbuco - 1991

	Ceará		Bahia		Pernambuco	
Variables	Schooling	%	Schooling	%	Schooling	%
Total difference between Rio Grande do Sul and each State	2.50	100	2.53	100	1.93	100
All observed effects	1.02	41	1.19	47	0.37	19
Family background	**0.84**	**34**	**1.17**	**46**	**0.28**	**15**
Parents education	0.63	25	1.05	41	0.27	14
Parents income	0.21	8	0.12	5	0.02	1
Education resources	**0.16**	**6**	**0.07**	**3**	**0.04**	**2**
Student/Teacher ratio	0.00	0	0.00	0	0.00	0
Teacher's education	0.15	6	0.07	3	0.04	2
Urbanization	**0.03**	**1**	**-0.04**	**-2**	**0.05**	**2**

Source: Barros, Henriques, Mendonça (1999)

Table 9 presents similar estimates. These estimates now aim to explain the improvement in educational attainment that occurs over time in three northeastern States. The conclusions from this table are identical to those obtained from Table 8. First, this table presents clear evidence that improvements in school availability were not an important factor in explaining the educational progress in these northeastern States. Secondly, the table reveals that improvements in parents' education were the most important explanation for educational progress. Finally, the table indicates that family background (parents' education) was much more important than improvements in school quality (teacher's education).

Table 9: Determinants of education performance in Brazil: age - grade gap Ceará, Bahia and Pernanbuco

	Ceará		Bahia		Pernambuco	
Variables	Schooling	%	Schooling	%	Schooling	%
Total difference between 1970-1991	0.99	100	0.68	100	1.20	100
All observed effects	1.06	107	0.39	58	1.23	103
Family background	**0.88**	**89**	**0.37**	**54**	**0.86**	**72**
Parents education	0.76	77	0.33	49	0.89	74
Parents income	0.12	12	0.04	5	-0.02	-2
Education resources	**0.13**	**13**	**0.06**	**9**	**0.17**	**14**
Student/Teacher ratio	0.02	2	0.01	2	0.00	0
Teacher's education	0.12	12	0.05	8	0.17	14
Urbanization	**0.05**	**5**	**-0.04**	**-5**	**0.20**	**16**

Source: Barros, Henriques, Mendonça (1999)

In terms of efficiency recent studies have concentrate their attention on the impact of decentralization.[7] In this study we estimated the impact of three decentralization devices on educational performance: (a) the election of the school principal by community members, (b) the existence of school boards, and (c) the direct transfer of resources to the school (school financial autonomy). As part of the re-democratization process several States introduced these management innovations over the 1980s and 1990s. In this study, some estimates are given of the contribution of these innovations to the improvement in several educational results from 1981-3 to 1990-93. They found that these innovations taken together could explain essentially half of the improvement in education that occurred in the period. Since the improvements in educational performance in the 1980s was not outstanding, the impact of these management innovations can be considered sizable but not as fundamental as expected.

[7] An example is the study by Barros et alli (1998).

Since one of the main costs of education is forgone earnings, labor market conditions ought to be an important determining factor of school attendance. In fact, everything else constant, better labor market conditions should attract poor children to the labor market with negative effects on their school attendance.

In other words, school attendance is part of children's time allocation process. At each point in time they have to decide how much time to allocate to leisure, work and study. As a result, the amount of time dedicated to school will depend on the relative attractiveness of the school and the labor market. In short, there is a race between schools and the labor market for the children's time. In areas with good schools and poor labor markets children are more likely to attend school than in areas with poor schools and good labor market opportunities.

Despite its theoretical importance, very few studies have been made to demonstrate the negative impact that active labor markets may have on school attendance and performance. In a recent study, Barros et alli (1999) found some evidence of this effect. The quantitative results, however, indicate that this factor may not be as important as suspected. The main reasons for the low importance of labor market conditions is the widespread use of evening classes that reduce the conflict between working and study activities.

Finally, it is worth mentioning that from a long term viewpoint, attending school is always a better choice than dropping out of school to work. This is particularly true in Brazil where the wage gap between educational groups is very wide. In Brazil it certainly pays to remain in school even if the only advantage is an increase in future wages. Thus, the attractiveness of the labor market to children in Brazil is shortsighted, resulting to a large extent from poor families being under credit constraint. In other words, the competition between the labor market and schools for the children's time is a problem constraint to children in poor families. As poverty is reduced this type of shortsighted behavior will be eliminated and labor market conditions will play no role in explaining educational attainment.

VI - Final Comments

This paper focused on three main questions relating to economic development and educational expansion. First, we presented evidence of the fundamental importance of a fast and continuous process of educational expansion for an equitable and sustainable socioeconomic development process. In fact, we presented evidence that, on one hand, educational expansion is essential for improvements in labor productivity leading to economic growth, increasing wages and diminishing poverty. On the other, education expansion is essential to improve equity and mobility. Moreover, we also presented evidence that the impact of education expansion goes beyond its direct influence on equity and economic growth. For instance, there is evidence that education has also an important direct impact on population growth and parental care. Through these channels education can further improve efficiency, reduce poverty and facilitate social mobility.

Second, we provided an overall evaluation of the Brazilian educational performance over previous decades. The evidence presented indicates a very weak performance over these decades. As a result of this poor historical performance, Brazil is today, in terms of education, a decade behind the typical country with a similar level of development. In other words, most countries with a similar level of per capita income attained the Brazilian current level of education ten years ago. Over the past five years, however, educational policy underwent major changes. Since the end results of these changes are only going to be completely visible in the next decade, the evaluation presented in this study is unable to assess the impact of this new educational policy on educational performance.

Finally, we investigated the main causes of the poor educational performance of the Brazilian educational system. The main conclusion is that weak family background continues to be the major determining factor for weak educational performance. For instance, we showed strong evidence that the parents' education is much more important to the educational performance of children than their teachers' education. This close link between family background and educational performance constitutes a severe impediment to the effectiveness of most educational policies, in addition to being a major source of unequal opportunities. As a result, we concluded that any successful educational policy in Brazil should be designed to function as a substitute for poor family background. In other words, policy should be carefully designed to compensate for a weak family background instead of working as a complement for family input. By following this strategy, educational policy will be able to reduce the impact of family background, increase equal educational opportunities, and make room for the influence of other educational policies.

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Sustainable Development and the Poverty Reduction Goal

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I - Introduction

Due to the moral imperative to work towards the goal of guaranteeing the vital minimum to all, poverty has been a permanent concern among development theorists. Economic growth had been originally considered the basic requirement for attaining such goal. By late fifties, there was widespread consensus in the academic milieu that economic growth per se was not enough for dealing with poverty: the fact that benefits of income growth are unevenly distributed placed under the spotlight equity questions associated to the antipoverty objective (Adelman, 1975). By late sixties, the theory of economic development has evolved to explicitly incorporate the concern for environmental protection, which results in establishing a logical link between poverty and the concept of sustainability.

Sustainability means "that the current generations should meet their needs without compromising the ability of future generations to meet their own needs" (World Bank, 1992, p. 34). It may be seen as an additional restriction to economic growth, and also to the already ambitious task of increasing income to eliminate absolute poverty under conditions of increased equity. Nevertheless, there are evident synergies between alleviating poverty and protecting the environment. In many instances reducing the poverty incidence may be a pre-condition for environmental sustainability, since the poor are both agents and victims of environmental degradation. On the other hand, providing infrastructure for urban development or soil protection in the countryside generates much needed employment for low skilled poor, improving their income and contributing to the social integration objective.

This paper will focus on the links between poverty and sustainable development in Brazil. The next chapter considers the relationship between both poverty/income growth, and poverty/income distribution. The idea is to highlight the fact that, although growth is necessary to attain higher levels of well being for all, reducing income inequality is a key element when trying to eliminate absolute poverty in a country where per capita income has reached intermediate levels according to the accepted international classification.

The question of how to reduce poverty by improving the poor´s earning capacity depends on recognizing the differences in poverty across Brazil. Since 76% of the poor are concentrated in the rural Northeast and in metropolitan areas, presenting almost diametrically opposed characteristics in terms of income levels, economic activity, social equity, labor market and environmental conditions, this fact justifies the description of these two benchmark situations. Chapter III deals with the specificities of rural Northeast and the São Paulo metropolitan area in what concerns creating labor market opportunities for the poorest.

When considering the relationship between poverty and sustainable growth in Brazil today, it is important to note that there is no critical trade-off between lower, but sustainable growth rates, that would result in a slower pace for poverty reduction, or otherwise, higher growth rates, which could lead to quicker results in poverty reduction, but at a cost in terms of environmental sustainability. Since technological choices in industry are essentially determined by the need to be competitive, guaranteeing sustainability does not seem to be a significant restriction to achieve higher growth rates for the country as whole. Nevertheless, this may be a real concern in the Amazon region, where, because of specific physical conditions, deforestation is an indicator of non-sustainable growth. Chapter IV focuses on the fact that deforestation and poverty incidence do not seem to be linked.

The relationship between poverty and environment sustainability is a relevant question in metropolitan regions in absence of adequate urban infrastructure. The violation of basic rules of land use, as well as large deficits in sanitation services, both for poor and non-poor, are important concerns when sustainability is considered in densely populated areas. Chapter V focuses on the subject and shows that deficits remain high, specially in sewerage. As a matter of fact expansion of services in the nineties were significant, but there is still a long way to go to meet adequate standards. Finally, Chapter VI summarizes the main conclusions.

Chapter I
Income and Absolute Poverty

Absolute poverty is theoretically associated to the condition in which the vital minimum is not achieved. In modern urban societies this minimum is expressed in monetary terms - the so-called poverty line - and income is taken as the basic parameter of well-being, at least in what concerns private consumption.

A monetary measure of absolute poverty is given by the poverty gap - that is, the consolidated amount necessary to raise all poor to the non-poor status in terms of income. It can be expressed as percentage of the GDP, thus revealing the weight of absolute poverty in relation to the usual measure of economic performance. In 1996 the poverty gap reached 1.17% of the GDP.[1] Alternatively, the poverty gap can be expressed as percentage of the non-poor income, which relates more directly to the income distribution issue: the income gap corresponding to the 20% proportion of poor represented only 2.15% of the non-poor income in that same year. These measures suggest that absolute poverty would be easily remedied through economic growth and/or income transfers. Nevertheless these statistical indicators do not take into account the difficulties associated to actual policy implementation. In the first case economic growth that can be achieved is not channeled exclusively to the poor, but to the different income groups according to the complex rules of production and appropriation. In the second case, income transfers are necessarily intermediated by fiscal policy, which has obvious difficulties in terms of correctly identifying those to be taxed and those to be benefited from transfers, which certainly means that total costs associated to policy implementation are much higher than those estimated on the basis of the statistical simulation. Moreover, income insufficiency is just one aspect of poverty, the one that relates to private consumption in order to meet basic needs. Other basic needs necessarily depend on government provision of goods and services. Costs associated to the provision of health, sanitation, education, social assistance, even in the scope of anti-poverty policies, are certainly higher than the estimated income transfers which would be necessary to fill the income gap.

From the association between poverty and insufficiency of income derives the incorrect notion that reducing absolute poverty necessarily depends on economic growth. As a matter of fact, absolute poverty may be associated to two different situations. [2]

[1] The poverty gap based on family per capita incomes as derived from PNAD and local specific poverty lines estimated by Rocha (1997) reached R$ 7.6 billions, or 1.15% of GDP.

[2] In developed countries, where the vital minimum is guaranteed to all, *relative poverty* is associated to income inequality and social exclusion.

In the first situation, resources are insufficient to guarantee the basic minimum for the majority of the population. This is the case of countries where poverty is widespread and resources are scarce overall, that is, most of the population is poor and per capita income is low. Increasing the national income level is essential, although certainly not sufficient to significantly reduce absolute poverty. In the second situation, poverty derives from an inadequate pattern of growth, where the absolute poverty syndrome is associated to income inequality. Brazil fits in the second situation, since it has attained a level of income that, if fairly distributed, would be sufficient to meet basic needs for all individuals in the population. As a matter of fact, per capita income around 4,000 dollars is well above any conceivable poverty line drawn to accurately represent the satisfaction of the minimum vital under Brazilian conditions. In this context, the relatively high levels of absolute poverty - around 20% of the total Brazilian population[3] - necessarily derives from the high degree of income inequality.

The relationship between poverty incidence, income growth and income inequality can be seen from different angles. In Brazil the importance still attributed to economic growth as the privileged mean for reducing poverty is certainly a heritage of the "miracle years". From 1970 to 1980, when average yearly GDP growth reached 7.85%, the proportion of poor was reduced from 68% to 35%[4], that is, to the levels not much higher than those that still prevailed fifteen years later, before the Real Plan. Inequality increased during the period - the Gini coefficient evolved from 0.50 in 1970 to 0.59 in 1980 [5] (Bonelli, Ramos, 1993), but this adverse tendency was tolerated because all income groups were better off. Furthermore, increased inequality was seen as a unavoidable aspect of the growth process, that would fade away in subsequent stages of development. Obviously the effects of income growth on reduction of absolute poverty could have been stronger had income inequality remained constant at 1970 levels.

Recent estimates have been derived in order to evaluate the impact of income growth on poverty reduction, assuming that growth would not affect income distribution, and alternatively, the effect of reduction of income inequality on poverty reduction if no growth takes place (Paes e Barros, Mendonça, 1997). The results show that reducing inequality is crucial for lowering poverty incidence, since the impact of income growth solely would be too slow in affecting poverty downward: yearly growth rates of 3% for a decade - 1993 is taken as departing point - would reduce the proportion of poor in seven percentage points (from 35% to 27%)[6]; a higher growth rate of 5% yearly, which is certainly difficult to achieve, would still only reduce poverty in thirteen percentage points in a decade, making the proportion of poor to decline from 35% to 22%. Alternatively a reduction in the level of inequality - the Gini evolving from .63 to .53 - would have the same impact in poverty reduction as the 3% income growth over a decade.

These results seem to place the income growth as a secondary objective to reducing income inequality. But how feasible is to reduce the Gini coefficient in ten percentage points? It is well known that income inequality has attained critical levels in Brazil and that Gini coefficients around .6 are among the highest in the world. It is specially

[3] Rocha (1997).
[4] Estimates based on the Demographic Census data (Rocha, 1996).
[5] Both coefficients relate to the Economic Active Population with positive income.
[6] A poverty line corresponding to 0.5 of the minimum wage was assumed in these simulations.

noteworthy that high income inequality in Brazil is related to very strong concentration of income in the higher brackets: to the 1% highest incomes corresponded 13.5% of total personal income, while to the lowest 50% of income distribution corresponded only 13% of total income in 1996. As a consequence of this markedly skewed pattern, the Gini coefficient associated to the lower 99% of the income distribution would decline from .57 to .53. Table I shows income distribution for selected years and corresponding Gini coefficients for the complete and the truncated distribution.

TABLE I: PERSONAL NON-ZERO INCOME DISTRIBUTION - SELECTED YEARS

INCOME BRACKETS IN PERCENTILES	1986	1989	1993	1996
Up to 50%	12.5	10.4	12.8	13.0
50% - 90%	38.7	36.4	37.4	39.1
90% - 99%	33.6	35.9	33.8	34.4
99% - 100%	15.2	17.3	16.0	13.5
Gini Coefficient (lower bound)				
100%	0.5814	0.6234	0.5829	0.5726
Up to 99%	0.5357	0.5770	0.5338	0.5329

Source: IBGE/PNAD 1996.

Data presented above shows that reducing income inequality does not seem to be easy either, since the evolution of the Gini coefficient is quite inelastic to ups and downs in the rate of economic growth. It is specially important to observe that from 1993 to 1996, when there was a significant increase of incomes at the lower half of the distribution and the reduction of the income share of the highest 1% simultaneously, the Gini coefficient showed only a slight decrease.

The reduction on poverty incidence between 1993 and 1995 - the proportion of poor declined from 30% to 20% -[7], was thus essentially due to income growth at the lower end of income distribution, which, although increasing significantly the share of income appropriated by the lowest 10%, had a very slight impact in income inequality as a whole (the Gini declined from .58 to .57).

These facts have implications for the poverty reduction goal. It is obvious that economic growth is necessary, but its effect on poverty depends on the distributive pattern. Under the present conditions, some considerations concerning the impacts of growth and inequality on absolute poverty in Brazil are in order.

For the next two years the perspectives for economic growth are adverse given the restrictions on investment financing, both from domestic sources and from abroad. The growth rate will certainly be affected by the present crisis, that combines high

[7] Rocha, 1997.

interest rates, overvalued exchange rate, high fiscal and foreign transaction deficits, all having an adverse impact on business expectations. Economic growth will be lower than one per cent this year and certainly also sluggish in 1999, even under the favorable assumptions concerning government initiatives to correct structural unbalances that have plagued Brazilian economy for so long. Thus, from the income growth side, there will be no effect on poverty reduction in the short term.

Under the no growth scenario the possibilities of reducing absolute poverty through income distribution are also adverse. In 1998, under the low growth conditions, labor income increases that followed the stabilization plan have already ceased in the metropolitan areas and an income concentration effect seems to be at work: average labor income for workers with less than four years of schooling is declining, as well as the number of jobs that require this low level of qualification. As a result, total labor income for this group of workers was reduced in 14% during the last year. Data in Table II also show that labor income and employment relative to workers with twelve years of schooling or more are still increasing. Since PNAD data for 1997 is not available, the impact of these documented metropolitan labor market tendencies on family income and on absolute poverty cannot be directly evaluated. Nevertheless, further poverty reduction seems hard to achieve under the present trends of income growth and labor market restructuring.

TABLE II: RECENT EVOLUTION OF WORKING POPULATION AND LABOR INCOME ACCORDING TO YEARS OF SCHOOLING IN SIX METROPOLITAN AREAS (*)

JANUARY / JULY	AVERAGE LABOR INCOME (R$)*			WORKING POPULATION (1,000)			TOTAL LABOR INCOME (R$ 1,000)**		
	0-4	5-11	12 AND	0-4	5-11	12 AND	0-4	5-11	12 AND
1996	359.84	535.73	1,642.40	5,115.0	8,562.0	2,693.0	1,912.5	4,697.9	4,377.1
1997	375.32	538.50	1,622.27	5,030.2	8,541.3	2,713.3	1,888.4	4,599.8	4,403.4
1998	359.35	534.35	1,654.14	4,503.6	8,920.3	2,825.5	1,618.5	4,766.4	4,671.4
Variation (%)									
1996-1997	4.3	0.5	-1.2	-1.7	-0.2	0.8	-4.4	-2.1	0.6
1997-1998	-4.3	-0.8	2.0	-10.5	4.4	4.1	-14.3	3.6	6.1

Source: IBGE / PME (Special Tabulations).

(*) Recife, Salvador, Belo Horizonte, Rio de Janeiro, São Paulo and Porto Alegre.

(**) Constant values July 1998 (INPC deflator).

In order to further reduce absolute poverty below the levels achieved after the Real Plan economic growth is needed. Not only because of the direct effects of growth on poverty reduction, but because the additional income makes changing distribution in favor of the poorest easier. Nevertheless, it is well known that the new pattern of growth requires modernization and automation to guarantee competitivity. As by product, the labor/capital ratio falls, specially reducing the demand for the abundant less qualified manpower. The undisturbed trend would mean reduction of labor income at the lower brackets of the distribution.

Chapter II:
Improving the Poor's Earning Capacity

The poverty reduction objective requires making income transfers to the poorest and /or promoting better engagement in the labor market. Creating new jobs and increasing labor productivity among the poor has to take into consideration the spatial distribution of poverty in Brazil and local differences in the poverty profile. A third of Brazilian poor are concentrated in the rural Northeast (17%) and in the primate metropolises of São Paulo and Rio de Janeiro (16%). To take into account their quite diverse characteristics is essential for drawing policy mechanisms that could lead to increases in their income earning capability.

Table III: Poverty Profile - Rural Northeast and Metropolitan São Paulo - 1996

	Rural Northeast	Metropolitan São Paulo
Family Indicators		
Children per family	2.81	1.71
% Children 7-14 years old out of school	22.32	7.58
% Female Households Heads	18.12	26.75
Household Head Indicators (%)		
Primary Occupation	89.09	2.77
Tertiary Occupation	6.28	56.38
% Illiteracy	60.06	14.19
% 1-4 Years of Schooling	38.17	41.28
Occupation Status		
Non payment	3.44	0.85
Employee	32.54	76.37
Self-employed	63.02	21.91
Employer	1.11	0.85
Unemployed	3.09	23.08
Housing Conditions (%)		
No Electricity	57.04	0.26
Inadequate Water	32.14	4.59
Inadequate Sewerage	82.30	34.99

Source: IBGE/PNAD 1996 (Special Tabulations).

Poverty in the rural Northeast is still typical of traditional societies. The percentage of female household heads is low. There is predominance of occupation on agricultural activities, thus unemployment is irrelevant. Most of household heads are illiterate or have less than four years of schooling. The majority of the poor are self-employed and some - even among the household heads - work for more than fifteen hours a week without pay, which is associated to labor in small holdings yielding just enough for family subsistence. Access to basic public services - education, electricity, sanitation - is largely inadequate, which means that the State is absent as provider. Poverty in the Northeast is clearly associated to low productivity in agriculture and to its determinants, that is, agrarian structure and geophysical conditions. Anti-poverty policy must aim at improving the living conditions of the poor by guaranteeing access to land and productivity increases as a result of integrated actions both in the social (education, health, nutrition) and agricultural assistance fronts. Adequate use of available resources should lead to job creation and income increases, which would contribute towards the reduction of poverty incidence in the region for two basic reasons. Firstly, because it disincentives migration to urban areas, where poverty is already high and harder to fight considering the profile of the poor. Secondly, although a large percentage of the Northeastern poor presently live in small urban centers, they have rural background and are better fitted to rural life[8]. Rural development initiatives should promote their engagement in agriculture activities on a new basis.

In the primate metropolises, poverty is socially and economically articulated to the functioning of the national economy dynamic poles. Families are smaller and the number of children lower than in the Northeast. Looser family ties mean higher percentage of female household heads, which is one of the main features of urban poverty in modern societies. The illiteracy rate is high, even among household heads, but much lower than in the rural Northeast. Most poor work in trade and services, that is, in the low productivity / low earnings activities in these sectors. Unemployment rate is high, which is typical of urban modernized areas, where formal aspects of labor market are enhanced. Most household heads work as employees. Access to public services is relatively good: most children attend school and there is almost universal access to water and electricity. The most critical deficit concerns sewerage.

Given these characteristics, changes in poverty incidence in the primate metropolises relate more directly to the rate of growth of the economy and to real wages at the bottom of income pyramid. In the diversified and articulated labor market, income and employment ups and downs affect all economic strata. Thus reducing poverty means guaranteeing that the trickle down effect is at work and minimizing the adverse impacts of technological and managerial changes on the labor market for the poor. Public works have the advantage of improving living conditions for the poor, specially in metropolitan peripheries where urban infrastructure is deficient, at the same time that it generates jobs and income for those less qualified, who tend to be excluded from the regular labor market. Poverty among female headed households, which is related to their adverse engagement in the labor market and to a higher dependence ratio, may be effectively minimized by direct aid to children (day care centers, for instance).[9] Quick and efficient training for youngsters at senior high school level would make labor market entrance easier, thus reducing the unemployment rate among those more affected by it.

Chapter IV
Poverty, Deforestation and Sustainable Development in the Amazon Region

There are empirical evidences of increasing poverty in the North Region. Estimates, considering poverty from the income point of view, may be derived both from

[8] More than a fifth of poor househeads in the urban Northeast worked in agriculture activities, thus showing that the concept of urban areas often encompass transitional situations (Rocha, 1995).

[9] Barros (1993) has shown that poverty among female headed households in Brazil is not related to a lower activity rate, but to lower earnings in the labor market despite of better schooling than among their male counterparts.

Demographic Censi and PNADs. As a matter of fact, there has been not only a deterioration of income-based poverty indicators both in urban and rural areas in the 1980/91 period, but PNAD data shows that reduction of urban poverty incidence after the stabilization plan of July 1994 was relatively meager compared to that in other regions. Adverse evolution of poverty indicators, where demographic growth rate is much higher than the Brazilian average, has resulted in a increasing participation of Northern Region in national poverty.

TABLE IV: INDICATORS OF POVERTY AS INSUFFICIENCY OF INCOME
NORTHERN REGION - SELECTED YEARS

REGION AND STRATA	POOR			GAP RATIO
	NUMBER (1,000)	PROPORTION (%)	CONTRIBUTION(*) (%)	
Census Data				
1980 Total	3,677.2	53.18	8.90	0.499
Metropolitan	427.2	52.74	1.03	0.451
Urban	1,426.1	50.77	3.45	0.591
Rural	1,823.9	55.35	4.42	0.438
1991 Total	5,800.2	54.49	10.18	0.504
Metropolitan	405.1	45.18	0.71	0.483
Urban	2,946.1	51.14	5.17	0.501
Rural	2,449.0	61.42	4.30	0.511
PNAD Data				
1993 Total	3,632.3	46.02	8.39	0.459
Metropolitan	414.5	45.75	0.96	0.452
Urban	3,217.8	46.06	7.44	0.460
1996 Total	3,121.7	35.77	9.76	0.476
Metropolitan	360.2	38.39	1.13	0.481
Urban	2,761.5	35.46	8.63	0.475

Source: IBGE/Population Censi and PNAD (Special Tabulations).

(*) Share of Northern Region in the total number of Brazilian poor.

Brazil is well known for encompassing in its large territory - 8.5 million square kilometers - a broad climatic and geomorphologic variety, as well as several important ecosystems, which are supposed to shelter 10 to 20% of world living species. Because of its size and the fact that its wide biodiversity is still largely untapped, there has been worldwide concern in guaranteeing sustainable development in the area covered by the Amazon rain forest.

There is consensus among specialists that deforestation is an adequate indicator of non-sustainable growth in the area where the forest is located. This consensus derives mainly from the fact that, because of specific physical conditions, once slashed, the forest cannot be recuperated. Cleared land is inadequate for agricultural use both for cropping and cattle raising, leading to desertification in the middle and long terms. Since an estimated 1.6 million km^2 of areas suitable for crops are still available in Brazil (Motta, 1996), the expansion of the agricultural frontier in the area is certainly to be avoided.

In spite of the strong arguments against deforestation, it has advanced at a quick pace after the seventies as a result of government initiatives and incentives to the private sector. During the 1978/1989 period the rate of deforestation attained its peak - an average of 21 thousand square kilometers/year, which corresponded to .54% of the area of the Legal Amazon being deforested each year (Table V). Although the pace of deforestation was reduced in subsequent periods, by 1992 it corresponded to an area equivalent to the United Kingdom (Motta,1996).

Table V: Deforestation in Legal Amazon

Periods	km^2/year	% year
1978 / 89	21,130	0.54
1988 / 89	17,860	0.48
1989 / 90	13,810	0.37
1990 / 91	11,130	0.30

Source: INPE(1996), as presented by Motta (1996).

Although there has been alarming concern related to deforestation of the Amazon rain forest, census data show that only a relatively small share of the land in the Northern region is owned by rural establishments. Moreover, most of the land in these establishments remain uncleared,[10] thus kept as a guarantee of land rights and for eventual future gains associated to its increased value. Cleared land represents less than 6% of total area, and the process of clearing land was lately reduced, after attaining a quicker pace during the 1975-80 period. Most cleared land is used as pastures. Cattle raising operation is extensive, requiring little manpower per unity of area, which has important implications in terms of reasons for deforestation and the relationship between deforestation and poverty incidence.

Table VI: Selected Land Uses as percentage of Total Northern Region Area

Area (km ^{2})	1970	1975	1980	1985	1996
Agricultural "Establishments" *	6.54	9.18	11.60	17.47	16.30
Cleared Area	1.32	1.66	2.67	5.16	5.54
Planted Pastures	0.18	0.44	1.05	2.55	4.12

Source: IBGE/Agriculture Censi (1970, 1975, 1980, 1985) and IBGE/Anuário Estatístico do Brasil 1971, 1976, 1981 and 1986.

** Concept used in Brazilian Agricultural Censi. It refers to a continuous extension of land - independently of ownership - under a single management. Decline in area from 1985 to 1996 is due to methodological changes.*

[10] Uncleared land includes native pastures, native forests as well as areas inappropriate for agricultural use.

It is well settled that "the rapid expansion of the agropastoral frontier is probably the most important factor behind deforestation" (Reis,1997). Nevertheless censi data allows for making an important differentiation: large ranches are responsible for most of the cleared area, while the small scale cropping – because of the area involved - has only a very marginal impact on deforestation. As a matter of fact, establishments of up to 10 hectares, correspond to 0.6% of the total area of agricultural establishments, but to 6% of cropping area. Nevertheless, they are particularly important in terms of working force: these establishments concentrate close to 21% of total agricultural working force in the Northern region. Thus migrants settling in small establishments do not seem to be an important determinant of deforestation.

The logical chain behind Amazon deforestation seems to be the following: in order to guarantee national rights over the area, government policies were aimed at increasing occupation through fiscal incentives for agricultural settlements, road building, mining concessions. Large agricultural establishments, most of them in the fringes of the rain forest, as well as other projects of local impact - like mining operation, *garimpos*, road construction -, created job opportunities that attracted a disproportional number of poor migrants. Some of them were permanently or temporally involved in these operations. Others became small squatters, whose main activity is cropping. Most of them ended up in urban areas were demographic growth was the strongest.

Thus, as far as deforestation is concerned, the inflow of poor migrants seems to have played a very minor role. Reis (1997) using deforestation data at the municipal level derived from census information and from UNH estimates based on landsat images found that growth of cattle output and growth of big farms (1,000 hectares and more) are the main determinants of Amazon deforestation. When investigating the causes of increased poverty – poor were defined as those with family per capita income below half a minimum wage - variables associated to cattle raising were the most important determinants[11]. Nevertheless, since the poor tend to move on and to concentrate in urban areas, the analysis based on municipal characteristics and not on the characteristics of the poor do not shed much light on the roots of poverty in the Northern region.

Since poverty incidence is high, it probably follows the same pattern of demographic growth, which is essentially urban and concentrated in the large cities. Urban growth in the Northern region has been 2.5 percent points above the one in rural areas since the seventies. Moreover, the distribution of municipalities by size of population show that demographic growth took place in the larger municipalities, not in the small nuclei that are associated to scattered occupation in the urban/rural transition: municipalities where population is above 100,000 inhabitants already correspond to 42% of the region's total population.[12] Even if most migrants have a rural background and their original intention was to settle in a piece of land in the agricultural frontier, most end up as urbanites. Since urban activities lack dynamism to absorb the demographic inflow, the result is increased poverty incidence.

[11] Six explanatory variables were used in the regression: growth of big farms (larger than 1,000 ha), growth of agricultural output, growth of cattle output, growth of squater area, growth of rural population, number of land invasions.

[12] Small municipalities - less than 10,000 inhabitants - have a declining share of total population: 3.8% in 1980 and 3.0% in 1991 (IBGE, Demographic Censi) .

It is important to emphasize that the primary causes of deforestation relate to a series of factors, most of them in the sphere of government policy[13] and that, given the physical characteristics of the region, deforestation and occupation of the frontier could not take place in the absence of important economic incentives. Although poverty incidence in the North has presented a growing pattern, it is associated to the attractiveness of the frontier to poor migrants, who find meager economic opportunities in the region. Increased poverty in the region is essentially urban and cannot be related to deforestation as a result of the action of small settlers.

Chapter V
Urban Poverty and the Effects of Inadequate Urban Infrastructure

Brazilian population is today predominantly urban and so is poverty. According to the most recent census data urban poor corresponded to 67% of the total number of Brazilian poor, thus a long way from the 1970 situation, when 52% of the poor lived in rural areas. Environmental impacts of poverty incidence are specially adverse in the large metropolises, where 9.5 million poor were concentrated in 1996,[14] because of the high number of precarious dwellings under conditions of high density per unit of area.

Illegal occupation of public areas place the poor under siege by the local government, although urban regulations are rarely enforced. In São Paulo irregular settlements have been established in the Cantareira Hills that are delimited as a natural reservation, because of its role both as green belt and as location of springs which contribute to São Paulo´s water supply. In Rio de Janeiro slums have grew inside the National Park of the Tijuca Forest. In Belo Horizonte and Rio de Janeiro, where hills are scattered across the urban area, the invasion of this areas has caused significant erosion, leading to aggravation of problems of draining water and increasing flooding of low areas whenever it rains. Irregular settlements along rivers and low areas in the seaside, like in Recife and Rio de Janeiro, cause water pollution and the destruction of natural swamp areas, that serve as habitat for several animal species.

The problem of land use itself is aggravated by the lack of infrastructure. Sanitation infrastructure - water, sewerage and garbage collection - are essential for guaranteeing adequate living conditions not only for the poor, but for the urban population as a whole. Rapid urbanization operated against the reduction of urban infrastructure deficits, specially in poor areas, which lack financial resources and management capability to meet the large and growing demand from both poor and non-poor subpopulations. Water and sewage services have been plagued by administrative problems coupled with artificially low tariffs and insufficient receipts, which are a major restraint to system expansion. Because of very high deficits in the provision of basic sanitation services after the demographic boom of the seventies, expansion of

[13] "The accelerated deforestation in Brazilian Amazon in the recent decades resulted from a multiplicity of factors which includes road and railway construction, spontaneous and government directed colonization projects, timber extraction, charcoal production, subsidized agropastoral projects, hydroeletric facilities, mining (both placer and corporate), and uncontrolled forest fires associated to human activities" (Reis, 1997).
[14] Number of poor as estimated by Rocha using PNAD data and locally specific poverty lines.

service networks has followed an unbalanced pattern. Since providing water is cheaper and easier, the service has expanded quickly without the corresponding investment in sewerage. The result has been a growing volume of sewage flowing to rivers, sea and lakes directly or through the drainage system. After 1985, improvements in service coverage, specially of poor populations, are partly due the fact that loans from international development agencies have been heavily focused on improving sanitation infrastructure and the anti-poverty component of projects has gained priority.

Indicators presented in Table VII refer to the two subpopulations - poor and non-poor. Actually, the income breakdown has important implications in terms of the impact of sanitation deficits for two reasons. Firstly, although the access to sanitation services is a basic necessity for all, the lower the per capita income, the more adverse is the impact of deficits on health conditions and on household comfort in general. The health conditions of the poor are disproportionately affected by environment hazards, such as parasitic and infectious diseases brought on by polluted water that is used for drinking and bathing. Secondly, the distribution of deficits between poor and non-poor is relevant when considering aspects related to price policy, as well as financing investment and maintenance of sanitation systems.

Data from São Paulo and Recife shows deficits of basic services under extreme conditions in terms of poverty incidence - proportion of poor was 19% in São Paulo in 1996, while it attained 33% in Recife in the same year. Some conclusions can be derived in relation to the evolution of sanitation service provision for the poor and the for non-poor from 1990 to 1996:

- the number of persons without inadequate water supply, that is, those who live in dwellings not serviced by the water supply network, declined in São Paulo and Recife, benefiting both poor and non-poor subpopulations. Progress was more accentuated in Recife, thus narrowing disparities in service provision in the two metropolises. It is specially noteworthy that, since the proportion of poor declined in the period, probably those who were closer to the poverty line in 1990 became non-poor in 1990, making the poor in this late year relatively lower in the social scale than in 1981, so proper to present more adverse social indicators. Results show that despite this fact, the poor have significantly improved their access to water.

- deficits in sewerage - defined as number of persons living in dwellings not serviced by the sewerage network and without a septic tank - have been reduced, but at a much lower pace than deficits in the provision of water services. Deficits are critical both in São Paulo - where indicators are lower, but refer to 4.3 million people -, and in Recife, where even among the non-poor subpopulation the deficit is high (a fourth of the non-poor subpopulation is not served). Actually the situation is still more critical than the one shown by the indicators. As a matter of fact, the role of the sewage network is often limited to collecting and transporting used waters, which are dumped untreated in the closest waterfront. In many cases, there is not a sewage system, but the informer takes the drainage system for one, since it is actually used as such. Thus adequate sewerage as derived from the PNAD data is not a guarantee of a safe environment for the community or for its neighbors in what human wastes disposal is concerned.

- deficits in garbage collection have been reduced, but are still very high, specially in Recife. It is noteworthy that the indicators do not adequately reflect the adverse impact of the deficit. Information for 1996 does not take into account the growing trend of garbage production per person, which relates to increases in income and to new consumption patterns.

TABLE VII: ACCESS TO BASIC SANITATION SERVICES (POOR AND NON-POOR) METROPOLISES OF SÃO PAULO AND RECIFE - 1990 AND 1996

Inadequate Services		Poor	Total	% Poor	Non-Poor Total	Total Non- Poor	% Total
Metropolitan São Paulo							
Water	1990	281,044	3,277,334	8.58	346,241	11,481,915	3.02
	1996	152,177	3,048,994	4.99	217,529	13,095,712	1.66
Sewerage	1990	983,213	3,277,334	30.00	1,232,513	11,489,843	10.73
	1996	725,080	3,048,994	23.78	1,255,940	13,095,712	9.59
Garbage	1990	340,075	3,277,334	10.38	288,966	11,489,843	2.51
	1996	146,809	3,048,994	4.81	128,018	13,095,712	0.98

Inadequate Services		Poor	Total	% Poor	Non-Poor Total	Total Non- Poor	% Total
Metropolitan Recife							
Water	1990	237,254	1,338,778	17.72	63,646	1,420,446	4.48
	1996	48,234	862,441	5.59	50,737	1,742,273	2.91
Sewerage	1990	1,071,246	1,338,778	80.02	634,716	1,420,446	44.68
	1996	348,255	862,441	40.38	428,485	1,742,273	24.59
Garbage	1990	618,696	1,338,778	46.21	268,410	1,420,446	18.90
	1996	231,202	847,057	27.29	208,520	1,742,273	11.97

Source: IBGE/PNAD 1990 and 1996 (Special Tabulation).

Note: Poverty lines used: São Paulo: 1990 - Cr$ 6425.19; 1996 - R$ 100.82 . Recife: 1990 - Cr$ 4470.87; 1996 - R$ 62.40.

The conclusions are obvious. Irregular settlements, which are directly associated to poverty, do have an impact in the urban environment. Although affecting most directly and adversely the poor, the deficits in sanitation are a critical urban problem concerning both poor and non-poor subpopulations in the Brazilian metropolis. Nevertheless, the poverty incidence issue is relevant when dealing with urban sanitation deficits and the way to eliminate them. Firstly, because high poverty incidence - that is the relative weight of poor in the total population - jeopardize fiscal ability to meet population needs in terms of public services. Secondly, because the poor require special provisions for paying for basic urban services whenever they are available, increasing current costs for the non-poor.

Recommendations for dealing with the large unmet needs of the poor in conditions of urban high density seems to favor the upgrading of unserviced settlements, and relocating the poor just in case of occupation of critical areas. Subsidizing land, housing and credit has proven relatively inefficient since better-off segments of the population often preempt these benefits. Use of local labor force in order to upgrade urban infrastructure has the advantage of providing jobs and increasing income levels among the poor, at the same time that improve their living conditions in which they depend on public service provision. Alternative and cheaper solutions in terms of use of building materials and the careful technical choice of sewage systems may reduce the cost of eliminating deficits. Water service may be generalized at lower costs if adequate parameters of distribution and use are established. Finally garbage collection in poor communities may take advantage of local availability of manpower, as well as of exchange mechanisms in order to meet adequate patterns without using conventional and expensive services.

Chapter VI - Conclusions

The links between sustainability and poverty in Brazil were examined in relation to three aspects. The first concerned the need of both economic growth and lower income inequality in order to reduce absolute poverty. Without the contribution of these two components, the poverty reduction goal becomes - at the best - a long term objective. It was emphasized that there is no evidence that guaranteeing environmental sustainability represents a limitation to attain higher rates of economic growth. On the other hand, in order to improve the poor´s earning capacity, the difference in the poverty profile across Brazil are to be considered explicitly. In the rural Northeast, anti-poverty policy must aim at improving the living conditions of the poor by guaranteeing access to land and productivity increases as a result of integrated actions both in the social (education, health, nutrition) and agricultural assistance fronts. In metropolitan areas, improving the poor´s capacity to engage in the labor market must be a well-defined public policy objective. Under the present conditions of growing automation and international market integration, the undisturbed trend would mean reduction of labor income at the lower brackets of income distribution and consequent increases in poverty incidence.

The second aspect refers to sustainability in the Amazon region, where deforestation is the privileged indicator of non-sustainable development. Although the Northern region has presented an increasing participation on national poverty, poverty incidence and deforestation do not seem to be directly linked. The primary causes of deforestation are related to government initiatives (road building, mining concessions) and to cattle raising activities, where the use of manpower is limited. Deforestation is not associated to cropping, which uses less than 1.3% of the region's total area. Thus, migrants who settle in small plots do not seem an important determinant of deforestation. Moreover, most poor live in urban areas, specially the largest ones, which presented the highest demographic growth rates in the last decade.

The third aspect relates to poverty in metropolitan areas and to the adverse effects on the urban environment of inadequate use of land and deficits in urban infrastructure, specially sanitation. In spite of the improvements in service provision since 1990, the percentage of unserviced dwellings - both poor and non-poor - are still high, which has adverse effects on the environment and on living conditions of the population as a whole, but specially among the poorest. The adoption of adequate parameters and alternative technologies may be the way to accelerate the rate of deficit reduction despite budgetary restrictions.

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Emergent Diseases

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In an international scientific congress held in Rio de Janeiro, a few years ago, in honour of the hundredth anniversary of the death of Louis Pasteur, Joshua Lerderberg, Nobel Laureate in 1955 for his discovery in bacterial genetics, told the following story about American demography: the population of the United States, from which data are available since the second half of the XIX century, has shown a continuous increase, following a curve without discontinuity, with a recent tendency to decrease its rate. No discontinuity was observed during or following World Wars I and II, or the Korean and Vietnam wars, in spite of the high number of deaths and disabilities that occurred in these periods in the male population at the reproductive age. No discontinuity ... with one exception: a clear drop in the year 1918, as a consequence of the "Spanish influenza" epidemics. Lerderberg called the attention of the audience to the fact that we have not, nowadays, many new tools against virus infections and are not, therefore, more prepared to defend ourselves against this kind of "accident". He concluded stressing the need for developing research on microbial pathology and virulence.

New threats against Human health have indeed been identified in the last decades, with the appearance of new transmissible diseases that, by their epidemic dramatic aspects and mortality effects, provoke crisis of panic in the public and the Health authorities in the World. Among these new pathologies, known as emergent or emerging diseases, the more important is AIDS, produced by a retrovirus, isolated in 1982 as the agent of acquired human immune deficiency, which spread throughout the World in the 80ties but probably was already circulating in Africa for a few decades. Other dramatic examples, that have not assumed, however, the same worldwide extension, were the outbreaks by the African viruses Ebola and Marburg, which produced fulminating haemorrhagic fevers, with violent but limited epidemic outbreaks. This limitation was perhaps due to the extreme virulence of the infectious agents, which induced quick fatal evolution, reducing the transmission efficiency. In another recent example, Europe has been struck (and still is) by the panic concerning the "mad cow" disease, produced by a new infectious agent – the prion – responsible for the bovine spongyform encephalitis that apparently can be transmitted to humans by digestive route. More recently, in Hongkong, a variety of the chicken influenza virus, considered until then as specific to the chicken, was shown to be infectious for man, producing, in some cases, a fatal evolution.

In South America, many new viruses, especially arboviruses (transmitted by arthropodes), have been described in the last decades in the Amazon region. The most frequent is Oropouche responsible for a benign acute infection but producing frequent epidemics in the Amazon region. The silvatic cycle is maintained by insects Culicoides in primate hosts and human infections are accidental. Urban epidemics may occur with man to man transmission by the ordinary urban mosquito Culex. Other benign infection are produced by virus Mayaro, also harboured by primates in silvatic cycles transmited by the same vector as the silvatic yellow fever. Four new infectious agents have been described in the last five years in Brazil as responsible for diseases of frequent fatal evolution: the Sabia virus, producing a systemic fatal infection, a Hantavirus responsible for an acute pulmonary syndrome (also serologically detected in Paraguay and Argentina); the Rocio virus, provoking an acute encephalitis and a new species of *Haemophylus, H. aegyptus*, provoking a purpuric fever. Scientists from the Arbovirus laboratory of the Evandro Chagas Institute in Belem, have isolated, in the last decades, more than 200 species of virus (186 from the Amazon region) from which at least 37 were shown to produce human infections. The more serious are represented by dengue and yellow fever. Dengue was absent from the country after the control campaign against Aedes aegypti which succeeded in eradicating the mosquito in 1955. With the reintroduction of Aedes in the country in the 70-80ties, a first epidemic of dengue occurred in 1982 in Boa Vista, Roraima, in the frontier with Venezuela and affected 12.000 persons. But the Aedes mosquito had already invaded all the territory and in the following years the epidemics spread over the country: 40 thousand cases in 1990 (most of the Northeast and Southeast areas), 97 thousand in 1991, with more than 78 thousand in the city of Rio de Janeiro, more than 500 thousands in 1998, with a pandemic distribution all over the country, with exception of the extreme southern States (Rio Grande do Sul and Santa Catarina). The situation is now more serious by the fact that three varieties of the dengue have already been identified in Brazil, which will eventually increase the incidence of haemoragic dengue with important lethal issues. After the erradication of the Aedes mosquito urban yellow fever disappeared from Brazil. The last epidemic occurred in 1928 in Rio de Janeiro. However the presence of silvatic yellow fever with primates reservoirs transmitted by silvatic mosquitoes is a permanent threat to the countries in the Amazon area, specially considering the re- invasion of Aedes in urban areas of the Amazon.

How do these new diseases appear? How do some of them spread so suddenly? These problems are the object of innumerous researches and speculation, but there is agreement in general about the animal origin of most of these "new" pathogens which were first circulating among wild animals and transmitted by arthropods or by direct contact and infect Man when he invades their natural environment. This can happen sporadically, as in the case of West equine encephalytis transmitted by *Culicidae* mosquitoes from their natural bird reservoirs. It can also happen systematically, as in the classic case of cutaneous and muco-cutaneous leishmania parasites, the natural host are forest of which rodents, transmitted by haematophagous insects from the group of *Phlebotomus. Leishmania* parasites infect people with frequent contact that have the forest. Most of the so called emergent diseases belong, therefore, to the classic category of Zoonosis. In a certain number of cases, the animal reservoirs are still unknown, as in the case of the EBOLA virus and the Sabia virus.

It must be added that the extremely versatile genetic material of virus and bacteria permit, in some cases by simples point mutations, the appearance of adaptive variability allowing them to escape the natural non specific immune barriers represented by antibodies and cytotoxic cells like the "natural killers". In this case, a "new" pathogenic agent may arise from a previously known one. The influenza virus from the "Spanish influenza epidemics" of 1918 had probably this origin. Among pathogenic bacteria, the capacity of exchanging genetic material has been shown, even between quite different species, through plasmids, phages or even directly by conjugation. This phenomenon plays an important role in the transference of foreign DNA sequences containing genes conferring resistance to antibiotics or promoting new virulence properties. The "virulence islands" described as circulating in various *Enterobacteria* species are examples of this kind of transfer, which seems, for instance, responsible for the virulence of *Vibrio cholera* 0139, the agent of the cholera epidemics in recent years.

As stressed by Lerderberg, we have not, today, many more tools than at the time of the Spanish influenza pandemic outbreak to defend ourselves against a series of infectious agents. On the contrary, we can say that, in some aspects, we are more exposed to this kind of accident for a series of reasons: the increase in number and rhythm of contacts and interactions of human populations; the degradation of human and natural environments by a wild search and exploitation of natural resources; the increased promiscuity in many human overcrowded communities, specially in urban areas, at the national and international levels. Finally, the phenomenon of invasion and occupation of new geographic sites, by the establishment of settlements in areas where Man was until now absent – forests, deserts – thanks to the new and powerful tools of intervention.

Brazil is a good example of accumulation of all the above factors. In what concerns population interactions, it must be recalled that a few decades ago, most of the international frontiers zones (with exception of those with Argentina and Uruguay) were sparsely inhabited and that population exchange was practically absent; the access to the Amazon region was possible only through the river, with fluvial navigation poor and limited; Central areas of the country (where now flourish Brasilia and Goiania, important urban communities and modern agriculture settlements) were poorly inhabited; Communication between South and North – North east areas of the country were practically dependent on maritime routes through the Atlantic Ocean, as all international communication. With the building of Brasilia, the opening of the Brasilia-Belem road (1961), the construction of the Trans-Amazonian road network (1970) and the development of air transportation traffic, these conditions have been dramatically changed. Travelling by air in Brazil increased from 6 million passengers/year in 1970 (only 350 thousands international travellers) to 39 million in 1996 (with 10 million international travellers). The Trans Amazonian road network allowed access to the frontier zones of the Guyanas, Venezuela, Colombia, Peru and Bolivia promoting an increase in human interchange and intense internal migratory movements of populations originating from the most diverse areas of the country, particularly in two directions: 1) From the North-east rural areas to South-east urban areas, resulting in megalopolis development of Sao Paulo and Rio de Janeiro; 2) From all rural areas of the country, particularly from the South and North-east regions, to the new colonisation areas of the Amazon region: people were attracted by the offer of land for the new agricultural settlements, and the open gold mining opportunities along the Amazonian basin. Thus a substantial increase in the population at the frontier zones came about. In Rondonia (Bolivian border) the population increased from 110 thousand inhabitants in 1970 to 1.5 millions nowadays; in Amapa (border of the Guyanas, from 130 thousand to 400 thousand and in Roraima (Venezuelan border) from 50 thousand to 300 thousand.

These new conditions have already had epidemiological consequences: the re-invasion of the country by *Aedes aegypti*, which had been eradicated in the 50ties, took place through the north (French Guyana) and west (Paraguay and Bolivia) borders; the consequent penetration of dengue (nowadays spread all over the country) also took place at the north border. Another example is the recent cholera epidemic (1995-96) that penetrated the Amazon region through the border area with Peru and now maintains and endemic presence in various areas of the North and North east States. The explosion of malaria in the Amazon region (50 thousand cases in 1961 and 500 thousand cases in 1990) was the result of wild migration, deforestation and colonisation of the new Amazon areas starting in the 70ties. It is interesting to observe that, the intense migratory movement, people coming to and going from the Amazon region to other places (especially gold mining adventurers), has been producing, in recent decades, short sporadic malaria epidemics in practically all regions of the country. The dramatic impact of these migrations in many Indian communities must also be reminded, with the introduction of respiratory infections, tuberculosis, malaria and other pathologies that have ravaged a series of Indian communities.

As already signalled, the accelerated and bewildering urbanisation, with the formation of megalopolis areas in Sao Paulo and Rio de Janeiro, devoid of basic sanitary infrastructure and overcrowded by population of low income, bad nutritional conditions and poor health care, are also responsible for the emergence and re-emergence of a series of diseases like tuberculosis, leprosy, cholera, infantile diarrhoea and pulmonary infections, dengue etc. It is relevant to observe that even some pathologies considered as classical rural infections are now invading urban areas. That is the case of malaria in Manaus and other cities in the North region and the appearance of cutaneous and muco cutaneous leihmaniasis in urban areas of Rio de Janeiro. These phenomena could be imputed to a degradation of environmental and sanitary conditions in urban areas.

In summary, emergent diseases constitute a large group of human pathologies, some of which are really new and have recently appeared, others that are still to come and finally others which are old companions of Man and, for reasons of genetic adaptive mutations, genetic exchanges and/or changes in the process of transmission (either of biological origin or socio-economic nature) are re emerging. All of them appear or reappear as serious problems of Public Health and even – at a maximalistic point of view – as threats to Human survival on Earth. Examples in the past are known. Small-pox has produced ravages in Middle Age communities. Plague, which was sporadically endemic in the Middle Age, produced ravaging epidemics in the beginning of Modern times when, after the introduction of potatoes in Agriculture, the construction of silos provoked the proliferation of rats in close contact with Man.

If, in recent years, the social and economical factors described have aggravated the threats of emerging diseases, from a biological point of view we must consider emerging diseases as a normal and permanent aspect of the Human adventure in the Planet. Since *Homo sapiens* appeared on Earth, he has been fighting against microbes and viruses inherited from the precursors of Man in the evolutionary scale or attacked by other pathogens originated from biological concurrent species in the hard reality of the Darwinian world. Until recently, this fight on the human side was dependent only on natural weapons provided by the immune system. With the development of Science and of human knowledge on the nature of disease, which led to the development of new tools and to the formulation of strategies for defence against infection, it became possible to interfere in the natural selective process represented by emerging diseases. This is the subject of the following considerations in this text.

From what it was said above about the complex nature and origin of emerging diseases, it can be concluded that defence strategies must involve measures at several levels: social, economical, urban, environment protection and planning, education, scientific and technical research, sanitary and medical measures etc. Therefore it concerns all levels of public administrations and the participation of numerous public and private organisms and Institutions.

At technical and professional levels the activities necessary for the formulation of strategies against emerging diseases have the following objectives: 1) to identify, clarify and define specific pathologies that represent threats and problems to specific areas and regions; 2) to create and organise operational structures, to take charge of the training of the operating agents and the decision makers; 3) to maintain a high level of scientific activity in training and research necessary permanent epidemiological surveillance of known pathologies and the identification of emerging ones; and finally, 4) to perform a permanent critical evaluation of the applied measures. Two sectors of the Society are equally responsible for the undertaking of these activities: the sector of Public Health, represented essentially by governmental structures and Institutions and; the sector of Science and Technology in the Health Sciences, represented by Research Institutions and Universities with their complex national and international networks.

To the Public Health sector belong, in principle, the responsibilities of running epidemiological and sanitary surveillance through a network of structures held by technical staffs able to detect the appearance of new pathologies and/or of departures from the normal course of the old ones. These structures must also be able to intervene to check or control their evolution, triggering off central technical structures at the national or international levels when necessary.

In Brazil, the situation in this respect, as in many other matters, is quite heterogeneous as a function of the geographic areas considered, reflecting the profound regional and social inequalities of the country. While the epidemiological and sanitary surveillance would be, in principle, a responsibility of the Federal Government foreseen by the Constitution, in reality, in the rich South and South-east areas of the country, these functions have practically been taken over by State and Municipal Health administrations. In the rest of the country the function is undertaken by the National Health Foundation (FUNASA), which suffers from its original sin of a vertical centralised organisation. FUNASA, indeed, originated in 1990 from a successive fusion of vertical centralised structures created in the 40ties and 50ties to control individual diseases under the denomination of National Service of Malaria, National Service of Yellow Fever, of Plague, of Tuberculosis and so on. Each "Service", in the past, took over all the responsibilities concerning individual diseases and suffered from both the artificial division of competence and fitness (by disease) and an equally artificial mixture of functions (epidemiological surveillance, operation of control measures and health and medical care of affected people).

In recent years, following the large national discussions and debates around the new Constitution of 1988, involving scientists, physicians, Public Health experts and technicians, the need for decentralisation of responsibilities in Health Services became consensual. The newly formed Unified Health Services (SUS) adopted the principle of transferring to Municipalities and State' administrations the activities concerning Medical Care of the population, keeping at Federal level the responsibilities of the National Health Foundation (FUNASA) in epidemiological and sanitary surveillance and in running vaccination campaigns, vector control measures and other activities concerning control of endemic diseases.

Again, the extreme regional and social inequalities in the country made it difficult to implement these projects. In the rich South and South-east areas of the country, Municipalities and States have already taken over the responsibilities of providing Medical Care for the population. However, in the poorest areas in the North, North-east and Centre-west, as well as in parts of South and South-east regions, Municipalities have neither the resources and nor the technical capabilities to assume these functions, while the respective States do not have the necessary competence for the recruitment and training of the necessarily complex staffs. It is, therefore, inevitable that the Federal Government maintain its presence in these functions and organise, in collaboration with the States, a long term project to organise and qualify State and Municipal Health Services.

In what concerns specific Public Health responsibilities, FUNASA has not been able to carry out conveniently the specific role and functions of sanitary surveillance, in spite of the large number of employees in its body. However, FUNASA has not inherited and did not create appropriate physical structures and human expertise in the field. Most of its personnel has been trained for diagnosis and treatment of endemic diseases specific to each region, which means malaria in the North, schistosomiasis in the North-east, leishmanaisis in various areas. A minor fraction of the personnel has been trained in vector control specifically directed to malaria, Chagas disease, dengue and yellow fever and schistosomiasis. A more rational role has been maintained by FUNASA in the organisation of the National Campaign of Vaccination for children which has known a large success and is developed by health unities of States and Municipalities, supervised and co-ordinated by FUNASA.

A large and profound reorganisation of FUNASA's structure and functions is proposed by the VIGISUS project, now in the phase of discussion and implementation at the Ministry of Health. The project proposes a period of four years for the transfer to States and Municipalities of all the activities related to Medical Care of the population and also most of the functions related to Sanitary epidemiological surveillance and control of endemic diseases, including, therefore, emerging and re-emerging ones. In the original project the function of FUNASA, at the its higher level in Brasilia would be "to coordinate the National System of Health Surveillance, with the function of establishing principles, rules and orientations, to search, obtain and analyse information concerning Health conditions and to stimulate and sustain research in Health Sciences".

In spite of the conceptual progress represented by this new approach to define responsibilities, functions and roles of administrations and Institutions at different levels, these definitions have not yet brought sufficient information on the functioning of the future National Health System of surveillance. Indeed, one can argue against an excessive decentralisation and the proposed limitations in the functions of the central administration of the System. In relation to emerging diseases, for instance, we referred above to their sudden appearance and reappearance at any time and at any place, without respect for municipal, state, national or international frontiers, calling, sometimes for a urgent mobilisation of human competence, physical and intervention tools, which demands a network of structures like laboratories, hospitals, pharmaceutical industries, communication tools and instruments at the national level. In many cases the intervention needs the activation of mechanisms at the international level (access to information, collaboration and help of technical capabilities, access to new technologies). These measures are possible only through the initiative of the Federal Government. It must be reminded that the United States of America, known as an example of decentralisation and private initiative, in what concerns Health surveillance has the world's most centralised, authoritarian and interventionist structure at the Federal level – the CDC – which keep all responsibilities of Disease Control – being or not emergent. In Europe, the corresponding structures are less strict. Paradoxically, France, well known for its centralised administration, has, in the Public Health System, a more decentralised and heterogeneous structure, with a network of laboratories at the regional and departmental level, with a multitude of Reference Centres belonging to public administrations, Universities, Research Institutions like the Pasteur etc. This, however, is tightly connected by central structures with capability for intervention and able to activate the mobilisation of human and technical resources from the periphery.

In Brazil there is yet no clear definition on the structures and mechanisms to be adopted and on the necessary evolution of the existing structures, as well as the new ones that must be created. With the VIGISUS project, that will be supported by important national and international resources, new opportunities are offered for developing the National Health System of surveillance. This will need the active participation of the scientific and technical community in Health Sciences in close contact with the Public Health administration. The development of pilot projects will be necessary to adapt the different structures of the National System to regional and local peculiarities as a function of the referred regional and social inequalities.

However, in any of the possible alternatives for defining the general organisation of the National Health System of Sanitary surveillance, more or less centralised, the basic essential factors necessary for its correct and competent functioning are two: the presence of adequate physical structures covering the national territory and the presence in these structures of competent and trained staffs. In this respect, it is necessary to recognise that the country disposes neither of adequate structures nor of enough adequately trained personnel. How should these deficient points be overcome? To whom belongs these responsibilities? We have come, therefore, to a final point concerning the general Politics of Health Science and Technology.

At the National Conference on Science and Technology in Health, held in 1994, with a large participation of the scientific and technical community, were defined general proposals and goals in the area. A critical evaluation performed during the Conference was able to characterise deficient areas, in particular "an immense gap between the teaching and research activities and the productive industrial activities". The original document (ref.) also stressed the "black hole in the transition areas of research to the activities of control of endemic diseases". Unfortunately, it is necessary to recognise that the holes and gaps still persist. Without a strong efforts of Universities and Research Institutions for training scientists, physicians, technicians and auxiliary personnel at all levels of laboratory and field activities of surveillance and control, the country will be unable to construct an efficient National Health System. Brazil has all the necessary Institutions capable of doing this. Political decisions of the Federal and State Governments are, however, missing to give enough priority to these goals.

Emergent diseases, as already discussed, are permanent problems for Humans on Earth. They stress the need for a permanent effort of research in biological and medical sciences. They also stress the need for training top scientists and technicians able to work in the border line of human knowledge to develop new tools necessary for the control of new appearing threats. However, for the efficient use of human scientific knowledge, it is essential to construct a National Health System of Sanitary surveillance that, in parallel with the permanent control of current endemic diseases, will have the capability both for developing improved tools to control these diseases, as well as the capability for control of emerging diseases.

Health and Environment

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I - Introduction

The concern with the environment is gaining increasing attention all over the world, in special since the decade of the 70ies. Porto (1998, p. 33), refers to a variety of factors conceived as threats for the human species:

- Exposure of different regions of our planet to high degrees of environmental degradation;
- Detection of ecological risks of global extent, affecting ecosystems to varying degrees and threatening the life of future generations;
- Increasing effects of pollution caused by industrial wastes, consumption and transports in urban-industrial regions, associated with problems related to basic infrastructure, sanitation and socio-environmental degradation, enhancing the social vulnerability of populations, especially in the developing countries;
- Expected lack of natural resources fundamental for the production of industrial and consumer items, demanding for strategies such as recycling and redefinition of models for the construction of a new ecological economy and
- Increasing political pressure practised by new social movements – groups concerned with fields such as industrial risks and environment.

A detailed examination of the question health and environment from the viewpoint of a peripheric economy and its specific aspects ranging from lack of studies and discussion of the problem to high incidence of risk situations - the dumping of effluents into rivers for example - is thus indicated.

According to Lacaz, several international initiatives resulted in a new approach to the subject in Brazil: in the late 70ies, projects directed to occupational health were contemplated by the World Health Organization (WHO). In 1983, the Pan-American Health Organization (PAHO) publishes a document entitled: "Programa de Acción en la Salud de los Trabajadores" (Programme for the Health of Workers); in 1975, the International Work Organization adopts in its 71st International Conference on the Work the "Convention and Guide for Health Services at Work", later ratified in Brazil in the Executive Act Nr. 127, of May 25, 1991.

In Brazil, the 70ies were marked by the upcoming discussion of the health/disease/work process in the context of social medicine. A number of different occurrences testify the social relevance of this topic: new technologies provoking new diseases; benzene contamination in petrochemical pools; intoxications caused by agrichemicals; inadequate working conditions for women, children and old-aged people (Lacaz, p.8).

Lacaz refers to the end of the military dictatorship and to the formation of strong labor unions as facts that stimulated the discussions concerning work environments harmful for Man. In this context we witness the estbalishment of the "Intersyndical Comission for Health and Work" in 1978, transformed into the "Intersyndical Department for Studies and Research on Health and Work Environment" in 1980. Two further events have to be emphasized: the participation of the "I National Conference on Health of the Workers" in the elaboration process of the Federal Constitution of 1988 and the "II National Conference on Health of the Workers", in 1994. The implantation of the "Center for Studies on Occupational Health and Human Ecology" of the Oswaldo Cruz Foundation, body linked to the Ministry of

Health, and several similar initiatives in other regions of the country constitute important facts occured in the 90ies.

This text intends to contribute in a non-exhaustive way with some thoughts to the question health and environment .

We will approach the interrelation between health, environment and economy, focus questions regarding industrialization, sanitation and risks resulting from technological development and conclude with some thoughts and suggestions for an agenda to be discussed in the forthcoming century.

HEALTH, ENVIRONMENT AND ECONOMY

The frequent discussions arising today in the different social classes concerning social and environmental claims and questions related to health demand for a deeper understanding of the problem by comparing a variety of approaches and concepts. As explained by Porto (p. 34): "*All these approaches are mirrored in one basic challenge, the need for integration of global and local levels, of different fields of knowledge and different governmental, social and economical segments in the conformation of policies and actions capable of meeting the needs of each national or local reality. It was in the context of this unifiying perspective that, principally since the late 80ies, the concept of a sustainable development was created and promoted, aiming to integrate the problem environment and development, even if in a not very clear and sometimes contradicting manner. International events like the RIO 92 are examples for the attempt to establish agreements and international agendas under the leadership of international organisms such as the United Nations Organization (UNO) and the World Health Organization (WHO)*".

Special attention should be given in this context to the conformation of national models through the elaboration of scientific-technological, health and environmental policies privileging interdisciplinary and intersectorial approaches capable of favoring and stimulating the development of each nation. A *sine qua non* condition for the achievement of a sustainable development is the harmonization of macroeconomic and specific sectorial policies - industrial, scientific, technological, urban, agricultural, related to transports, among others - from the point of view of health and environment (ibidem, p. 35).

In the attempt to minimize the social and environmental inequalities today characteristic for the economy in the world, especially in the recently industrialized countries like Brazil, the historical, economical and cultural realities of each region and country have to be understood without detaining oneself in preconceived models of the environmental question. The problems of the tropical regions and their mega-biodiversity are very different from those found in the richer regions of the northern hemisphere, great generators of technology. While the poorer nations sufffer from misery, the wealthy nations are concerned with questions such as global warming and the hole in the ozone layer (*ibidem*, p. 35).

The pressures for dis-regulamentation of the State imposed by increasing flow of international capital, the consequences of prolonged economical recession, the ongoing process of tributary adjustment represent increasing limitations for the elaboration of national projects and endanger the role of the State as formulator of policies, planner and regulator of health and environmental problems related to economical development. These difficulties are reflected in increasing polarizations claiming for restraint of public expenses, privatization of public enterprises, liberation of trade and investment and in regional pressures exercised by the working class and society in general for better life, working and environmental conditions. The speed of this process and the lack of forums for negotiation of the most important questions can, besides the present state of perplexity, create serious implications for the health and environment of the country, by reducing the power of the State to plan, formulate and coordinate inter-institutional and inter-sectorial policies; to implement industrial, scientific and technological policies compatible with sustainable development and specific regional aspects ; to organize health and sanitation services; provide for adequate levels of employment and just remuneration; develop control actions; enforce the adherence to the sanitary and environmental legislation in force and finally, to form professionals capable of carrying out such activities.

The risks involved in the loss of capacity of the State to implement environmental and health standards in its political, economical, technological and industrial policies, repassing the competency for these regulating activities completely to the private initiative - environmental control, for example - can lead to an even greater exclusion of society and degradation of the social, working and health conditions of the population.

The advent of the industrial revolution extending from Great Britain to other countries of the occident resulted in deep transformations in the social relationships and in the technical bases of human activities. The relationship between Man and his environment was changed markedly and, as a consequence, the objective and subjective conditions of human health and the sustainability of the environment (Franco & Druck, p. 62).

The relation between Man and work environment underwent modifications. The figure of the handicraftsman - owner of the means of production - disappeared and gave place to a mass of workers, always more increasing with the migrations from rural areas to the forming cities. New production systems were developed and executed in an intensive and predetermined rythm, potencializing pre-existing agressive agents as well as new " *interactive and of distinct nature -physical, chemical, ergonomic and organizational" (ibidem*, p.62).

The modification of the technical bases of the work process was only possible through the use of new sources of energy. Manpower passed to be substituted by steam and combustion of renewable and nonrenewable resources and nuclear energy for productive or destructive purposes. Machinery incorporated more and more technological innovations, gaining increasing potency (*ibidem, p.63).*

Along with the increase of the global production capacity, the natural resources - water, raw materials - were complemented by new synthetic, chemical and petrochemical materials - used in substitution of cotton, natural fibers, rubber, ceramics - resulting in industrial wastes to varying degrees hazardous for human life (*ibidem*, p. 63).

To talk with the authors' words:

"Socially and economically, this production model took in an always more concentrated and intese way the form of capital whose expansion and crises are today expressed in economical globalization , increased social exclusion and inequality of countries of the northern and southern hemispheres, rich and poor, as well as in the appearance and need for consolidation of local and global environmental problems, challenges left for the future by the XX century."

The use of space in the contemporanean societies took a new shape. Cities emerged, rural populations migrated to urban regions, *"investments were guided by factors such as disponibility of renewable and nonrenewable natural resources and labor cost". (ibidem, p. 63).*

The new urban agglomerations and the emerging industrial activities also caused environmental problems - carbon monoxide, different pollutants - more recently resulting in phenomenons like acid rain, depletion of the ozone layer and of nonrenewable natural resources (*ibidem, p. 65).*

As explained by Moimon (apud Franco & Duck, p. 65):

"Recent estimates indicate that only 12% of the industrial establishments of the developed countries, concentrating 20 % of the value added, are responsible for 2/3 of industrial pollution. A paradox and contradiction, having in mind that at present 80% of goods and merchandises produced by Man are consumed by less than ¼ of the population of the world."

Today, not only the question of social exclusion but also the great socio-political and scientific challenges in the construction of a solid development and just and acceptable life standards have to be taken into consideration. The forms of production and consumption engendered between the XVIII and XX centuries are not only affecting the use and manipulation of renewable and nonrenewable natural resourcers but also the conditions of human existence: *"their living and working space, their migratory flow, the situations of health and death: (...) there is a historical relationship betweeen industrial risks, environment and populational health, changing with the features of the different forms of civilization" (Franco & Druck, p.65).*

Health, Environment and Technological Risks

In the beginning of the industrialization process, technological development and its negative aspects affected in the first place the worker. Today the risks are universal, affecting not only the workers but the entire society as well as local and global ecosystems (Porto & Freitas, p. 60).

The concept of technological risks for the environment arouse in this context. The development of technologies involving chemical and radioactive substances and genetic engineering, points forward to new hazards for health and environment. (*ibidem, p. 60).*

The authors explain:

"Reconsideration of the question from a technological point of view will confront us with the need to analyse the questions related to the risks inside and outside the walls of the industries by integrating the problem occupational health and environment in general. The need for such integration becomes particularly evident when analysing the problems of the chemical industry: the fragmentation of policies and institutional actions represented by the environmental groups - responsible for the "outside" - and occupational health policies concerned with risks and common causes is absolutely articificial".

The increased complexity of effects caused by production processes upon the biologic and social life of the planet demands for an integrated approach to the question health at work and environment, fundamental for the study and solution of the risk situations. (*ibidem, p. 60).*

Today, in an atmosphere of strong economical competition, the production processes are always more automatized, industrial plants allow complex, sophisticated and quick processes, greater capacity of production, storage, circulation of different consumer items. In the case of the chemical industry, for example, "*the different steps of the production process - extraction, production, storage, transport, use and discard - contributed to elevated concentrations of chemical substances normally inexistent in not industrialized environments*". (*ibidem, p. 60).*

The speed with which technological innovations are introduced into the production environment frequently hinders the analysis and management of the consequently introduced risks. In the developed countries, strong labor unions, environmental groups and society are claiming for rigorous forms of social control (*ibidem, p. 60).*

From the point of view of Theys (*apud Porto & Freitas, p. 61*), "*The question technological hazards is of increasing importance for analysing the vulnerability of contemporanean societies for revealing different characteristics of social disorders as: loss of autonomy of the citizen in the control of risks; obscurity of facts in cases of accidents; exposure to multiple risks; fragility of the society in face of disasters; the impossibility to govern critical situations; rigid centralization of the technological systems, creating domino effects in different interdependent areas necessary for the functioning of these systems; the possibility of extremely high loss and damage involved, among others*".

In developing countries like Brazil the combination of social misery, poor distribution of income and deficient scientific-technological capacitation only worsen the risks created by the industrialization process.

Biosafety

The increasing development of biotechnology is provoking great changes in the dynamics of different industrial sectors. Adequate use of biotechnology can be of great benefit for the society - new drugs, reagents, diagnostication kits, vaccines and engineered plants. Safe development of these activities implies in the first place in standardised norms and procedures and on strict adherence to these regulations.

In the developed countries good laboratory practices[1] are adopted for more than 20 years. Studies on biosafety improved quickly. Today this topic makes part of the agenda of international organisms working in the construction of a basic framework of regulations aiming to harmonize the norms and procedures adopted by the different countries.

Many developing countries do still not dispose of consistent legal instruments dealing with this subject. The lack of such legislation, however, can expose a nation to the most varied interests, including the use of its territory for experimental activities considered unlawful in countries where biotechnology is legally controlled.

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[1] Further sources of information:

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In Brazil, the regulation of biotechnology began to be discussed in the late 80ies, following the international example. The process was initiated with the legislative bill, proposed in 1989 by the then Senator, today Vice-President of the Republic, Marco Maciel, and resulted in the Law for Biosafety, enacted in 1995.

In our understanding, the State has to play an active and fundamental role in this process through the control off all biotechnological activities involving any risk – agriculture, nutrition, human and animal health.

In Brazil, the first legislative bill was proposed by the Senator Marco Maciel in November, 20, 1989 (PL Nr. 114/91). During the 5 years the bill was proceeded in the Federal Congress two substitutions were proposed, one in 1992 and one in 1994. The Law for Biosafety (Nr. 8.974) was ratified by the President Fernando Henrique Cardoso on January, 1995 but some vetoes resulted in the complementary Act (Nr. 1.752/96).

The Oswaldo Cruz Foundation, institution involved for almost one century in biomedical research played a fundamental role in the definition of the norms for biosafety. The original proposal elaborated by Specialists of FIOCRUZ in cooperation with technicians of EMBRAPA for the second revision of the law was almost entirely maintained and constituted the basis for the law presently in force.

Adherence to the established principles and norms allow research institutions, universities and industries to act with more responsibility in protection of our society. Besides that, the adherence to international quality standards favors the establishment of technological cooperation projects and grants the particpation in the international market, fundamental in a globalized world.

The Law for Biosafety (Nr. 8.974) of January 5, 1995, regulating § 1 of article 225 of the Federal Constitution estbalished safety norms and control mechanisms for the use of genetic engineering techniques in the construction, cultivation, manipulation, transport, commercializing, consumption, liberation and discard of genetically modified organisms (GMO), aiming at the preservation of life and health of humans, animals and plants and the environment.

The Act Nr. 1.752 regulating the Law Nr. 8.974 of January 5, 1995, disposing about the competency and composition of the National Technical Commission on Biosafety was ratified on December 20, 1995.

In spite of the progress in the legal aspect of the question, the basic structure of the organizations continues precarious, demanding for substancial investments. Besides the need for capacitation of human resources on technical and management level it is necessary to foster the implementation of working groups in different disciplines: economy, public policies, biology, chemistry, safety, management, among others. Few studies are carried out about risk evaluation methods, fundamental for providing a scientific basis for the emotional discussions about use and consumption of transgenic products.

Final Considerations

The serious social, sanitary and environmental situation in Brazil demands for articulation of corrective measures and projects for regional planning and development, meeting the needs of the country and future generations.

We have to invert the logic of the traditional economic policies, inclined to satisfy the demands of the big enterprises and of the medium and high social classes of the urban populations, to the detriment of the populations living at the margins of the big centers and the small rural producers.

This reorientation of the development model implies necessarily in the creation of a regional job market, reducing the still extense migration to the big and increasingly problematic urban centers. The development of regional competitive economic activities, socially and ecologically sustainable, requires better equilibration of the different levels of power and increased capacity of local and regional planning and actions, together with greater participation of the population in the decision processes, essential in participative democracies.

Based on a diagnosis of the present conditions of the developing countries, it is possible to propose integrated actions of the sectors health and environment, involving the following aspects:

Professional qualification – should occur through the establishment of cooperations involving post-graduation courses *latu senu* and *strictu sensu.* The development of interdisciplinary contents and methodologies should be encouraged, specially with regard to the formation of docents in fields such as health, environment, sanitation, biosafety and hydric resources.

Information systems – health and environmental information systems should be strengthened. The integration of the different systems should be favored through adaptation of concepts, spaces and methods. The improvement of indicators and development of specific indicators for the quality of life, associated with indicators for the quality of water, air, soil, levels of noise etc. besides systematization and quick dissemination of information should make part of these actions. The same way, the definition of combined indicators for life and health conditions, including social violence, and respective information systems should be encouraged.

Education – strategies should be elaborated for the promotion of formal and informal health and environmental education activities and programmes, capable of promoting sustainable development.

Research and technological development – systematic evaluation of form and degree of use biomedical research results in the implementation of public health actions; evaluation of the effects of research and technological development upon the improvement of methods of environmental control; evaluation of the contribution of scientific-technological development in general to sustainable development; implantation of mechanisms favoring interdisciplinary studies on the relation health/ environment including complex systems. All these efforts should be associated with the establishment of priorities, incentivated and encouraged by the financing agencies as well as with the engagement of researchers with this agenda. Resarch and the development of appropriate technologies in search of equal socio-economical, environmental and health conditions in all regions of the country should be encouraged

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Energy and Sustainability

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I - Introduction

Energy is a concept invented by physicists to measure the capacity to perform work which is necessary to move things around and perform other activities that are characteristic of human behavior such as growing food, its metabolism when we eat, building shelter, transportation etc.

The good functioning of the "human machine" i.e. the "primitive man" in the forest requires approximately 2,000 kilocalories of energy per day (24 hs). This is the energy contained in a cup of petroleum Such energy is spent at the rate of 100 watts, equivalent to the electrical energy needed to keep a regular size lamp "on".

The presence of energy is ubiquitous in all human activities and as agriculture, commerce and industry developed the energy consumption grew hundred fold from the 2,000 kcal/day mentioned above to more than 200,000 kcal/day which is the average consumption of the "technological man" in the United States today (Figure 1).

The world's average energy consumption is 30,000 kcal/day i.e., 1,5 tons of oil equivalent (toe) per capita. With the current population of almost 6 billion people this leads to an overall consumption of approximately 8 X 10^9 toe.

Such large energy consumption coming mainly from fossil fuels (coal, oil and gas) poses two basic problems concerning the sustainability of the present "energy system":

- exhaustion of available resources;
- environmental problems caused by the use of fossil fuels

II - Available Resources

The evolution of energy resources consumption in the last 150 years is shown in Figure 2 which indicates that fuelwood was the main resource until 1880 being rapidly replaced by coal which in turn was partially replaced by oil, then gas, more recently nuclear energy and to a small extent by solar technologies.

Fuelwood - of paramount importance in the past - was always used rather inefficiently for cooking, heating and more recently for steam production and electricity generation. Such use led to a considerable depletion of natural forests which were not regenerated. Because of that, a renewable resource - which could be used in a sustainable way - was wasted. As we will discuss later there is a revival of the use of fuelwood with modern efficient technologies.

Fossil fuels (coal, oil and gas) became the dominant source of energy and account today for more than 80% of all commercial energy used around the world. Reserves of such fuels are large but not infinite and therefore their continued use is not sustainable as can be seen in Table 1 which gives the world estimated reserves and the expected duration of such reserves if present patterns of consumption persist.

Oil and gas reserves are not expected to last for more than 50 years but coal might last for another 200 years which means several generations. In a human scale this approaches sustainability since in all likely hood alternative energy technologies will be developed in that timespan.

The problem with fossil fuel is therefore, not strictly, one of exhaustion but one of the environmental degradation it produces.

Nuclear energy was considered, until the middle 70's, an attractive option for the replacement of fossil fuels for the generation of electricity and indeed it reached a point of accounting for 16% of all generated electricity in the 80's. In the early 90's the share has increased to 17% but it is evident that this rate of growth is much smaller than the rate of growth observed in the early 80's (14.3% share of global electricity production in 1985 compared with 8.2% in 1980) as shown in Figure 3. Safety problems and cost escalation - due in part to such concerns - led to an almost complete freeze in the construction of new nuclear reactions as shown in Figure 4 and therefore to a leveling of the electricity generated.

Barring a revival of nuclear energy such option seems to be slowly being relegated to be a reduced contribution to the world electricity generation which is growing rapidly in developing countries at approximately 6% per year. Electricity generation in the world has been growing at 3.2%/year.

III - Environmental Problems

The extensive use of fossil fuel has generated the most serious environmental problems faced by industrialized regions of the world (Table II).

These are not new problems: coal was used widely in England in the 16th century and London, particularly, was affected by serious "episodes" of air quality at that time. The persistence of such problem until recently led to the adoption by the United Kingdom in 1956 of the Clean Air Act after a very serious "environmental fog incident" in 1952 which caused 4,000 deaths and more than 20,000 cases of illness.

After the adoption of such Act other countries followed the same path particularly the United States with the Clean Air Art of 1970 which opened the way for the establishment of EPA (Environmental Protection Agency) and Ministries of Environment around the world.

The main pollutants emitted in the combustion of fossil fuel (coal and oil) are sulphur and nitrogen oxides, carbon monoxide, suspended particulate matter and ozone (natural gas is significantly better in that regard). Such pollutants are responsible for "smog" in cities and are responsible for "acid rain" which sometimes is precipitated hundreds of kilometers from the place where the pollutants originate, crossing, sometimes, national boundaries. In addition to that, combustion of all fossil fuel (gas included) produces CO_2 which is the most important contributor to "greenhouse warming".

These are the concerns that are putting a lot of pressure to reduce fossil fuel consumption and the recent Kyoto Protocol on greenhouse gas emissions reflects such concerns. According to this Protocol the industrialized countries will reduce - by the year 2010 - their emissions by 7% bellow their emissions in the base year of 1990. This is a substantial reduction since the emissions of such countries have been increasing approximately 1% per year since 1990.

Efforts to reduce environmental degradation are therefore leading a reduction in consumption of fossil fuels which is consistent with efforts to make them last longer, giving thus more time for the development of new sustainable technological solutions that will eventually replace them.

What are those solutions?

IV - Renewable Energies

Renewable energies are all solar energies (wind, photovoltaics, solar thermal, biomass and hydro) and therefore inexhaustible. In addition to that, they produce a minimum of pollutants and their use could lead to a sustainable energy future if they could produce enough energy to replace fossil fuels presently in use at an acceptable cost. We have not reached that stage yet.

Tables III and IV give the most important available technical characteristics of renewable energies.

As one can see in these tables commercial[1] renewable energies (excluding hydro energy) account today for approximately 35,000 MW of electricity which is only 2% of the total in use in the world and less than 1% of the liquid fuels in use.

The cost of renewable energies is higher than energy from fossil fuels (or hydro and nuclear) but such cost is falling according to 'learning curves" that look quite promising.

For example, Figure 5 show the decline in cost of photovoltaics, one of the most promising of all renewable sources. In 1975 the cost per MW was US$80,000 which fell 20% for each doubling of production. Present cost is US$3,000/kW and will probably be competitive to other sources at US$l,000/KW in 5 or 10 years.

Another very promising source is biomass which still represents some 20% of all the world's energy consumed mainly in rural areas of developing countries as fuelwood and charcoal. The very low efficiency in the use of biomass which has been commonplace can however be improved substantially either by gasifying or liquefying it before burning.

Although geographically well placed extensively direct solar energy either through photovoltaics or thermal energy, the utilization of solar energy in Brazil is mostly done through the use of biomass either as ethanol or by the use of biomass for the generation of electricity.

The Ethanol Program

Ethanol is produced from fermented sugarcane juice and used as a substitute for automobile gasoline in Brazil. Approximately 200,000 barrels per days of ethanol are used, reducing the amount of gasoline needed for the 16 million - automobile fleet by 50 percent. Although it has a lower caloric content than gasoline, ethanol is an excellent motor fuel: it has a motor octane number of 90, exceeding that of gasoline and it is suitable for use in higher compression engines (l2:1 versus 8:1). The development of high compression motors in Brazil constitutes an example of technological leapfrogging by itself.

The expansion of sugarcane plantations from less than 1 million hectares in 1975 to 4 million hectares in 1990, and the construction of nearly 400 processing plants to produce large quantities of ethanol, have resulted in the creation of approximately 700,000 jobs. The initial environmental problems encountered by the distilleries -

[1] Most of low quality biomas energy (fuelwood, dung, food residues) are used without involving commercial transaction. The proper evaluation of this amount of energy is difficult, but some evaluations claim that this represents 10% of the total world energy consumption.

such as the disposal of liquid effluents and bagasse (dry residue) have been solved by converting the stillage into fertilizers and using bagasse to generate electricity.

In addition, the substitution of ethanol for gasoline avoids emissions of 9.45 Mt of carbon per year, corresponding to 18 percent of all carbon emission in Brazil.

This is a very significant result contrary to the one obtained in the US with the production of ethanol from corn. In this case fossil fuel is used extensively for the processing of ethanol, such is not the case of Brazil where bagasse is the fuel used. Both ethanol and bagasse are renewable energy sources.

The estimated remaining amount of bagasse and other agricultural residues from ethanol production is estimated to be 4 Mt/yr of dry matter, a significant portion of which is or could be used for electricity generation.

Ethanol production increased from less than 3 billion liters per year in 1978 to 12.6 billion liters per year in 1995 (Figure 6).

In the initial phase of Brazil's ethanol program, the cost of production was very high and ethanol could only compete with gasoline if supported by heavy government subsidies.

Figure 7 shows the cost evolution of ethanol from 1981 to 1995. Between 1981 and 1987, ethanol price declined moderately (PR=70%), from 1987 to 1990 it decreased very quickly (PR=50%) and after 1990 it practically stagnated (PR=90%).

The expectation that alcohol prices would drop to make it competitive with gasoline did not materialized which led to serious problems. Present prices paid for ethanol from sugar producers are very high, US$400/m^3 (tax excluded) shich is almost twice the price of gasoline. Approximately US$2 billion per year is being collected from the consumers to guarantee ethanol production. Since its inception the fuel price policy adopted to open the way for the use of ethanol was the following: the Government indexed the consumer price of alcohol to the price of gasoline and charged for gasoline a price which was approximately double the price in the United States. The proceedings of this "tax" on gasoline were used to reduce the cost of other petroleum derivatives (LPG and nafta) and in the case of ethanol to cover its higher production costs. The justification for such a policy was the beneficial environmental and social consequences of petroleum substitution.

Ethanol from sugarcane is also used in Zimbabwe. It could play an important role in Cuba and other sugarcane producing countries.

Gasification and Electricity Generation from Biomass

Burning fuelwood, bagasse and other agricultural residues to produce steam and generate electricity is a proven technology used in many countries. In the United States, some 8,000 MW of electricity is generated from biomass. However, present systems in operation in sugar mills use low pressure boilers with efficiencies of under 10 percent. The most basic improvement is to use condensing-extraction stream turbines (CEST) at higher pressures. These systems can achieve efficiencies of up to 20 percent.

Advanced technologies have been proposed to convert solid biomass into a low BTU gas through gasification and then using this gas to power gas turbines. Efficiencies of higher than 45 percent can be expected from a biomass integrated gasifier/gas turbine (BIG/GT) system The merit of BIG/GT systems is the ability to provide high efficiencies in units of a size suitable for biomass fuels (20 - 100 MW).

In a 25 MW demonstration plant in Brazil, supported by the Global Environmental Facility, General Electric has adapted its aero derivative turbines for low BTU gas and a Swedish company has developed atmospheric pressure gasifiers. Shell Brazil and local electricity companies are also shareholders in the pilot plant. Once developed and fully tested, the technology could be used worldwide. Producing fuelwood in large "energy farms" will be particularly significant to rural development efforts and employment in developing countries.

V - The Future

Projections have been made of the possible role of renewable in the next few decades by different groups.

One of the most interesting of them is the one produced by the World Energy Council (WEC) which constructed different scenarios ranging from "business as usual" to an "environmentally driven" scenario in which public policies are introduced to enhance the contribution of renewables. Another important projection is RIGES (Renewable Intensive Global Energy Scenario) which tries also to maximize the contribution of renewables including different types of new technologies in development.

A comparison of these scenarios is given in Table V.

In a "business as usual scenario" the contribution of commercial renewables will not surpass 10% in the period 2020-2025. While in the WEC Scenario it is 30% in 2020 and 45% in the RIGES scenario in 2025.

If these projections are fulfilled by 2025 one would not reach a sustainable energy supply but will be well underway to reach it in the following few decades.

Table I: World Energy Consumption and Proven Reserves (1991)

PRODUCTION	TEP X 10^9	Reserves/Production (in years)
Coal	2.16	209
Oil	3.11	45
Natural Gas	1.78	52
Hydro Electricity	0.19	renewable
Nuclear Electricity*	0.53	very long
TOTAL	7.78	

* *efficiency of 30% in the conversion to electricity*

Table II: Human Impact on the Global Environment Portion Attributable to Energy Supply*

			Portion of Human Disruption Caused by			
Affected Quantity	Natural Baseline	Human Disruption Index**	Industrial Energy	Traditional Energy	Agriculture	Manufacturing Other
Lead Flow	25,000	15	63% fossil fuel burning including additives	Small	Small	37% metals processing, manufacturing, refuse burning
Oil Flow to Ocean	500,000 tons/yr	10	60% of oil harvesting, processing, transport	5% burning traditional fuels	12% agricultural burning	70% metals processing, manufacturing, refuse burning
SO_2	50 million tons/yr	1.4	85% fossil fuel burning	1% burning traditional fuels	1% agricultural burning	13% smelting, refuse burning
Methane Stock	800 parts per billion	1.1	18% fossil fuel harvesting and processing	5% burning traditional fuels	65% rice paddies, domestic animal, land clearing	12% landfills
Mercury Flow	25,000 tons/yr	0.7	20% fossil fuel burning	1% burning traditional fuel	2% agricultural burning	77% metals processing, manufacturing, refuse burning
Nitrous Oxide Flow	10 million tons/yr	0.4	12% fossil fuel burning	8% burning traditional fuels	80% fertilizer, land clearing, aquifer	small
Particle Flow	500 million tons/yr	0.25	35% fossil fuel burning	10% burning traditional fuels	40% fertilizer, land clearing, aquifer disruption	15% smelting, non-agricultural land clearing, refuse burning
CO_2 Flow	280 parts per million	0.25	75% fossil fuel burning	3% net deforestation for fuelwood	15% net deforestation for land clearing	7% net deforestation for lumber, cement manufacturing

** Energy systems account for a significant portion of the human impact on the environment through emission to toxic and other pollutants in amounts rivaling or exceeding natural flows.*

*** The human disruption index is defined as the ratio of human-generated flow to the natural (baseline) flow.*

Source: (Holdren, 1990)

Table III: Technical Status of Renewable Energy Systems

Technology	Status	Technical Feasibility	Unit Size	Conversion Efficiency (%)
Active Solar Systems			1-50 MWt	25-50
• Heating	Commercial	H		
• Cooling	R&D	M/H		
Solar Thermal Power	Demonstrated	M/H	7-100 MWe	15-30
Photovoltaic Systems				
• Grid-Connected	Demonstrated	M/H	1-7000 kWe	10-25
• Off-Grid	Commercial	H	0.01-1000kWe	10-25
Biomass				
• Fuel	Commercial	H	n.a.	n.a.
• Power	Commercial	H	5-50 MWe	25-35
Wind. Power	Commercial	H	0.02-1.5 MWe	25-45
Small Hydroelectricity	Commercial	M/H	0.5-25 MWe	80-90
Ocean Wave and Tidal Energy	Commercial/R&D	L/H	3-10 MWe	n.a.
Ocean Thermal Energy	R&D	L	100-1000 MWe	n.a.

Notes: Wood combustion is commercial along with ethanol

MWt = megawatts thermal

MWe = megawatts electric

kWe = kilowatts electric

n.a. = not applicable or not available

L, M, H = low, medium, high

Technical feasibility, conversion efficiency and unit size are based upon current views. All of the tables shown are meant to convey a sense of progress and direction.

Table IV: Characteristics of Renewable Energy Sources

Technology	Current Estimated Cost: Capital ($/kW)	Current Estimated Cost: Total (cent/KWh)	World Installed Capacity	Environmental Problems
Active Solar Systems	2,500 - 3,000	15 - 20	US$ 650 million sales in 1991	small
Solar Thermal Power	3000	20 - 25	< 1000 MW	land constraints
Photovoltaic Systems	7000	25 - 35	500 MW 0.5 TWh in 1994	land constraints 1 MW 20 to 50,000m^2
Biomass Energy • Fuels • Power	 n.a. 1700 - 2000	 30 - 35 7 - 15	 15X10^9 liters/year 10,000 MW	no SO_2 but plenty of particulates land use issues
Wind Power	900 - 1400	5 - 10	4,900 MW 7.5 TWh in 1995	visual pollution
Small Hydroelectricity	1000	5 - 10	5% of total hydro ~ 20 X 10^3 MW	small
Ocean Wave and Tidal Energy	1400 - 2500	15 - 20	–	?
Ocean Thermal	10000	30 - 40	–	?
TOTAL			35 X 10^3 MW and 12 X 10^6 toe/ of fuels	

All costs are expressed in US dollars per kW of peak electric power, operating and total costs are in US cents per kWh of electric energy delivered. Estimates refer to grid-connected installations, 30-year system life, 7 per cent real discount rate per year. Biofuels costs are provided in cents per liter of ethanol derived from biomass priced at US$ 3 a gallon; fossil fuel costs are between US$ 1 and 2/gallon.

One dollar = 100 cents

n.a. - not aplicable

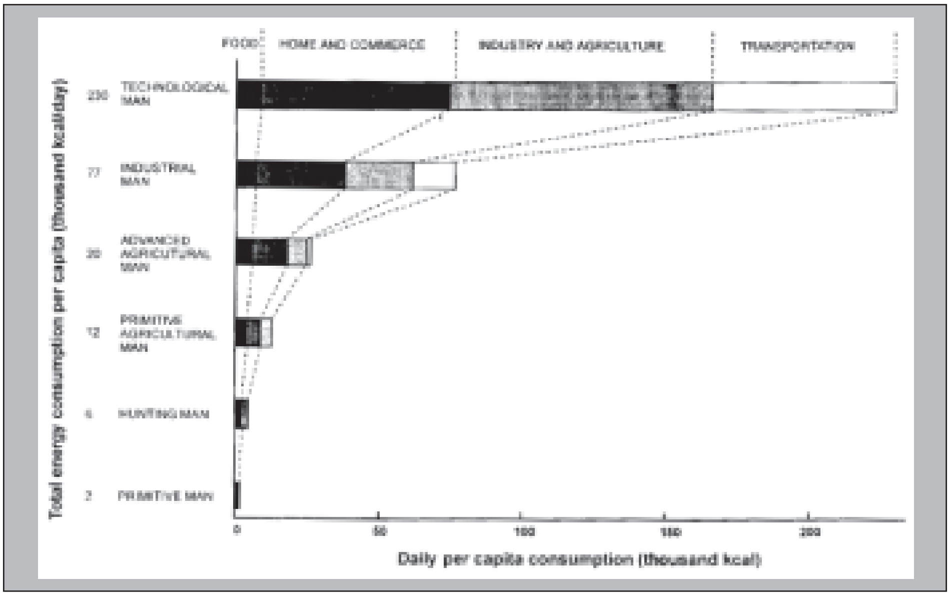
Table V: Comparison of Scenarios - Primary Energy Consumption in GTOE

		WEC scenario C (year 2020)		RIGES (Year 2025)	
Fossil Fuels					
	Solid		2.1		2.00
	Liquid		2.7		1.72
	Gas		2.4		2.10
Nuclear			0.7		0.33
Renewables			3.4		5.02
	Largo hydro	0.9		0.68	
	New renewable*	1.4			
	Intermittent renewable			0.84	
	Traditional renewable	1.1			
	New biomass			3.3	
	Solar H_2			0.2	
Geothermal					0.04
TOTAL			11.3		11.21

Note:

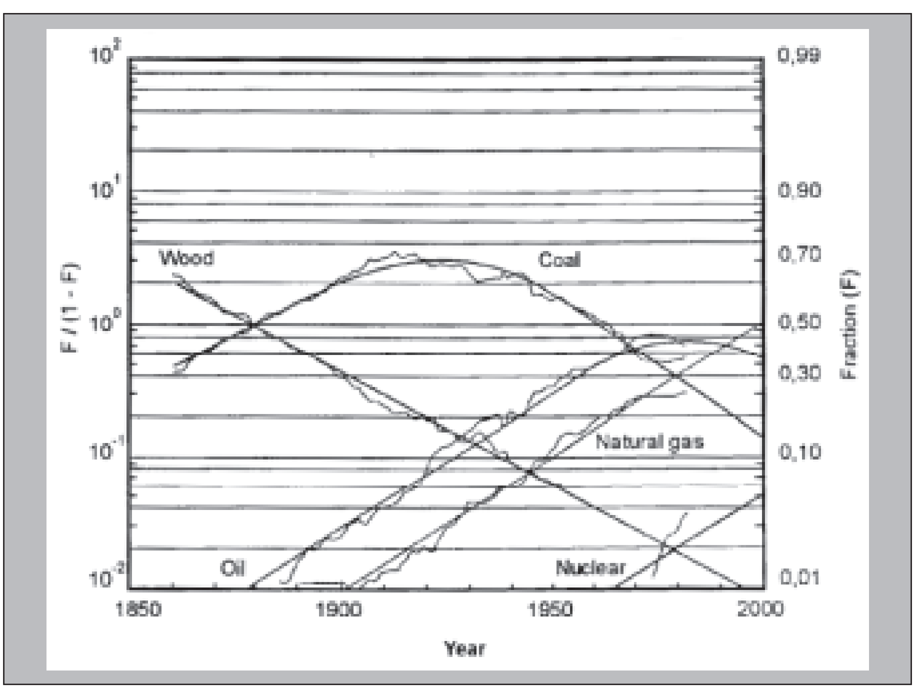
In "new renewable", "modern biomass" contributes 0.6 GTOE. This category is considered "new biomass" in RIGES along with traditional biomass which is all converted into "new biomass" in the year 2025. The WEC scenario thus give 1.1 + 0.6 = 1.7 GTOE for "new biomass" in the year 2020. Subtracting 0.6 GTOE from "new renewable" in WEC reduces it to 0.8 GTOE for what RIGES considers "intermittent renewables". This compares well with 0.84 GTOE in the RIGES scenario.

Figure 1
Stages of Development and Energy Consumption



Source: Cook, E., Man Energy Society, W H Freeman and Co. , San Francisco, US (1976)

Figure 2
Historical Market Penetration Curves for Various Fuels



Note : Fraction (F) is the fractional market share.

Source: Nakicenovic, N. et al (eds), "Long-term Strategies for Mitigating Global Warming", Energy, 18, 401 (1993).

Figure 3

Growth of Nuclear Electricity Generation Since 1970

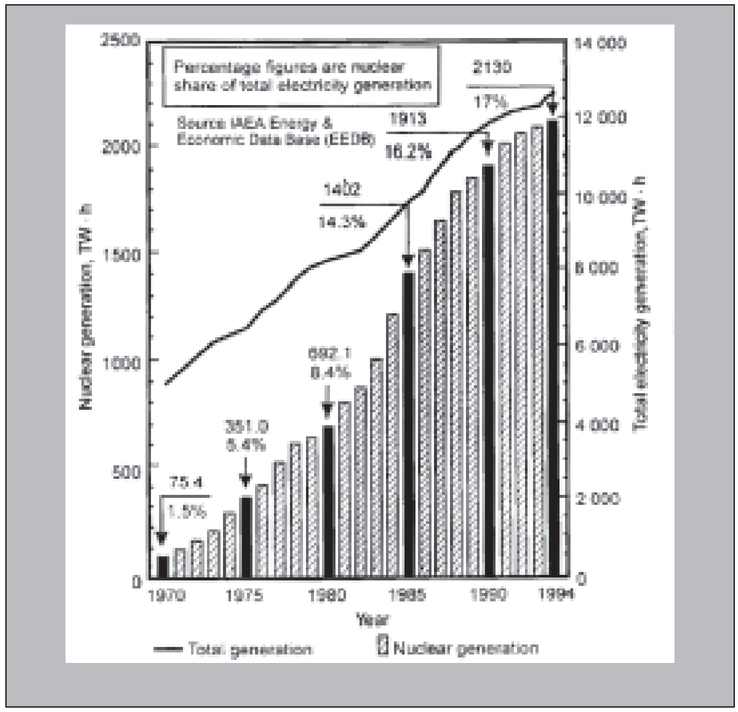
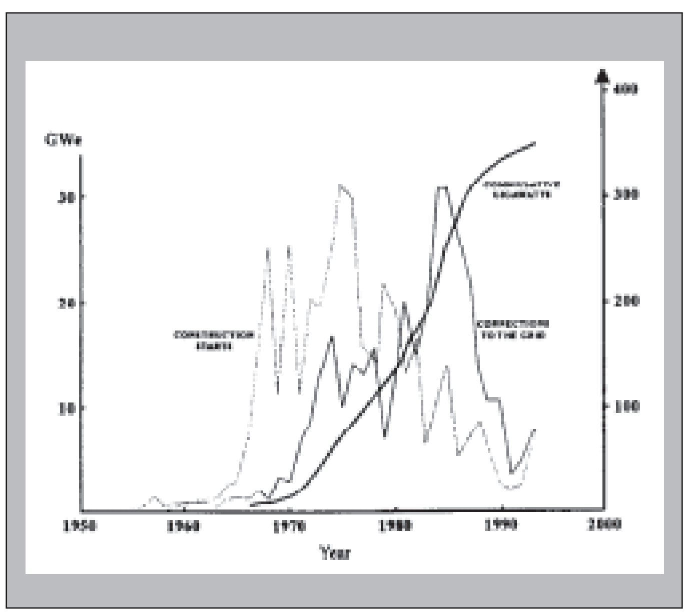


Figure 4

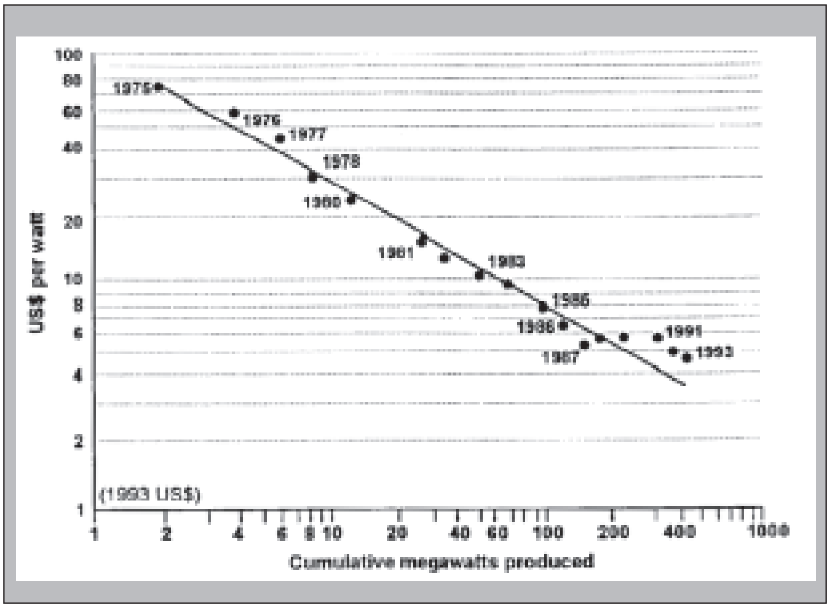
World Nuclear Energy



Source: International Atomic Energy Agency (IAEA), Energy, Electricity and Nuclear Power Estimates for the Period Up to 2010, IAEA, Vienna, Austria (1993).

FIGURE 5

PENETRATION CURVE FOR PHOTOVOLTAICS



Source: Flavin, C. and Lenssen, N. - Power Surge Guide to the Coming Energy Revolution, W W Norton & Co., New York, US (1994)

FIGURE 6

EVOLUTION OF ETHANOL PRODUCTION IN BRAZIL

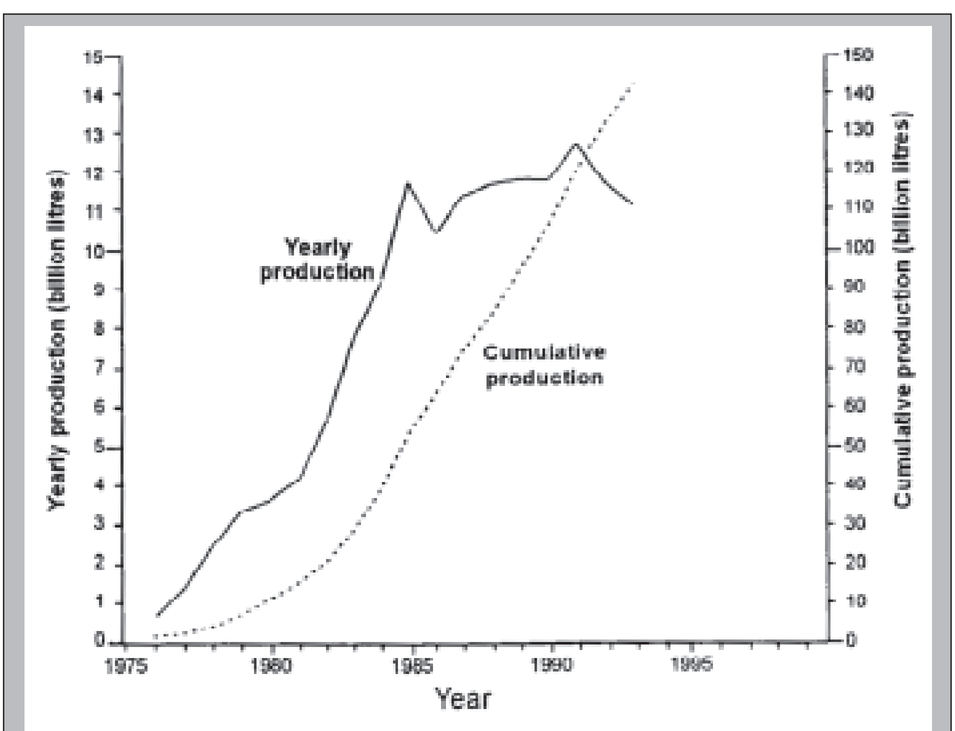
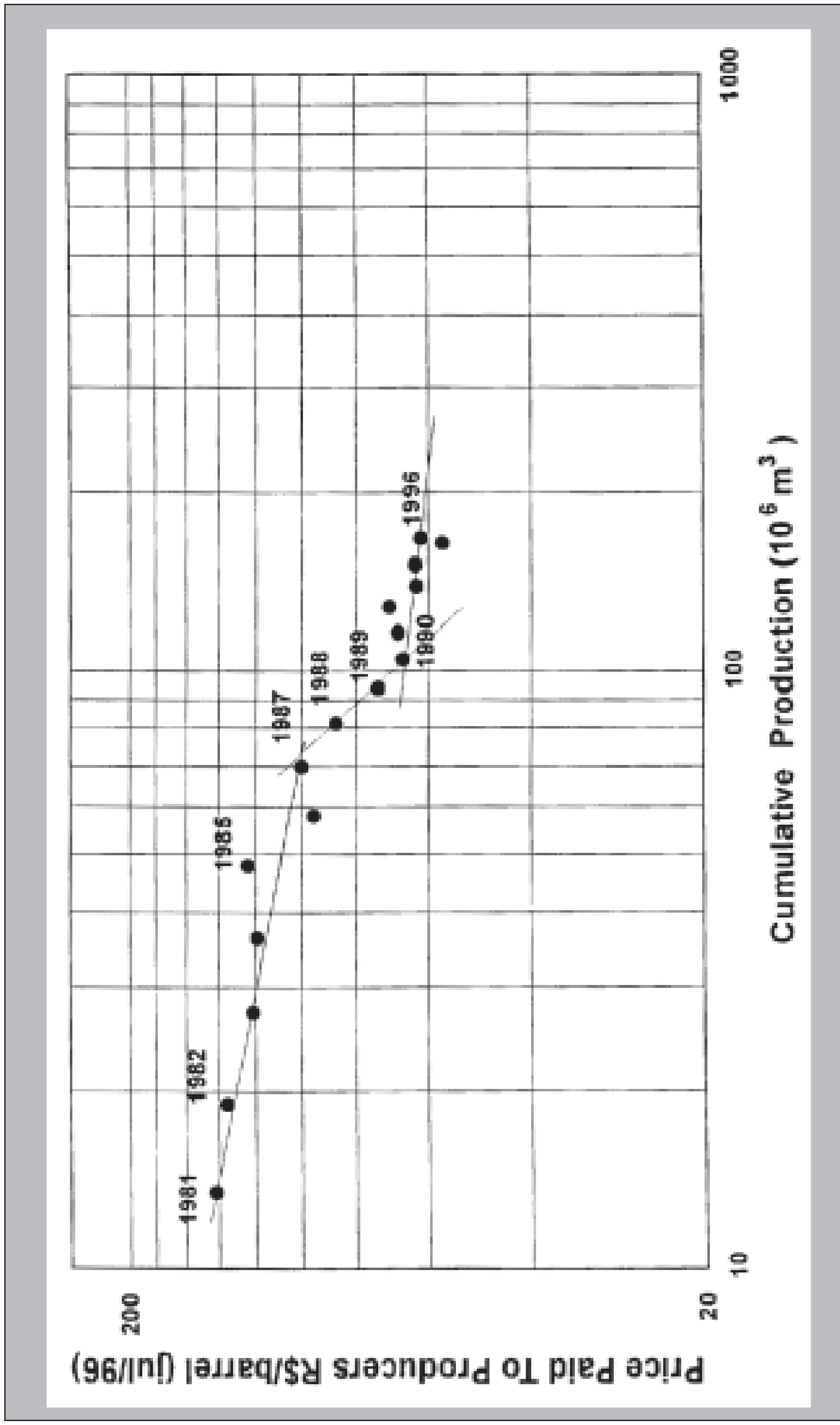


Figure 7

Cost Evaluation of Ethanol in Brazil



Source : Goldemberg, 1996

Energy Production From Biomass Sustainability:

The Sugar Cane Agro-Industry in Brazil

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Introduction

Sugar cane production in Brazil reached 300 million t in 1997 (25% of world's production), leading to 14.8 million t of sugar and 15.3 million m^3 ethanol. Sugar cane is produced in almost all Brazilian regions, with concentration in S. Paulo, Minas Gerais and Paraná. Industrial processing occurs in more than 300 units, all privately owned.

The high proportion of ethanol in product mix, as well as the large scale use of bagasse as fuel, make the Brazilian sugar cane industry the largest commercial biomass to energy system in the world.

After more than twenty years of ethanol utilization as large scale automotive fuel in Brazil, technology evolution and a strong knowledge of agricultural and industry-based environmental impacts make it possible to analyze the whole cycle and to evaluate the system sustainability.

Some technological changes introduced in 1998 (mainly the schedule for phasing out sugar cane burning before harvesting) will significantly impact the figures for GHG emissions; one scenario is considered for the next 12 years.

Main aspects analysed are:

- The energy balance for the whole agro-industrial cycle including sugar/ethanol production and utilization; the fossil fuel to renewable energy ratios; the main results for 1985 and 1996, showing the trends and the impact of new technologies. Correspondingly, the 1985-1996 CO_2 emissions (and avoided emissions) for the sugar cane to ethanol and bagasse energy system are calculated. The 1996 CO2 balance shows a net saving equivalent to 18% of all fossil fuel emissions in Brazil.
- For the agricultural/industrial cycle, 1996, the CH_4 and N_2O emissions are also estimated, and added to the greenhouse gases inventory.
- Scenarios based on legal and technical considerations are established for the phasing out of sugar cane burning practices: the most likely scenarios were used to quantify the beneficial impacts in atmospheric pollution (particulate emissions; CH_4, NO_x and CO emissions) 12 years from now, both in industry and agriculture. The net increase in biomass availability for energy (a fraction of the 45 million t, dry mass, lost today by burning practices) is used to estimate further CO_2 avoided emissions.
- Utilization of herbicides and pesticides today, is quantified/estimated and compared with other main crops in Brazil (soy beans and corn).
- The existing legislation towards re-forestation is analyzed for the sugar cane production situation in S. Paulo, the main Brazilian producer.
- Water industrial utilization at the sugar mills is quantified, at the present situation, as well as the goals for the near future.

The overall results indicate the strong evolution towards a sustainable agro-industry based on sugar cane, with simultaneous production of food and energy.

Energy Production and Utilization

Energy utilization/production figures for the cane agro-industry in Brazil were up-dated from the 1985 (1) to account for the situation in São Paulo State, 1996 (2).

Main results are summarized in Table 1.

Table 1: Energy in sugar cane and ethanol production (MJ/t cane)*

	Averages		Best Values	
Sugar Cane Production (total)	**189.87**		**175.53**	
Agricultural Operations	30.10		30.10	
Cane transportation	34.92		31.87	
Fertilizers	66.96		56.09	
Lime, herbicides, etc.	19.06		19.06	
Seeds	5.76		5.34	
Equipment	33.07		33.07	
Ethanol Production (total) **	**46.08**		**36.39**	
Electricity (bought)	0.00		0.00	
Chemicals and Lubricants	7.34		7.34	
Buildings	10.78		8.07	
Equipment	27.96		20.98	
External energy flows, (agriculture + industry) ***				
	Input	Output	Input	Output
Agriculture	189.87		175.53	
Industry	46.08		36.39	
Ethanol produced		1996.37		2045.27
Bagasse surplus		175.14		328.54
Totals (external flows)	235.95	2171.51	211.92	2373.81
Output/Input	**9.2**		**11.2**	

(*) Three levels of "energy utilization" are considered: direct fuel and (external) electricity utilization; energy used for production of chemicals, lubricants, lime, etc.; energy used for production and maintenance of equipment and buildings.

(**) Only "external" energy: not including energy from bagasse utilized at the sugar mill, as steam or electricity.

(***) External energy inputs are mainly from fossil fuels (fuel oil, diesel); although in Brazil most of the electric power input is renewable (hydroelectric) it is considered here as a component of buildings, equipment, chemicals, etc.

Differences between 1985 and 1995 correspond to increases in cane productivity and cane production cycle; improvements in the cane transportation sector; harvesting mechanization; increase in overall industrial conversion (from 73 to 85 l ethanol/t cane); and better use of bagasse in the cogeneration systems.

The large output/input ratio for energy (average, 9.2) is expected to increase in the next ten years due to the possibility of green cane harvesting and trash utilization as fuel.

The net contribution to the evolution of atmospheric CO_2 is due mainly to:

- Increase atmospheric CO_2 due to fossil fuel and energy-using inputs in the agricultural/industrial production of sugar and ethanol;
- Reduction in the rate of release of CO_2 by substituting ethanol for gasoline and sugar cane bagasse for fuel oil in sugar production and other industrial sectors.

In the life-cycle analysis to estimative the CO_2 equivalent emissions, consideration was also given to:

– Methane emissions from burning sugar cane, from stillage and from bagasse burning boilers;

– GHG emissions from ethanol engines (relative to gasoline engines)

– N_2O emissions from soil

Results are shown in Table 2

Table 2: Net CO_2 (equivalent) emissions due to sugar cane production and utilization in Brazil (1996) (measured as C)

	10^6 t C (equiv.)/year
Fossil fuel utilization in the agro-industry	+ 1.28
Methane emissions (sugar cane burning)	+ 0.06
N_2O emissions	+ 0.24
Ethanol substitution for gasoline	- 9.13
Bagasse substitution for fuel oil (food and chemical industry)	- 5.20
Net contribution (Carbon uptake)	- 12.74

The net savings in CO_2 (equivalent) emissions correspond to nearly 20% of all CO_2 emission from fossil fuels in Brazil.

Trends in the energy output/input ratios and CO_2 (equiv.) emissions

Recent legislation has established limits to sugar cane burning before harvesting. Although differences in the time schedule and scope for phasing out burning exist between the Decreto Federal (2661, 8-7-98) and the Decreto Estadual SP (42005, 6-5-97) a simple scenario was set to analyze the impacts on GHG emissions and energy output/input.

The main hypotheses considered the use of portion of the recovered trash as fuel, in high-efficiency cycles (3).

The analysis considered as the baseline the average situation today: 100% burnt cane on harvesting; 10t (DM)/ha* burnt trash; energy self-sufficiency.

Future: 55% unburnt cane; trash recovery: 100% or 50%, depending on harvesting route.

Harvesting routes:

R1 - Whole cane with trash; 100% transported to the mill

R2 - Chopped cane (extractor off); 100% trash, to the mill

R3 - Chopped cane (extractor on); baling, 50% trash to the mill

* DM: dry mass.

The complete set of hypotheses, and the energy balance for the whole cycle are presented in (3). Differences on diesel consumption for the agricultural operations, harvesting and transportation of cane and trash, as well as the differences due to higher biomass availability and conversion efficiencies in the new routes, as compared to today, were used to evaluate the net CO_2 emission. Results are summarized in Table 3:

TABLE 3: DIFFERENCES IN CO_2 EMISSION (FUTURE – TODAY)
PARTIAL TRASH UTILIZATION AND HIGHER CONVERSION EFFICIENCIES

Routes	Diesel used in agriculture (kg CO_2/t cane)	Fossil fuel substitution (kg CO_2/t cane)	Total emission difference (kg CO_2/t cane)	Brazil: 300 x 10^6 t cane/year (10^6 t CO_2/year)
R1	+ 2.1	- 139.	- 137.	- 41.1
R2	+ 7.3	- 139.	- 132.	- 39.6
R3	+ 2.3	- 87.5	- 85.	- 25.5

The last column shows the (hypothetical) CO_2 emission reduction achievable in Brazil, with the BIG-GT** technology implanted according to the scenarios adopted. Even considering that there will be further restrictions due to scale of production, the potential shown is very large.

In this scenario, the main differences in the emission of other greenhouse gases (specifically, Methane, CO and NOx) from the situation today will be mostly in the agricultural area (sugar cane trash burning). The contribution of NO_x and CO emission differences (bagasse boilers and future gasification/gas turbines) is expected to be small. Also, trash methanization in soil does not seem to be significant.

Emission factors for sugar cane trash burning measured in wind tunnel experiments, were compared to the available USEPA-AP42*** factors; also "general results" for burning of agricultural residues, from IPCC****, were considered.

The ranges of final results are shown in Table 4.

TABLE 4: REDUCTION IN EMISSIONS OF GREENHOUSE GASES (CH_4, CO, NO_x) DUE TO THE PARTIAL HARVESTING OF NON-BURNT CANE

	Future – Today (kg/t cane)
Methane	– 0.028 (wind tunnel)
	– 1.195 (IPCC)
CO	– 1.76 (wind tunnel)
	– 4.10 (IPCC)
NO_x	– 0.097 (wind tunnel)
	– 0.301 (IPCC)

** BIG-GT: biomass gasification- gas turbine cycle.
*** USEPA: U.S. Environmental Protection Agency.
**** IPCC: International Panel on Climate Change.

It must be noted that the impact of green cane harvesting (even if only in 55% of total area) is important, although much smaller than the effect of CO_2 reduction.

It may also be noted that the hypothesis of only 55% of green cane harvesting may be changed in Brazil in the next years.

Herbicides, pesticides and fertilizers

It is known that the sugar cane agro-industry in Brazil is relatively mild, with low environmental impacts, when compared with most of the other large volume crops. Some characteristics are:

- Low level of utilization of herbicides and pesticides; the sugar cane agriculture has incorporated an extensive biological control of the borer which is the main predator, and the recycle of residues (stillage and filter cake) also reduce the need for fertilizers (mainly potassium).
- Rapid growth allows for soil protection for most of the time, reducing erosion; the practice of culture rotation is also well accepted.
- Industrial production (sugar and ethanol) is driven by renewable energy (from bagasse), with no sulfur; processes and inputs are relatively safe with respect to environment, and effluents are recycled.
- Beyond the local environmental benefits of fuel ethanol, by far the most important feature is the significant reduction in CO_2 emissions due to the use of renewable fuels, ethanol and bagasse.

– With respect to fertilizers, average numbers for the sugar cane, soybeans and corn production in Brazil are shown in Table 5. It is seen that today the sugar cane crops are (on a hectare basis) equaly dependent on mineral fertilizers. One interesting exercise shows that the better use of residues (filter cake and stillage) in the future, as well as the possibility of leaving large amounts of trash in field, without burning, can lead to significant reductions in mineral fertilizers (see Table 6). A fraction of this potential is expected to be used.

Table 5: Harvested area and mineral fertilizers used in sugar cane, corn and soy beans in Brazil, 1997

Crop	Area* (Million ha)	Total Nutrient, (1000 t)			Total ** (1000 t)
		Nitrogen	Phosphorous	Potassium	
Sugar cane ***	4.9	317.	202.	415.	935.
Corn	13.6	406.	813.	677.	1897.
Soy beans	11.5	0	690.	805.	1495.

*Source: *IBGE/1977*

*** Based on Averages IAC/BTC 100/1996*

**** Stillage used in 33% of ratoon area*

Table 6: Potential for nutrient recycling in sugar cane

By products	Nutrients (kg/t)			By Product Production (Million t/year)	Total Availebility (1000 t)
	Nitrogen	Phosphorous	Potassium		
Filter cake *	2,16	10,10	2,79	3.6	54.2
Stillage **	0,11	0,10	2,33	168.3	427.6
Trash ***	0,72	0,21	5,17	45,9	280.4
					762.3

** 12 kg/t cane*

*** Recycled; needs optimization (areas, distances)*

**** Assuming 3.4 million ha with no-burnt cane, in 12 years; trash left in field.*

– Considery herbicides, the relative position with respect to soybean and corn is shown in Table 7.

Table 7: Herbicides in corn, soybeans and sugarcane (1997)

Crop	Area (Million ha)	Herbicides (1000 t)
Sugar cane	4.9	22.6
Corn	13.6	15.1
Soy beans	11.5	65.6

Source: IBGE, 1997; ANPEI, 1997

Again, leaving a trash blanket in sugar cane fields harvested without burning can lead to a great reduction in herbicides (equivalent to the reduction in the area of burnt sugar cane); for 55% green cane harvesting, herbicides would be only 10200. t.

– With respect to pesticides, the use of biological control with the sugar cane borer, the main sugar cane predator, (common practice in most of the area of S. Paulo) has controlled infestation to 2 – 3%, against initial levels of 10 –11%. The overall use of pesticides today amounts to 0.52 kg/ha, against 1.17 for soybeans and 0.26 for corn (IBGE and ANDEF, 1997).

The pesticides used in sugar cane deal mostly with soil insects (also ants). For corn and soybeans, there is no need to control soil insects.

The is some uncertainly about the future increase in predators for the aerial portions of sugar cane, with the limitation in sugar cane burning; specific biological controls are being developed and evaluated for a few possible problems.

It is possible, however, that the use of transformed sugar cane varieties (transgenic) could allow for resistance to some soil insects and further reduce the need for insecticides.

Soil and water protection; re-forestation

The sugar cane fields are subjected to the same legislation as the other agricultural activities, with respect to reforestation and water protection; namely, the Codigo Florestal (Lei 4771, 15-9-65) defining the areas for preservation. Besides, the "legal reserve" concept established in Lei 7803/89 (20% of the total area to be re-forested), after the Lei Agrícola 8171, 17-1-91, is being analyzed for many implications (legal, environmental and economic). More recent propositions in the State of S. Paulo are expected to address the issue.

Basically, today the actual implementation of the areas for permanent preservation is just beginning; it is expected that the analyses in course will lead to an adequate mix with the "legal reserve" concept. Some thousands of hectares of re-forested areas have already been established (protection of watercourses, hills, etc.); the next decade will no doubt see substantial changes.

Water utilization by the sugar mills is very high, today. A sample of 36 mills, processing 60 million tons of sugar cane in S. Paulo, indicated (CTC-Copersucar*, 1997) an average of 5 m^3 water/t cane processed (varying from 0.7 to 24.0) in water intake.

In the next years, the mills will be involved in a program to reduce water utilization; the expected target is $1m^3$/t cane.

Conclusion

The sugar cane agro-industry in Brazil is a very important example of a sustainable biomass to energy large scale system. Energy output/input ratio (renewable/fossil fuel) is 9.2, leading to an extraordinary value CO_2 abatment (nearly 20% of all fossil fuel emissions in Brazil).

Those figures can be improved if the enforcement of the legislation to stop burning portion of the sugarcane before harvesting leads to the use of trash for energy, as expected.

Better management of residue recycling (fitter cake, stillage and some trash) can also lead to substantial reduction of mineral fertilizers and herbicides.

Although the use of water is very high, there are no technical difficulties in reducing the average to 20% of the value practiced today.

Technologies for soil preservation (including culture rotation and soil preparation for heavy rainfall) are well known, although not practiced in all areas; re-forestation and water course protection is expected to increase significantly in S. Paulo.

(1) Macedo, I.C. – The sugar cane agro-industry – its contribution to reducing CO2 emissions in Brazil, Biomass and Bionergy, 1992. 3, 77-80.

(2) Macedo, I.C. – Greenhouse Gas Emissions and Energy Balances in Bio-Ethanol Production and Utilization in Brazil (1996), Biomass and Bioenergy, 1998, 14.1, 77-81.

(3) Projeto BRA-96/G31, Geração de Energia por Biomassa: bagaço de cana-de-açúcar e resíduos; Report RLT-018, Centro de Tecnologia Copersucar, Março –1998.

* CTC: Centro de Tecnologia Copersucar

Responsibility and Climate Change

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I - Introduction

Climate change, as defined in the Convention, means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and which is in addition to natural climate variability observed over comparable time periods.

General Circulation Models are now starting to incorporate some of the radiative forcing resulting from human-induced changes in sulfate aerosols and stratospheric ozones. However, important uncertainties remain. These uncertainties are related to water vapor feedback, clouds, ocean circulation, ice and snow albedo feedback, and land-surface/atmosphere interactions.

In 1988, the Intergovernmental Panel on Climate Change (IPCC) was established to assess available information on the science of climate change, in particular that arising from human activities.

However, most of the scientific literature assessed is written in English or other languages that can be easily assessed by the experts. This is a drawback to the process in the sense that all scientific literature related to climate change written in languages other than those that can be quickly understood by Annex I experts are not reviewed. In addition, the vast majority of scientists (convening lead authors, lead authors and contributors) in the IPCC process represent Annex I countries (85.3%, from which 39.2% are from the USA).

In the political arena, the Third Conference of the Parties to the Climate Change Convention in Kyoto, Japan, resulted in a consensus decision to adopt a Protocol under which industrialized countries will reduce their combined greenhouse gas emissions by at least 5% compared to 1990 levels by the period 2008-2012. This legally binding commitment promises to produce an historic reversal of the upward trend in emissions that started in these countries some 150 years ago.

Nevertheless, there has been no attempt to establish an objective criterion for how to mitigate climate change (by how much and for how long) in Kyoto. Also there has not been explicit quantification through the whole Berlin Mandate process and discussions in Kyoto of the effort that the overall greenhouse gas emission reduction would represent in terms of decreasing the rate of temperature increase. Actually, the emission reduction or limitation Kyoto targets imply that the mean surface global temperature will continue to increase during the whole period of the Kyoto Protocol until 2012.

Climate change arising from greenhouse gas emissions poses new challenges to the global community because of its unique feature of time dissociation of causes from impacts. The temperature increase resulting from greenhouse gas emissions represents a long-term process that will span over a period greater than a hundred years.

This long-term time dependence creates a very difficult policy framework under the United Nations Convention on Climate Change in addition to the intrinsic complexity of the physical problem of radiative forcing. There is an intergenerational problem both in regard to the responsibility for causing the global warming problem as well as concerning policies and measures to be undertaken to combat the adverse impacts of climate change.

The preamble of the Climate Change Convention acknowledges that "change in the Earth's climate and its adverse effects are a common concern of humankind" and that "the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions”.

On the other hand, developed countries argue that greenhouse gas emissions from fast developing key countries will equal the emissions from developed countries in some point in time between the years 2020 and 2030 in accordance with IPCC scenarios.

This debate creates an impasse, with developed countries looking to the future and forgetting the past emissions and developing countries looking to the past but concerned with their own future emissions.

The Climate Convention is based on emissions accounting by means of inventory reporting by each country of its anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. This is the basis for all policies and measures established in order to mitigate climate change.

The choice of a base year and consequent high or low emission starting point for emission reduction or limitation target objectives has a clear policy implication. This choice of a convenient base year is completely irrelevant from the perspective of the atmosphere, both in terms of causing or solving the problem of climate change, but is recurrent in this debate and in the Climate Change Convention.

It becomes therefore of central importance to establish the relationship between the net anthropogenic emissions and the resulting change of climate. As it is recognized that the change of climate is predicted to have a complex geographical distribution, it is important to have a unique measurement of the global climate change.

The choice of the global mean surface temperature indicator as a proxy to define global warming permits the formulation of a model to analyze the responsibility of individual countries. The current debate creates an impasse because of lack of adequate criterion for measuring the relative responsibility of individual countries for causing global warming.

II - The Climate Science[1]

The ultimate energy source for all weather and climate is radiation from the Sun (solar or short wave radiation). Averaged globally and annually, about a third of incoming solar radiation is reflected back to space. Most of the remainder is absorbed by land, ocean and ice surfaces. The solar radiation absorbed by the Earth’s surface and atmosphere (about $240 W/m^2$) is balanced by outgoing radiation at infrared wavelengths. Some of the outgoing infrared radiation is trapped by naturally occurring greenhouse gases (principally water vapor, but also carbon dioxide (CO_2), ozone (O_3), methane (CH_4) and nitrous oxide (N_2O) and by clouds, which keeps the surface and troposphere about 33° C warmer than it would otherwise be. This is the natural greenhouse effect[2].

[1] Climate Change 1995, IPCC Technical Summary of the Working Group I, WMO, UNEP. Most of this section is a brief discussion of the IPCC Technical Summary of the main features of the climate science relevant to the responsibility attribution discussion or definitions as stated in the Climate Change Convention.

[2] Climate Change 1994 Radiative Forcing of Climate Change and an evaluation of the IPCC IS92 emission scenarios, IPCC, Cambridge University Press.

Climate change, as defined in the Convention, means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and which is in addition to natural climate variability observed over comparable time periods.

A change in average net radiation at the top of the troposphere, because of a change in either solar or infrared radiation, is defined as a radiative forcing. A radiative forcing perturbs the balance between incoming and outgoing radiation. Over time climate responds to the perturbation to re-establish the radiative balance. A positive radiative forcing tends on average to warm the surface; a negative radiative forcing tends on average to cool the surface.

The anthropogenic greenhouse gas emissions accumulate in the atmosphere increasing concentration. Increases in the concentrations of greenhouse gases interfere with the cooling of the Earth, and the atmosphere absorbs more of the outgoing terrestrial radiation from the surface. An increase in atmospheric greenhouse gas concentration leads to a reduction in outgoing infrared radiation and a positive radiative forcing. This results in a positive change in the energy available to the global Earth/atmosphere system. For balance to be restored, the temperature of the troposphere and of the surface must increase, tending to warm the planet and producing an increase in outgoing radiation. These anthropogenically emitted greenhouse gases contribute to an enhanced greenhouse effect.

The amount of warming depends on the size of the increase in concentration of each greenhouse gas, the radiative properties of the gas, and the concentration of greenhouse gases already present in the atmosphere.

Ozone is produced in the troposphere during the oxidation of methane and from various short-lived precursor gases (mainly carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane hydrocarbons (NMHC). Decreases in stratospheric ozone have occurred largely because of anthropogenic chlorine and bromine compounds. Anthropogenic aerosols derived from sulfur dioxide emissions and biomass burning can absorb and reflect solar radiation. Volcanic activity can inject large amounts of sulfur containing gases, which are transformed into aerosols. Changes in aerosol concentrations can alter cloud properties. Solar radiation has changed over time. Any human-induced changes in climate will be superimposed on natural climatic variations.

One first difficulty is the attribution of causes, because observed warming is of the same magnitude of natural climate variability. Future climate is projected using climate models. The most highly developed climate models are the AOGCMs - atmospheric and oceanic general circulation models.

The major components of the climate system that are important for climatic change are the atmosphere, oceans, terrestrial biosphere, glaciers and ice sheets, and land surface. In order to project the impact of human perturbations on the climate system, it is necessary to assess the effects of all key processes operating in these climate components and the interaction between them. These climate processes can be represented in mathematical terms based on physical laws such as the conservation of mass, momentum, and energy. However, because of the complexity of the system, these mathematical equations are solved numerically using a computer. In the most complex models of the atmosphere and ocean used to study climate (AOGCMs), physical quantities (e.g. temperature, humidity and wind speed) are represented by a three-dimensional (longitude-latitude-height) grid with typical horizontal resolutions of several hundred kilometers.

There are few of such models being developed around the world. Normally, the most referenced studies using General Circulation Models - GCMs come from the work of groups in developed countries. These modeling groups include the Geophysical Fluid Dynamics, in Princeton, USA; Main Geophysical Observatory, in Leningrad, Russian Federation; CSIRO in Australia; National Center for Atmospheric Research, in Boulder, Colorado, USA; the Canadian Climate Center; the Meteorological Research Institute, in Japan; Meteorological Office, in the United Kingdom; Meteorologie Institut, University of Hamburg; and the Max Planck Institut für Meteorologie, Hamburg, in Germany.

GCMs are now starting to incorporate some of the radiative forcing resulting from human-induced changes in sulfate aerosols and stratospheric ozones. However, important uncertainties remain. These uncertainties are related to water vapor feedback, clouds, ocean circulation, ice and snow albedo feedback, and land-surface/atmosphere interactions.

An increase in the temperature of the atmosphere increases its water holding capacity, and it is expected to be followed by an increase in the amount of water vapor, leading to a further enhancement of the greenhouse effect. Clouds can both absorb and reflect solar radiation and absorb and emit long-wave radiation depending on cloud height, thickness, and radiative properties. Oceans carry large amounts of heat from the tropics to the poles. Ice and snow covered surfaces strongly reflect solar radiation (high albedo). Increased temperature, changes in precipitation, etc, will influence land surface, and in turn, altered land surface can alter the overlying atmosphere. In summary, confidence in climate models has increased since 1990 but will still be enhanced as models continue to improve.

Different from the ozone depleting substances, the greenhouse gas emissions need not to be phased out. It is enough to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. However, this level is not scientifically defined yet. The stabilization of concentration requires emissions eventually to drop well below current (or 1990) levels. The IPCC emission scenario that allows higher maximum emissions (15GtC/y) still reaching concentration stabilization at 1000 ppmv requires a decline to current levels (7 GtC/y) by about 240 years from now and further reductions thereafter.

Carbon dioxide - CO_2, the main anthropogenically emitted greenhouse gas, is removed from the atmosphere by a number of processes that operate on different time-scales, and is subsequently transferred to various reservoirs, some of which eventually return CO_2 to the atmosphere. If emissions were reduced, the CO_2 in the vegetation and ocean surface water would soon equilibrate with that in the atmosphere. Most of the excess atmospheric CO_2 would be removed over about a century although a portion would remain airborne for thousands of years because transfer to the ultimate sink - ocean sediments - is very slow. There is large uncertainty associated with the future role of the terrestrial biosphere in the global carbon budget. Future rates of deforestation[3] and regrowth in the tropics and mid-latitudes are difficult to predict and mechanisms such as CO_2 fertilization remain poorly quantified. Carbon could be released rapidly from areas where forest die, although regrowth could eventually sequester much of this carbon.

[3] Deforestation in addition to releasing carbon to the atmosphere reduces the ability of forests to store carbon and act as a carbon sink by destroying them.

Although the anthropogenic flux of CO_2 is small compared with mean natural fluxes, it is enough to perturb the carbon cycle. The net uptake of anthropogenic CO_2, particularly by the deep ocean, occurs slowly, on a time-scale of centuries, so addition of anthropogenic CO_2 has a long-lasting effect on atmospheric concentration. If emissions were held constant at present day levels, atmospheric concentrations would continue to rise for at least two centuries[4].

Key processes in the carbon cycle include the exchange of CO_2 between the atmosphere and the ocean and between the surface waters and long-term storage in the deep ocean, and the photosynthetic uptake of CO_2 by land plants, and the long-term storage of their carbon in wood and soils. Additionally, the response of these processes to changing CO_2 and climate, and the release of CO_2 back to the atmosphere through plant and soil respiration are also important.

Most carbon cycle models include only simple representations of terrestrial biotic processes. The oceanic components vary in complexity from a few simplified equations to detailed descriptions of ocean biology, chemistry, and transport processes. The main anthropogenic sources of CO_2 are the burning of fossil fuels (5.5 ± 0.5 GtC/y) and land-use change (releases of 1.6 ± 1.0 GtC/y by tropical deforestation and uptakes of 0.5 ± 0.5 GtC/y by Northern Hemisphere forest regrowth after clearing in the past). The oceans are a large sink of anthropogenic CO_2 (current estimate 2.0 ± 0.8 GtC/y). The summation of sources, sinks and atmospheric storage leads to an apparent unattributed terrestrial sink of 1.4 ± 1.5 GtC/y (known as "missing" carbon or sink). However, mechanisms have been identified that could account for the imbalance, like CO_2 and nitrogen fertilizations, climate and interaction between these processes.

CO_2 concentrations have increased from about 280 ppmv in the pre-industrial times to 358 ppmv in 1994. There is no doubt that this increase is largely due to human activities, in particular fossil fuel combustion. For at least 160,000 years before the start of the Industrial Revolution, atmospheric concentrations of carbon dioxide never exceeded 300 ppmv.

Political and economic groups have become involved with the climate change issue, mainly from the coal and the oil industries. Some scientists, supported by these groups, consider that when other natural factors are considered, pointing to a cooling next century, the expected greenhouse warming may be partially balanced out. They also consider that an increase in atmospheric CO_2 concentration must be considered beneficial for nature and human activities. They also propose that the biosphere should be used to re-capture atmospheric CO_2 in order to rebuild the stock of natural resources by means of a global afforestation program[5].

This is a recurrent idea in the climate change debate, that it is possible to compensate the fossil fuel combustion emissions by an equivalent uptake by afforestation and reforestation programs in abandoned areas. This idea in not feasible in the long run because at current CO_2 emission level of 7 billions tC/y it would imply that an area of 35 million ha/y had to be planted with forests each and every year. This estimate assumes an uptake of 100 tC/ha as a maximum uptake rate assumption, and that half of anthropogenic greenhouse gas emissions is absorbed by natural sinks.

[4] Climate Change 1994 Radiative Forcing of Climate Change and an evaluation of the IPCC IS92 emission scenarios, IPCC, Cambridge University Press.
[5] Global warming – the rest of the story, Gerd R. Weber.

Even in this best estimate, the trees could not be cut down because the carbon would be released back to the atmosphere (even considering storage as furniture in a 20-30 years term). This annual area of 350,000 km^2 would cover the Brazilian territory completely in just 25 year, demonstrating that a strategy based upon CO_2 sequestration by forests only is not feasible, even if the carbon contained in the wood is somehow permanently fixed.

In particular, regarding forest sinks, no account has been taken of carbon releases to the atmosphere because of die back of forest if climatic zones shift too rapidly[6]. Between 50 and 90 percent of the existing Northern boreal forests are likely to disappear as a result of a doubling of atmospheric levels of carbon dioxide and other greenhouse gases (expected to take place over the next 30-50 years). This is likely to create abrupt changes in the Earth's climate that would result in severe forest decline[7]. The accelerated rate of climate change caused by the carbon pulse (estimated to be over 70 billion tons of additional carbon into the atmosphere) could cause further carbon release, and hence even more rapid climate change.

III - Climate Change: the Intergovernmental Negotiation Process

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to assess available information on the science of climate change, in particular that arising from human activities.

The IPCC is composed of experts chosen from knowledgeable scientists from all over the world. The last part of the previous sentence is only partially true because in practice, most of the experts that participated in the Second Assessment Report (SAR) in 1995 came from developed countries (the so-called Annex I countries, a list of countries in an Annex to the Climate Convention).

A simple accounting exercise of experts who have undertaken a role in the SAR is presented in the table 1a below. Considering the total amount of convening lead authors, lead authors and contributors in the Working Group I (science), 93.6% came from Annex I countries (64.2% of which were from the United States) and only 6.4% of total experts were composed of third world scientists. Although a larger participation of non-Annex I scientists is achieved in the groups of impacts, adaptation and mitigation and economic and social dimensions, the overall participation presents a similar pattern: the vast majority of scientists represented Annex I countries (85.3%, from which 39.2% were from the USA).

[6] An introduction to simple climate models used in the IPCC second assessment report – IPCC Technical Paper II, February 1997, page 26.
[7] The carbon bomb – Climate change and the fate of the Northern boreal forests. Greenpeace International.

Table 1a: IPCC 1995 SAR experts
Convening lead authors, lead authors, and contributors

IPCC Group	Annex I		USA		Non-Annex I		Total	
I (Science)	335	93.58%	215	64.18%	23	6.42%	358	100%
II (Impacts, adaptation and mitigation)	635	82.36%	181	28.50%	136	17.64%	771	100%
III (Economic and Social)	124	80.52%	33	26.61%	30	19.48%	154	100%
Total	1094	85.27%	429	39.21%	189	14.73%	1283	100%

Table 1b: IPCC 1994 Radiative Forcing of Climate Change
Convening lead authors, lead authors, and contributors

IPCC	Annex I		USA		Non-Annex I		Total	
1994 Report	134	93.71%	85	63.41%	9	6.29%	143	100%

Table 1c: IPCC 1992 Supplementary report to the IPCC Scientific Assessment
Convening lead authors, lead authors, and contributors

IPCC	Annex I		USA		Non-Annex I		Total	
1992 Report	107	90.68%	55	46.61%	11	9.32%	118	100%

This is a serious drawback to the IPCC process because the outcome of the literature review is strongly influenced by the source of information (the vast majority coming from Annex I countries). The political understanding of the current situation of the climate change issue by Annex I scientists is influenced by Annex I governments point of view, public opinion (as perceived by reading newspapers and magazines), and mainstream political trends that formed the tacit knowledge of the scientist. This does not necessarily mean that the result of the process is not correct, but most of the outcome are presented in such a way that "explain" or "emphasize" the underlying view point of developed societies.

If third world scientists do not contribute with their own perspectives of the climate change problem during the negotiation process, the discussion will not spring up from reviewing literature. This can be easily shown by the fact that no attempt has ever been made to estimate the "common but differentiated responsibility", a theme that has never appeared in IPCC literature. Another example of this situation was the extraneous discussion of life value that occurred in the IPCC Working Group 3. The consideration of the "willingness to pay" for life insurance did not take into account the poverty dilemma of "ability to pay" for life insurance in the third world.

For the IPCC Third Assessment Report – TAR it can be imagined that this problem will be repeated again. From 28 nominations of Brazilian scientists only 6 were chosen to collaborate on the literature review process (three Brazilian scientists that had not been nominated by the Government were invited in addition).

Moreover, the IPCC was established in order to assess available scientific information on climate change; assess the environmental and socioeconomic impacts of climate change, and formulate response strategies.

Normally most of the scientific literature assessed is written in English or other languages that can be easily assessed by the experts. This is a drawback to the process in the sense that all scientific literature related to climate change written in languages other than those that can be quickly understood by Annex I experts are not reviewed. The literature on climate change that is not considered under the IPCC review comprises most of scientific literature elaborated in third world countries on this subject. This is mostly important in relation to the objectives of assessing socioeconomic impacts and formulating response strategies because the perspective of the response and impact assessment is strongly related to the point of view of Annex I societies and policy perspective. Another side of the same coin is that most of review documents produced by IPCC are not widely available or assessed in third world countries, because they are mostly available only in English.

The same difficulties are found in terms of producing independent scientific analysis from a developing country perspective.

Most of developing countries do not have capacity to analyze a GCM, or supercomputer facilities to run or develop this type of sophisticated modeling. This is not the case for the most developed among developing countries, including Brazil. Brazil has a very well equipped Center for Weather Forecast and Climate Studies (CPTEC) at the National Institute for Space Research (INPE), running supercomputer models including GCM. The researchers at CPTEC/INPE are developing specific analyses for Latin-America, in close collaboration with the University of São Paulo, another Brazilian center studying and developing GCMs with very good facilities.

The Convention has a different constituency. As the Convention was signed and ratified by the vast majority of countries from all over the world, the Annex I and non-Annex I countries are well represented, despite the fact that lack of financial resources prevent a wider participation of developing countries representatives. The problem with the representation of countries in the Convention process is of a different nature: as the problem is regarded as a political one, diplomats have an outstanding participation in most of delegations.

Another fact is related to the origin of the climate change debate: established by the World Meteorological Organization and the United Nations Environment Program, cosponsors of IPCC, a significant portion of delegations is formed by meteorologists who have been involved and actively participating since the beginning of the climate change debate.

The problem of global warming is in fact related to the climate science and climate long-term forecast. But impacts and mitigation measures are not. Mitigation measures (or inventory preparation) cover different sectors like energy, land-use change and forestry, agriculture and livestock, industry, solvent use and waste treatment, requiring very specific sectoral knowledge.

In the case of vulnerability assessment, different expertise should be involved in areas like human health, human settlements, water resources, coastal zones and marine ecosystems, desertification, food (crops and fishery), agriculture (grassland and livestock), forestry, industry and energy, wildlife, rate of extinction of species, etc. This poses a difficult burden on the Subsidiary Bodies of the Convention, in particular the Subsidiary Body for Scientific and Technological Advice, where scientific themes are to be discussed lacking the appropriate multidisciplinary background.

IV - The Kyoto Protocol

The Third Conference of the Parties to the Climate Change Convention in Kyoto, Japan, resulted in a consensus decision to adopt a Protocol under which industrialized countries will reduce their combined greenhouse gas emissions by at least 5% compared to 1990 levels by the period 2008-2012. This legally binding commitment promises to produce an historic reversal of the upward trend in emissions that started in these countries some 150 years ago[8].

According to Article 25, the Kyoto Protocol will enter into force 90 days after it has been ratified by at least 55 Parties to the Convention, including developed countries accounting for at least 55% of the total 1990 carbon dioxide emissions from this industrialized group.

Article 18 of the Kyoto Protocol states that "the Conference of the Parties ... shall at its first session, approve appropriate and effective procedures and mechanisms to determine and to address cases of non-compliance with the provisions of this Protocol, including through the development of an indicative list of consequences, taking into account the cause, type, degree, and frequency of non-compliance".

Three flexibility mechanisms were established. Two among developed countries, Article 6 (joint implementation) and Article 17 (emissions trading) and one mechanism involving developed and developing countries, Article 12 (clean development mechanism).

The outcome of the Kyoto Protocol, the quantified emission limitation or reduction commitment (as a percentage of base year or period), is the Annex B of the Protocol that established a different commitment for each country.

This outcome was the final agreement reached by Annex I Parties through an "auction" process, each country offering its bid. The European Union offered emission reductions of 8% as compared to 1990 level for the ensemble of nations that constitute the group. Japan offered 6% emission reductions and the United States offered 7% emission reductions. Good dealers got an "emission limitation" bid, actually increasing their emissions, like Iceland increasing its emissions by 10% as compared to 1990 level, Australia increasing by 8%, and Norway increasing by 1%. The Russian Federation, Ukraine and New Zealand offered stabilization at 1990 levels.

It is worthwhile to note that the Russian Federation and Ukraine emitted in 1995 around 50% of their 1990 emission levels. So these "stabilization" bids actually mean that both countries got an allowance for increasing their emissions.

[8] The Kyoto Protocol, UNFCCC, Introduction.

There was no attempt to establish an objective criterion for how to mitigate climate change (by how much and for how long). Also there was no explicit quantification through the whole Berlin Mandate process and discussions in Kyoto of the effort that the overall greenhouse gas emission reduction would represent in terms of decreasing the rate of temperature increase. Actually, the emission reduction or limitation Kyoto targets imply that the mean surface global temperature will continue to increase during the whole period of the Kyoto Protocol until 2012. Amazingly, the emission reduction effort does not imply combating the global warming by Annex I Parties as can be misunderstood by the public in general. It can be very easily demonstrated that the outcome of the Kyoto Protocol, emission reduction for all Annex I countries of 5% in average in the period of five years centered around 2010 as compared to 1990 levels, represents an additional enhancement of the greenhouse effect as compared to the previous (and not legally binding) commitment of developed countries to stabilize their overall greenhouse emissions at 1990 levels by 2000, and maintaining these levels until 2010.

The differentiation criterion developed in Kyoto was the ability of a country to negotiate a better bid and impose acceptance of its bid on the other Annex I countries. Another aspect to be considered is that only the first commitment period was defined, hampering a confidence building process and postponing new debates on how to combat global warming.

In order to establish the rank of responsibility of different countries, an objective differentiation criterion (or criteria) has (have) to be defined in the future. This will be as more urgent as more countries reach high development conditions.

Most of the criteria that were proposed during the process launched by the Berlin Mandate, a two-year negotiation process that led to Kyoto, were defined on an ad-hoc basis with the aim to give some kind of advantage for the proponent country.

Several differentiation proposals were presented during the Berlin Mandate process. These proposals included defined indices in terms of a convenient choice of indicators, like emissions per unit of socioeconomic or physical indicators of the different countries or a combination of these:

- projected population growth, projected real GDP per capita growth, emission intensity of GDP, emission intensity of exports, fossil fuel intensity of exports (Australia)
- net per capita emissions of greenhouse gases in 2000 (France)
- share of renewable energy sources, level of greenhouse gas emissions and GDP per capita (Iceland)
- economic growth of GDP, historical share of greenhouse gas emissions, dependency on income from fossil fuels, access to sources of renewable energy, defense budget, population growth, special circumstances, share in international trade (Iran)
- based either on total emissions, or on emissions per capita (Japan)
- emission intensity, level of greenhouse gas emissions, level of economic development or wealth (Norway)
- GDP per capita, contribution to global emissions, emissions per capita and/or emission intensity of GDP (Poland et al)
- CO_2 equivalent emission per capita (Switzerland)

In a document called "Proposed Elements of a Protocol to the UNFCC, presented by Brazil in response to the Berlin Mandate" [9] five tables illustrate the use of this type of socioeconomic indicators. Looking carefully through those tables it is apparent that the above proposals would normally be very attractive to the proponent countries. In order to unveil the "self-advantage" strategy used by some countries, in the Annex V of this document it was also included one indicator that would obviously favor Brazil (emissions per renewable energy supply)[10]. This would be the favorite indicator for Brazil, being a low CO_2 emitter, regarding the energy and cement sectors, and around 60% of its energy supply coming from renewable energy sources.

There was a difficulty in the choice of the reference indicator to be used, since countries had naturally given preference to the selection of indicators that resulted in a better performance for themselves. This choice would make it possible for them to reach a given target with less effort or less burden on their economies. In addition, all the indicators suggested are, in one way or another, related to the causes of emissions, rather than to their effect[11].

The United States Senate Resolution 98, agreed upon in July 25, 1997, resolved that "the United States should not be signatory to any protocol ... which would mandate new commitments to limit or reduce greenhouse gas emissions for the Annex I Parties", unless "the protocol mandates new specific commitments to limit or reduce greenhouse gas emissions for Developing Country Parties with the same compliance period".

The Senate threat to the USA ratification process poses a challenge to the entry into force of the Kyoto Protocol, using the table of total carbon dioxide emissions of Annex I Parties in 1990, attached to the report of the Conference of the Parties on its Third Session[12], as the criterion for definition of the 55% share of Annex I CO_2 emissions for entry into force as defined in Article 25. In accordance with this table, the United States together with the Russian Federation represent 53.5% of the total carbon dioxide emissions of Annex I Parties in 1990. Therefore, two countries alone may veto the entry into force of the Kyoto Protocol.

The absence of a compliance mechanism defined in the Protocol instead of Article 18 may also cause delays in putting into place emission limitation or reduction mechanisms in Annex I countries thus preventing early action by private companies and governments in general in these countries.

V - The new challenge: an intergenerational problem

Climate change arising from greenhouse gas emissions poses new challenges to the global community due to its unique feature of time dissociation of causes from impacts. The temperature increase resulting from greenhouse gas emissions represents a long-term process that will span over a period greater than a hundred years.

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[9] Proposed Elements of a Protocol to the UNFCC, presented by Brazil in response to the Berlin Mandate, submission dated 28 May 1997, FCCC/AGBM/1997/Misc.1/Add.3.

[10] Proposed originally by Prof. Luiz Pinguelli Rosa, from COPPE/UFRJ, Rio de Janeiro, Brazil.

[11] Brazilian Proposal, reference 9.

[12] Actually, four Annex I countries are missing under the list of CO_2 emissions in 1990: Belarus, Lithuania, Ukraine, and Turkey. Two other countries that have targets in Annex B of the Kyoto Protocol joined Annex I only in 1997, Croatia and Slovenia, and another country, Czechoslovakia, was replaced by the Czech Republic and Slovakia (Decision 4/CP3). In addition, the table shows CO_2 emissions from the energy and cement sectors only.

This characteristic can be better understood when we acknowledge that the current concentration of greenhouse gases in the atmosphere, like CO_2 for instance, is the result of accumulated emissions being released into the atmosphere since the industrial revolution era. The magnitude of the problem causes real concern when we remind ourselves that a portion of the CO_2 emissions (around 13%, according to the Bern carbon cycle model) remains airborne for thousands of years[13].

The Kyoto Protocol included a list of greenhouse gases to be controlled under the Climate Change Convention as its Annex A. This list includes, for the first time, greenhouse gases with very long lifetimes in the atmosphere explicitly, like perfluormethane (50,000 years of lifetime), and perfluorethane (10,000 years of lifetime), the so-called perfluorocarbons. On one hand, the inclusion of these long-lived man-generated gases creates difficulties for understanding some concepts that were developed previously regarding mainly CO_2, methane, and N_2O, as is the case of the concept of Global Warming Potential, which is defined for time horizons of 20, 100 and 500 years. On the other hand, it demonstrates that current emissions do not tell the whole history of climate change because part of current emissions will stay for a long period in the atmosphere.

This long-term time dependence creates a very difficult policy framework under the United Nations Convention on Climate Change in addition to the intrinsic complexity of the physical problem of radiative forcing. There is an intergenerational problem both in regard to the responsibility for causing the global warming problem as well as concerning policies and measures to be undertaken to combat the adverse impacts of climate change.

The intergenerational problem arises from the very fact that the generation that causes the problem will not suffer the consequences of its actions. On the other hand, the generation that will bear the burden of changes in climate was not responsible for causing those climate disturbances and will be forced to adapt to a new climate, likely to be very different from the present climate eventually. This is a direct consequence of the inertia of the climate system: the effects of greenhouse gas emissions will be completely realized only two centuries after the release of the gas.

The same problem arises in terms of policies and measures to combat climate change. The current governments of all nations are overwhelmed by short-term problems. They can not take into consideration appropriately the welfare of future generations in their current decisions, although in the last paragraph of the Convention it is said that the Parties are "determined to protect the climate system for present and future generations". The ideas of sustainable development are to be implemented in the future. Some of these ideas are quite future, abstract, and revolutionary ideas, requiring changes in technology and consumption patterns that are difficult to be put into practice as compared to urgent, real, and concrete financial, employment, shelter, health care and educational daily problems. In addition, most of developing countries governments face the problem of poverty eradication.

The intergenerational problem and its no-action and "wait and see" consequences is left unfolded during the negotiations. One way to uncover it is to explicitly identify the responsibility of current nations and governments and how they are committing future welfare of mankind.

[13] Climate Change 1995, IPCC Technical Summary of the Working Group I, WMO, UNEP, page 20.

Another problem that is not taken into due account is that no attention is paid for the future commitment in terms of mean surface temperature increase or mean sea level rise represented by current greenhouse gas emissions.

VI - The North-South Antagonism

The Convention is based upon two principles that correspond to a soft law (or *jus cogens*) that have a normative character as countries adopt these principles as political and moral commitments to be respected in good faith.[14]

The first one is the precautionary principle stated as "The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost".

The second and most important principle is the principle of common but differentiated responsibilities. The preamble of the Climate Change Convention acknowledges that "change in the Earth's climate and its adverse effects are a common concern of humankind" and that "the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions"[15]. It is also noted that "the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs"[16].

The responsibility is common because the greenhouse gases are completely mixed in the atmosphere in around two weeks and therefore it is not possible to attribute emissions directly to individual countries that have originated them. It is impossible to identify from the atmosphere where greenhouse gas emissions came from because of the large number of greenhouse gases and sources. Furthermore, the responsibility is differentiated because some countries have more responsibility for causing the global warming than others. For instance, even if we consider only two developed countries like France and Monaco, there is no doubt that France has more responsibility than Monaco for causing the greenhouse effect. Along the same lines, but taking into account two developing countries like Brazil and Haiti, there is no doubt that Brazil has more responsibility than Haiti for causing global warming[17]. This is due to differences in size, population, and level of development, in other words the level of anthropogenic interference with the climate system.

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[14] Direitos Humanos e Cultura: a Contribuição da Unesco nos anos 90, Candeas, Alessandro W and Candeas, Ana Paula L. S., in Boletim da Sociedade Brasileira de Direito Internacional, Ano LI nº. 113/118.
[15] Climate Change Convention, Preamble, first and sixth paragraphs.
[16] Climate Change Convention, Preamble, third paragraph.
[17] Meira Filho, L. G. , speech in FIESP, São Paulo, Brazil, 1/20/99.

The Climate Change Convention acknowledges this principle and states that "the Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof". The developed countries have voluntarily adopted this commitment to take the lead to combat climate change. This is reflected in the Annex I commitments: only developed countries have accepted the commitment of limiting their anthropogenic emissions of greenhouse gases with the aim of returning individually or jointly to 1990 levels the anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol. The developed countries recognized that the return by the end of the present decade to earlier levels of anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol would contribute to modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention.

Nonetheless, the differentiation is not clear and therefore not broadly accepted, because it is loosely defined how the developed or developing countries are chosen, and based upon which criteria. The Convention lists the developed countries as Annex I. This list was formed putting together OECD countries and the industrialized countries of Eastern Europe and Former Soviet Union. This simple selection criterion created difficulties for some countries like Turkey that was an OECD member, although its development level was still lagging behind most OECD countries. The inclusion of new developing countries as OECD members, like the Republic of Korea and Mexico, and probably Argentina in the near future, countries that are not listed in Annex I and are not willing to accept the burden of developed countries commitments, deepen the difficulties of establishing differentiation criteria.

Moreover, this policy framework generates a new north-south antagonism.

Developing countries argue that the main industrialized countries are historically responsible for causing the change in climate. This is recognized in the preamble of the Convention where it is noted that "the largest share of historical and current global emissions of greenhouse gases has originated in developed countries". The industrialization process starting for some developed countries during the industrial revolution implied large amount of carbon emissions from fossil fuel combustion since the end of the eighteenth century and beginning of the nineteenth century.

The developed countries were responsible for 75% of CO_2 emissions from fossil fuel combustion in 1990. OECD countries were responsible for 62% of these Annex I CO_2 emissions. Furthermore, it is estimated that emissions from OECD Annex I members will be about 5% and 13% above 1990 levels in 2000 and 2010 respectively[18]. Aggregate emissions of greenhouse gases from Annex I countries as a whole are projected to be approximately 3% below 1990 levels in the year 2000 and about 8% above 1990 levels in the year 2010. This is a consequence of the fact that emissions in countries with economies in transition (industrialized countries from Eastern Europe and Former Soviet Union) will be about 24% and 7% below 1990 levels in 2000 and 2010 respectively, but because of economic depression in these countries, not as a result of mitigation measures.

[18] Review of the implementation of commitments and other provisions of the Convention, Second compilation and synthesis of second national communications of Parties included in Annex I, FCCC/CP/1998/11, Fourth Conference of the Parties, UNFCCC, 1998, Projected levels: 2000 and 2010, pages 7/8, in particular, footnote 10.

In addition, it is also noted that "per capita emissions in developing countries are still relatively low" due to the industrialization process of developing countries that started in the middle of the twentieth century.

The Climate Convention also acknowledges that "the extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology and will take fully into account that economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties".

On the other hand, developed countries argue that greenhouse gas emissions from fast developing key countries will equal the emissions from developed countries in some point in time between the years 2020 and 2030 in accordance with IPCC scenarios. This is also noted in the text of the Convention – "the share of global emissions originating in developing countries will grow to meet their social and development needs".

The US Senate Resolution states further that "whereas the Convention intended to address climate change on a global basis, identifies... the remaining 129 countries, including China, Mexico, India, Brazil, and South Korea, as "Developing Country Parties"; ... the Berlin Mandate specifically exempts all Developing Country Parties from any new commitments in such negotiation process for the post-2000 period; ... that it is critical for the Parties to the Convention to include Developing Country Parties in the next steps for global action; ... the exemption for Developing Country Parties is inconsistent with the need for global action on climate change and is environmentally flawed".

This debate creates an impasse with developed countries looking to the future and forgetting past emissions and developing countries looking to the past, but concerned with their own future emissions. These concerns of developing countries are sometimes referred to as a new form of "environmental colonialism" by developed countries or expressed by means of preoccupation with ISO 14,000 regulations or green labels requirements, or concern with transfer of high emission technology to developing countries. Most of these concerns arise from economic reasons and concerns with unemployment in both groups of nations.

Another way of looking to this conflict is through the dialectic arguments. Developed countries are concerned with the "explosive population growth" that is occurring in developing countries and developing countries are concerned with "unsustainable patterns of consumption" in developed countries[19].

The outcome of this antagonism is that, despite the precautionary principle, little or no action is taken to combat climate change.

VII - Emissions: the Current Paradigm

The Climate Convention is based on emission accounting by means of inventory reporting by each country of its anthropogenic emissions by sources and removals

[19] Meira Filho, L. G. , personal observation.

by sinks of all greenhouse gases not controlled by the Montreal Protocol. This is the basis for all policies and measures established in order to mitigate climate change. The use of country emissions as the main indicator in the Convention can be due to two main reasons. First, policy makers can only have some level of control and establish regulations over anthropogenic emissions (or at least part of them). Therefore all targets are established in accordance with emissions for some base year (like 1990 for developed countries and 1994 for developing countries inventories).

Second, in urban atmospheric pollution or water contamination, actual emissions have been used as a measure of the responsibility of polluters. Such procedure is justified by the fact that, when the residence time of the pollutant is relatively short, the concentration of the pollutant is proportional to the emission[20]. The detrimental effects are related to the concentrations of (short-lived) pollutants and therefore the emission is a valid measure of the effect to be mitigated. This is not the case for the climate change problem because of the long-lived greenhouse gases.

These considerations highlight the problem of regarding anthropogenic emissions of greenhouse gases as the central issue in the climate change debate.

The problem of choosing a base year has two policy implications in addition.

First, countries that were very efficient in the past, like Japan, with well-known energy conservation programs that lowered the consumption per capita of fossil fuels, do not have their efforts recognized and these efforts are not taken into account. Along the same lines, countries, like Norway, that generate the vast majority of their electricity through hydroelectric power plants have hard times discussing reduction targets (they are already very "clean" in the strict sense of greenhouse gas emissions). In this sense, countries like Norway are punished for being "cleaner" because it will be more difficult for them to reduce emissions in the remaining emission sectors than a similar large emitter country with several sources of high greenhouse gas emissions.

The second implication is that countries tend to choose a convenient base year in accordance with some national strategy. This can be done in both directions, hiding emissions in order to show that the country is not a big emitter and negotiate some kind of handicap. A different strategy used by some countries is to inflate the base year emission in order to lower the cost of achieving an emission reduction target. Some Annex I countries have used this strategy, considering imports of electricity generated by hydroelectric power plants as being produced by an equivalent internal mix of coal-fired power plants or stating that the winter was hotter than previous years and for this reason adjusting "actual" greenhouse emission for an average winter temperature.

In the Brazilian case, the 1994 base year for the preparation of the national inventory of greenhouse gases, established by the Second Conference of the Parties in Geneva, Switzerland in 1996, can be regarded both as beneficial or prejudicial to the establishment of hypothetical targets along the same lines. Beneficial because the deforestation process in Amazonia had a local minimum considering the 1985-1996 period and this low circumstantial deforestation emission would imply a decrease in Brazilian total emissions and Brazil would not be a large emitter. Prejudicial because the emissions in the energy sector were also very low in that year. This was a

[20] Brazilian Proposal, reference 9.

conjunction of a large share of hydroelectric generation in the power sector and high use of ethanol fuel in the transportation sector. This fact would represent low emissions in the base year and a greater difficulty reaching hypothetical future limitation targets.

As pointed out before, the choice of base year and consequent high or low emission starting point for emission reduction or limitation target objectives has a clear policy implication. This can be illustrated by the joint implementation (JI) dilemma. If a developing country starts a new emission reduction project it will be double punished. The developing country would have a lower base for an eventual emission based target (increasing its difficulty to achieve an hypothetical target) and it would have implemented lower cost projects (and sold this emission reduction) and all projects remaining to be implemented (at its own expenses) would have higher costs. This was the main reason of the complete failure of JI programs. There was no incentive for early action, but punishment.

This choice of a convenient base year is completely irrelevant from the perspective of the atmosphere, both in terms of causing or solving the problem of climate change, but is recurrent in this debate and in the Climate Change Convention. For the atmosphere, early action would reduce emissions or would foster enhancement of sinks, decreasing future levels of greenhouse gas concentrations and contributing to mitigate climate change. The policy choice of using emission as basis for the Climate Change Convention is not contributing to solving the global warming problem from the perspective of the atmosphere.

VIII - Building a new Paradigm

The necessity of changing from the annual emission basis to another indicator that could better reflect the global warming problem has been presented by Prof. Luiz Gylvan Meira Filho, representative of the Brazilian Ministry of Science and Technology. He had spoken several times on behalf of the Brazilian delegation in meetings of the Convention from 1992 to 1996. His idea was that building upon the outcomes of a General Circulation Model, it would be possible to establish a very simplified model (even simpler than the box diffusion model) that would take into account all the essence of the global warming problem. This model should be based upon the essential description of the problem, skipping irrelevant details, and describing the relationships of greenhouse gas emissions and climate change. The parameters for this essential modeling should be adjusted by using the results of supercomputer models, ensuring that all complexities of AOGCMs were duly taken into account.

In a first approximation, the dependence of the atmospheric concentrations upon the emissions over a given period of time is proportional to the accumulation of the emissions up to the year in question. It is necessary to take into account that the older the emission the smaller its effect on the concentration, because of the exponential natural decay of the greenhouse gases in the atmosphere with a different lifetime for each gas[21].

[21] Brazilian Proposal, reference 9.

The physics of the radiative forcing indicates that the rate of deposition of energy on the surface, that is, the warming itself, is proportional to the concentration of the greenhouse gas. The constant of proportionality is different for each gas (1 for carbon dioxide, 58 for methane, and 206 for nitrous oxide, for the present level of concentrations, with respect to carbon dioxide)[22].

The increase in global mean surface temperature is roughly proportional to the accumulation over time of the radiative warming. The radiative warming is, in turn, proportional to the atmospheric concentration of the greenhouse gas. It follows that the temperature increase itself is proportional to the accumulation of the atmospheric concentration of the greenhouse gas[23].

It was recognized that this was a first approximation to solving the problem: "in reality, the above statement is only approximately true, in view of the non-linearities of the system and the existence of other mechanisms such as the delay introduced by the dissipation of heat into the oceans through advective and diffusion processes"[24].

The idea was to demonstrate that a very simple calculation scheme can be used in lieu of the complex climate models, while still maintaining the correct functional dependence of the increase in mean surface temperature upon the emissions over a period of time[25]. This is a very interesting aspect because with such a tool it would be simpler to analyze several different scenarios using simple models that still keep the accuracy of the GCMs without being necessary to resort to supercomputers. This proposal addresses the central question of the relationship between the emissions of greenhouse gases by Parties over a period of time and the effect of such emissions in terms of climate change, as measured by the increase in global mean surface temperature.

In the perspective of the Brazilian Government, international negotiations were leading to several conflicting ideas, as explained before, because of different factors. The focus of the discussion was trying to involve developing countries to share the burden of mitigating climate change.

Discussions so far have been misleading because it has been repeatedly reaffirmed that developing countries would account for the same amount of developed countries greenhouse gas emissions between 2020 and 2030, according to IPCC scenario IS92a. This was stated, for example, in the US Senate Resolution "greenhouse gas emissions of Developing Country Parties are rapidly increasing and are expected to surpass emissions of the United States and other OECD countries as early as 2015". An USAID document on Climate Change[26] also states that "Developed nations currently contribute with approximately 73% of anthropogenic emissions of carbon dioxide. ... Despite the current disparity, the growth in emissions from developing nations is accelerating. The current rate of increase in carbon dioxide emissions from developing nations is approximately 6 percent per year. If current growth trends continue, developing nations will account for half of annual greenhouse gas by 2035".

Although it is a future estimate of greenhouse gas emissions, therefore embodying all uncertainties related to forecast, the main problem with this kind of conclusion is

[22] Brazilian Proposal, reference 9.
[23] Brazilian Proposal, reference 9.
[24] Brazilian Proposal, reference 9.
[25] Brazilian Proposal, reference 9.
[26] Climate Change Initiative 1998-2002, USAID, page 12.

that it is based upon annual emissions. Emissions, as the cause of the problem, do not correspond to the responsibility for causing climate change. Responsibility has to be associated with the effect of emissions in terms of global warming.

The responsibility of both groups (Annex I/non-Annex I) of countries under the Convention has never been estimated in terms of temperature increase. This is a natural consequence of the focus on annual emissions in the negotiations. The same aspect has also been neglected in the IPCC negotiations and therefore the differentiated responsibility has never been discussed in IPCC documents so far.

Another recurrent discussion has been the establishment of the 1990 base year for all countries under the Convention as a way to establish a division-line for country's responsibility. Before 1990, the nations were not aware of the problem and so they could not be blamed for causing a problem they did not know. Under this rationale, countries should be responsible for their actions in terms of greenhouse gas emissions only after 1990. This kind of argumentation was aligned with the political point of view of developed countries: forgetting the historical emissions and leveling the playing field as related to new industrializing countries (with high emissions in 1990), keeping an equal ground for trading competitiveness. This would correspond to forgetting that new industrialized countries have only started their industrialization processes thirty or forty years ago and that the increase in temperature is a double accumulation process.

Moreover, there has also been an attempt to involve developing countries in joint implementation projects. This kind of mechanism appeared from the word "jointly" written in Article 4.2.a of the Convention referring to Annex I Parties commitments ("these Parties may implement such policies and measures jointly with other Parties"). The wording clearly refers to Annex I Parties implementing projects among themselves jointly. However, the new interpretation has been adopted by Annex I Parties to enhance the scope of the original idea and involve developing countries in order to obtain their extraneous participation in the global effort against the spirit of the Convention. The idea was that early action by developing country would assist in achieving the Convention ultimate objective of greenhouse gas concentration stabilization.

This joint implementation idea was perverse in the sense that it would create a new form of debt – an environmental debt. Annex I Parties would implement projects in non-Annex I countries keeping part of the credits for the emission reductions and the non-Annex I Parties would not be allowed to account for such emission reductions in their inventories. This would create a future problem when developing countries would commit themselves to binding commitments. They would have sold their less expensive reduction opportunities of emission reduction projects (and would then have created a debt to be paid back in terms of emission reductions in the future). However, they would bear the burden of further reducing emissions through the implementation of more expensive projects in case they eventually committed themselves to emission reduction or limitation targets. Moreover, it would be counterproductive in terms of early action because if countries were to implement many of such projects their emissions would be lower as compared to 1990 emission levels. Therefore, it would be more difficult to meet future targets of greenhouse gas emission reduction eventually, creating a disincentive for early action. Finally, there would be little, if any, incentive to transfer of technology in this type of "cooperation" agreement.

This was perceived by the Brazilian Government as a means for transferring the burden of mitigation from Annex I to non-Annex I countries. It is important to note that non-Annex I countries are being obliged to take actions on emission reductions by the implementation of non-tariff regulations like ISO 14,000 or measures like green labels and consumer boycott.

Because of all these aspects and considering the complexity of climate change science, the Brazilian Government decided to present a formal document[27]. The idea was to present a developing country viewpoint and put in perspective all aspects of the climate change debate that were not very well considered, according to the Brazilian Government, neither by IPCC reviews or IPCC plenary discussions nor in the Convention meetings.

IX - The Brazilian Proposal

The Brazilian document entitled "Proposed elements of a protocol to the United Nations Framework Convention on Climate Change, presented by Brazil in response to the Berlin Mandate" submitted in May 1997, presented two elements for the discussion regarding the Berlin Mandate process. The first element was to establish the responsibility of individual countries in terms of causing the greenhouse effect. The second element established the idea of a Clean Development Fund to replace the unpopular concept of joint implementation at that time and to break the impasse between North-South that was growing during the process. The quantification of the principle of common but differentiated responsibilities was one of the subjacent and basic aims of the proposal.

The first problem faced when writing the proposal to change from causes (emissions) to effects (global warming) was the establishment of an objective criterion to measure climate change.

It becomes therefore of central importance to establish the relationship between the net anthropogenic emissions and the resulting change of climate. Whereas it is recognized that the change of climate is predicted to have a complex geographical distribution, it is important to have a unique measurement of the global climate change[28].

The obvious choice of a unique variable to measure climate change is the change in global mean surface temperature. Other global variables, such as the time rate of change of the global mean surface temperature and the rise in mean sea level, are derived from the change in global mean surface temperature[29].

This criterion is closely connected to the physical reality of the greenhouse warming, a property not applicable to the absolute emissions, these being an instantaneous "snapshot" of a situation for an arbitrary calendar year. Furthermore, the global mean surface temperature can be used as an indicator of global warming and the attribution of individual country responsibility can be stated in terms of its individual contribution relative to total temperature increase. This individual contribution

[27] Brazilian Proposal, reference 9.
[28] Brazilian Proposal, reference 9.
[29] Brazilian Proposal, reference 9.

to global mean surface temperature increase weights differences among countries in terms of starting points (e.g. 1990) and approaches, economic structures and resource bases, the need to maintain strong and sustainable economic growth, available technologies and other individual circumstances, as stated in Article 4.2.a of the Climate Change Convention.

The change in temperature is also an objective measure of climate change, for it can be argued that the detrimental effects of climate change hold some sort of proportionality to it[30].

It is to be noted that the uncertainties remaining in the present knowledge of the absolute value of the predicted temperature change do not affect the conclusions about the relative contribution of countries. This is reflected, for instance, on the margin of uncertainty in the climate sensitivity (the change of temperature resulting from a doubling of the carbon dioxide concentration is known to be within the range of 1.5 to 4.5 degrees Celsius). Future improvements of the complex models, as the uncertainties are progressively decreased, can be easily incorporated by updating the calibration constants of proportionality in order to improve the accuracy of the absolute results through the incorporation of the best available scientific knowledge, without prejudice to relative contribution adjustment[31].

The choice of the global mean surface temperature indicator as a proxy to define global warming permits the formulation of a model to analyze the responsibility of individual countries. The core of the model corresponds to a double accumulation process that is the essence of the global warming. The accumulation of emissions increases concentrations and for each annual level of concentrations, the accumulation of radiative forcing increases (global mean surface) temperature[32].

The current concentration of greenhouse gases in the atmosphere is the result of past emissions, since the industrial revolution (period post-1750). The current generation is bearing the burden of effects of previous interference with the climate system resulting from human activities during the last two centuries mainly in developed countries. The same argument can be used to reflect that current human activities all over the world will impact the future climate during the next two centuries.

Reconstructing the series of anthropogenic greenhouse gas emissions by sources and removals by sinks in all sectors in the past allows the calculation of the relative share of total temperature increase attributable to an individual country. Hence, the estimation of the relative responsibility of a given country for causing global warming can be estimated even under the current uncertainty of the absolute temperature increase attributable to the greenhouse effect alone.

This proposal provides a means to measure objectively the relative responsibility of each Party or each group of Parties in producing climate change. Given the fact that the Convention contains the all-important principle of a common but differentiated responsibility, it provides an objective criterion for the differentiation of responsibilities.

Furthermore, it provides a means to quantify the relative responsibility of developed countries with respect to developing countries as a result of their contribution to

[30] Brazilian Proposal, reference 9.
[31] Brazilian Proposal, reference 9.
[32] Notes on the time-dependent relationship between emissions of greenhouse gases and climate change, Meira Filho, L. G. and Miguez, J. D. G., in press.

the atmospheric concentrations of greenhouse gases by the time the Convention was negotiated[33].

An evaluation of the relative responsibility of Annex I versus non-Annex I countries over the period extended to the year 2200 was performed using this simplified approach, taking into account the concentration in 1990 estimated to be attributable to those two groups of countries.

Published historical data on CO_2 energy and cement sector emissions for every country for the 1950-1990 period have been used[34], in conjunction with a backward extrapolation into the period preceding 1950, to estimate the atmospheric concentrations in 1990 attributable to Annex I and non-Annex I countries, for illustration purposes[35].

The effect of the emissions of the other greenhouse gases was not considered, because of lack of available data. However, this effect is known to be small in comparison with that from carbon dioxide, according to the IPCC Second Assessment Report. In addition, the relatively short lifetime of methane in the atmosphere tends to decrease the importance of historical emissions of this gas. For these reasons, the carbon dioxide emissions from the energy and cement sectors are likely to be a sufficiently good proxy for the estimation of the global mean surface temperature increase for the purposes of evaluating the relative responsibility of Annex I and non-Annex I countries[36].

It is interesting to notice that, whereas the annual emissions of non-Annex I countries are estimated to grow to be equal to those of Annex I countries by 2037, according to the IPCC IS92a scenario, the resulting change in temperature because of greenhouse gas emissions attributable to non-Annex I countries are estimated to equal that of Annex I countries in 2147.

This double accumulation process (from emissions to concentrations, and from concentrations to temperature increase) creates a time lag between emissions and temperature increase of more than 100 years[37]. Approximately, there is an inertia of around 50 years from emissions to concentrations (due to long-lived gases) and another inertia of around 50 years from concentration (radiative forcing) to temperature increase (because of long-time steady state adjustment of the climate system).

Another important result was the estimation that whereas the non-Annex I (developing countries) 1990 emissions correspond to 25% of global anthropogenic greenhouse gas emissions, the non-Annex I relative share of the temperature increase in 1990 corresponds to only 12% of global (mean surface) temperature increase.

Both conclusions demystify the relevance of the debate on which year Annex I and non-Annex I emissions will be the same, because in this hypothetical year the responsibility for causing global warming will still be attributable by a large share to Annex I countries.

[33] The estimation of initial concentration for each individual country in 1990 can take into account the differences in starting points of each individual Parties as stated in Article 4.2.a of the Climate Convention.
[34] These data were obtained from the Oak Ridge National Laboratory (USA). This is a comprehensive and very well done data collection. The present available data set was enhanced after the submission of the Brazilian Proposal. See the site on the Internet http://cdiac.esd.ornl.gov/
[35] Brazilian Proposal, reference 9.
[36] Brazilian Proposal, reference 9.
[37] Brazilian Proposal, reference 9.

This was a powerful answer two months prior to the submission of the US Senate Resolution. It is important to note that the Brazilian proposal was submitted to the Climate Convention Secretariat in May 1997 whereas the Senate Resolution was agreed in July 1997. This argument provided also support for the agreement reached at the Berlin Mandate. The aim of the Berlin Mandate was the strengthening of the commitments in Article 4.2(a) and (b) of the Convention for developed country and not to introduce any new commitments for Parties not included in Annex I.

It is worthwhile noting, according to the estimations performed for illustration purposes in the Brazilian proposal, that the relative responsibility of Brazil in terms of causing global warming would be around 0.4% in 1990. Even if Brazil had established a very expensive (and likely to be unfeasible) policy for preventing carbon dioxide emissions in the energy and cement sectors, Brazil would only contribute with 0.4% to the solution of the global warming problem!

The second element established by the proposal was the idea of a Clean Development Fund in order to replace joint implementation. It was envisaged that this fund could be a way to break the impasse of little action by fostering technology transfer and providing the financial resources needed by developing countries to actively contribute to mitigate climate change.

It should be noted that instead of establishing emission limitation or reduction targets based upon emissions related to a base year like 1990, the adoption of a criterion of relative contribution to temperature increase would be pro-active. The adoption of targets based upon temperature increase caused by individual countries in a time period and proportional to the relative contribution of the country to causing global warming would be beneficial to foster the implementation of mitigation projects. This would also contribute to early action by all countries (they would be decreasing their relative present and future responsibility) and countries would not be penalized for being "cleaner" in the past (e.g. Brazil, Norway, Iceland, Sweden, and also Japan as previously explained). If countries start developing projects to mitigate, even in the case they are not obliged to, the development path would occur in a cleaner way. In this context "cleaner" means "less intensive in greenhouse gas emissions". Therefore, cleaner countries with early action would receive a clear incentive (despite recognition for action by their own society) for decreasing their relative responsibility in terms of eventual future emission reduction or limitation targets.

X - How to break the impasse

The current debate creates an impasse because of the lack of adequate criterion for measuring the relative responsibility of individual countries for causing global warming. Moreover, the misleading perception that the concept of temperature increase is very complex as a substitute for the traditional use of emissions as the basis for establishing country's responsibility contributes to this impasse and is leading to a deadlock. Developed countries are looking to the future (the year when emissions will be equal to those of developing countries) and forgetting their past emissions, which are really causing the current global warming. Developing countries are looking to the past (to the historical emissions of developed countries), but concerned with their development needs and their own future emissions.

The idea proposed by Brazil was to break the impasse by establishing a fund that would allow developing countries to join developed countries in the common effort of combating climate change. It is recognized that the difficulties are overwhelming for developing countries because of lack of financial resources and technology. The idea of the fund would create the necessary conditions for global action on climate change.

The basic idea was to create a penalty for the non-compliance of developed countries targets. The penalty was proposed to be based upon additional temperature increase attributable to an individual country that had failed to reach the established emission reduction or limitation target. The fine would be expressed in terms of US$ per degree Celsius of additional temperature increase. It should be noted that in the Protocol approved in Kyoto no criterion was established to quantify the emission reduction or limitation target in terms of temperature increase avoided.

The financial resources of the clean development fund would be made available to non-Annex I Parties for use in climate change mitigation and adaptation projects according to guidelines to be established in the Convention. It was also proposed that the portion of the fund allotted to climate change adaptation projects should be bounded by a small percentage of available funds, clearly defining a priority use of the financial resources for mitigation projects.

The establishment of a special destination for part of the fund was conceived in order to support the efforts of the least developed countries to adapt to climate change. If the sea level rises, developed countries like the Netherlands will have to cope with the problem, but they would be in a better situation than least developed countries. The most vulnerable countries among them, like Bangladesh, will have no safeguards or financial or technological resources for adapting to a rise in the sea level. Therefore the basic idea was to provide a support to the least developed but most vulnerable countries.

The idea of establishing penalties for non-compliance would have two practical implications. First, if all Annex I countries complied with their commitments there would be no reason for a complementary action by developing countries and no penalty would be charged. Otherwise, for the achievement of the overall Annex I target, complementary actions by developing countries would be necessary and the financial resources and technology would be automatically obtained by the intrinsic mechanism established by the existence of the penalty in a cost-effective manner. It would be possible to rank mitigation projects according to the amount of greenhouse gas emission avoided per US dollar invested.

Second, it would break the impasse established by the alleged lack of emission reduction commitments by developing countries. The fund would allow early action by developing countries voluntarily and would not create any burden regarding future environmental passive in terms of emissions to be paid back as in the idea of "joint implementation" projects.

Another aspect to be considered as an interesting consequence of a fund proposal is the ability to prove if the alleged motivation for a "joint implementation" project - that emission reduction projects in the third world are less expensive - would be confirmed. This has not been analyzed yet. Because of "joint implementation" drawbacks only few projects have actually been implemented (50% of which located in Costa Rica). Also, because of a flawed project certification process, "joint implementation" allowed very cheap projects for "conservation" of native forests (not an anthropogenic sink and therefore not in accordance with the spirit of the Climate Convention) with almost no need for investment. It is left for a future proof if the marginal costs of emission reduction projects for large amounts of emission reductions are really as cheap in developing countries (likely to be correct only for some countries, like China and India) as alleged by some developed countries.

The penalty idea is not a new one. It was applied in the United States of America in the case of SO_2 reductions. There was the establishment of an overall SO_2 reduction target for most utilities in the US and a penalty system was established for non-compliance. The fine was defined as 5 times greater than the average cost for the reduction of 1 ton of SO_2 in the industry. Different from the Kyoto process, the plan for SO_2 reductions in the US established two future commitment periods, with decreasing targets in the future, creating a clear sign for further reductions in the future.

The United States had some objections to the idea of a clean development fund. There were two main reasons for that. First, the idea of a fund would be confused with the idea of using budgetary funds for developing countries assistance. The establishment of fine for non-compliance would also be interpreted as a very dangerous precedent in an international treaty. Second, it was a common feeling that the idea of fund as associated with budgetary resource would not create incentives for an energetic action by the private sector of developed countries. This was the basic aim of the idea of "joint implementation" projects: a direct implementation of projects by a developed country company in a developing country with the least control possible and little or no regulation or certification.

The ideas of the United States government were discussed in Rio de Janeiro and a common proposal embodying the concerns of both sides was envisaged. The original idea of a fund was modified and transformed into a clean development mechanism during these negotiations and improved during the sessions of the Conference of the Parties in Kyoto involving other interested Parties. The mechanism was finally approved in Kyoto and adopted as Article 12 of the Protocol.

The idea of penalty was stated in the text of the Protocol as "the purpose to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3". Developed countries would not pay a fine for non-compliance but "use the certified emission reductions accruing from such project activities to contribute to compliance".

As expressed by a Brazilian delegate during the discussion, this rhetoric debate of not allowing the inclusion of a penalty idea in the Protocol was analogous to discussing whether a glass half-full of water is actually "half-full" or "half-empty".

The idea of the clean development mechanism is still embryonic. It has to be further discussed and improved. But it causes concern that some experts are misunderstanding the idea of the clean development mechanism as "joint implementation". As noted before, there is no environmental passive established by the mechanism as opposed to the "joint implementation" idea. This can be very easily verified through the comparison of the symmetrical clauses of Article 3.10 and 3.11 related to "joint implementation" by Annex I countries and the sole clause of Article 3.12 for the clean development mechanism. Furthermore, there is no idea of a project to be implemented jointly by two countries. The basic idea of the clean development mechanism is associated with its origins. The mechanism is associated with the ideas of penalties and of voluntary projects by developing countries if and only if financial funds and technology are available. This can be translated into a clear separation of the emission reduction certificate (a financial asset) from the actual implementation of the project. For example, the Brazilian National Economic and Social Development Bank could invest in several emission reduction projects with its own financial resources and sell emission reduction certificates in the market. There would be no "joint implementation" at all.

Moreover, the mechanism is a clear incentive for early action not penalizing the developing countries that opt for contributing to combat climate change. Building projects under the mechanism, a developing country will decrease the rate of increase of its greenhouse gas emission following a cleaner development path and contributing to mitigate (to make less severe) climate change.

It is worthwhile noting that if the global mean surface temperature increase criterion for measuring climate change is adopted by the Convention, developing countries will be awarded a decrease in their future responsibility for causing global warming, as a result of early action. This feature is closely linked to the physics of the greenhouse effect. As pointed out before, this would not be the case if emission reduction or limitation targets were established in terms of a base year emission level.

Last but not least, the adoption of the temperature increase as a criterion for sharing the burden of mitigating climate change anticipates a future global solution. If all countries are to be involved in the common and global effort of reducing future temperature increase it is unlikely that the "auction" process adopted in Kyoto will be effective. A permanent and steady solution for all countries has to be based upon a criterion that associates an overall emission reduction target for the mitigation of global warming measured in terms of the aimed decrease in global mean surface temperature. The climate change mitigation effort for each individual country will then be established in proportion to its responsibility in causing the greenhouse effect.

XI - The Road Ahead

Several criticisms have been raised in relation to the Brazilian proposal in the initial discussion undertaken in Subsidiary Body for Scientific and Technological Advice - SBSTA. Most of them were desires for better modeling the essence of the greenhouse effect that have been pointed out previously in the text of the Brazilian proposal[38] and can be easily taken into consideration[39]. Examples of these improvements are a better consideration of time dependence of climate adjustment, and consideration of non-linearities related to radiative forcing in terms of actual concentration levels of the different greenhouse gases in the atmosphere. The review work of the Brazilian proposal being elaborated will also discuss the definition of Global Warming Potential and its appropriate use.

Other type of complaints were related to the sole use of energy and cement data for the illustration analysis presented in the Brazilian submission to the Berlin Mandate

[38] See reference 24

[39] See reference 32.

process, mainly because of lack of data on CO_2 emissions attributed to deforestation and data on methane and nitrous oxide emissions. As pointed out previously, the justification for this procedure was the lack of time for a detailed data survey.

So apart from the difficulty of data gathering and performing computer calculations, it is likely that the result of this calculation will not change the conclusions of the Brazilian proposal in terms of countries' relative responsibility. Of course this statement should be confirmed by proper calculation.

It was argued that the Brazilian responsibility would be increased if deforestation were duly considered. This argumentation forgets that the proposal establishes the relative responsibility of countries based on historical anthropogenic greenhouse gas emissions. The deforestation process has also occurred in most developed countries from seventeenth to nineteenth centuries and the Brazilian process of Amazonian occupation and population migration has only started in 1970. A recent study carried out by the World Resources Institute[40] tried to improve the calculations done in the Brazilian proposal to calculate the relative responsibility of Annex I and non-Annex I groups in terms of concentrations attributable to both groups of countries (not temperature increase) taking into consideration deforestation data. It should be noted that in this document it is said that "the amount of CO_2 added to the atmosphere from changes in land use ... is mostly attributable to releases from developing countries". Then it is said in addition that "part of the reason... is that deforestation occurred in the developed world earlier and that carbon has now been removed from the atmosphere". This is not correct taking into consideration the fact that in accordance with the Bern model of carbon cycle 13% of the CO_2 emitted remain airborne for thousands of years. This fact has an important consequence not duly taken into consideration: the developed countries are still responsible for a significant part of the temperature increase caused by their deforestation long ago.

Anyhow, the Brazilian proposal was just a first step into clarifying the debate of the greenhouse effect. A process is being developed under the Subsidiary Body for Scientific and Technological Advice to consider the Brazilian proposal and Brazil has in addition offered to host a workshop to further discuss these issues in March 1999. Several countries have also established groups of scientists to analyze the new approach proposed. Much work has to be done in order to raise consensus in a metric for climate change that considers at the same time equity and responsibility and is widely accepted by all countries.

[40] Contributions to climate change: Are conventional metrics misleading the debate?, Austin, D. , Goldemberg, J., and Parker G., in Climate Notes, October 1998, World Resources Institute.

Climate Change: Specific Research Issues in the Tropical Area for Developing Countries

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I - Introduction

Developing nations are faced with some important scientific challenges related to origin of climate change induced by anthropogenic sources and their impact on human activities. The following points deserve special attention:

(a) Effect of aerosols and gases produced by biomass burning;

(b) Carbon balance and the role of vegetation;

(c) Impact of land use change and cover on regional and global climate;

(d) Detection studies of climate change and impact studies of climate variability on human activities and health.

The IPCC (1996) report calls the attention to the possibility of opposing effects of the human influence on global climate change. The burning of fossil fuel as well as other industrial efluents certainly contribute to the increase of greenhouse gases which contribute to the global warming. On the other hand, the aerosols produced by the human activity seems to induce cooling of the atmosphere through two effects: (a) the direct effect, associated to the increased reflection of solar energy to space (increased terrestrial albedo) by the aerosol load in the atmosphere and (b) the indirect effect, associated to the increased cloudiness in view of seeding effect of the sulfate aerossols which act as cloud condensation nuclei. The current observational and modeling evidences suggest that the human influence on climate is already discernible in spite of the opposing effects associated with the increasing concentration of greenhouse gases and sulfate aerosols.

Besides the aerosol production by industrial and mining activities, biomass burning, a widely used agricultural practice in the tropics, is another major source of aerosols, though much less studied. The effect of biomass burning on the aerosol load of the atmosphere and their effective role on the atmospheric energy balance remains an important scientific issue. Precise determination of the cooling and/or heating role of the biomass burning aerosols is still in progress.

The current Climate Convention poses an important challenge to tropical nations in view of the need to identify the carbon stock and fluxes. In particular, the tropical forests constitutes a large global store of carbon, which may be exchanged with the atmosphere through (i) changes in land use brought about by fire, clearing, logging, planting and regrowth and (ii) changes in the balance between photosynthesis and respiration occurring as a result of variations in climate and atmospheric chemistry. Both of types of change introduce uncertainties in the global carbon balance (Higushi et al., 1994, Tans et al. 1990, Ciais et al. 1995) and both may influence the carbon dioxide of the atmosphere and thus interact with the climate system (Enting et al. 1995). Several uncertainties are still significant such as the evaluation of the annual deforestation rate, carbon fixation at the soil and forest regrowth, carbon efficiency factor during the biomass burning as well as the effective large-scale transport of carbon.

It is also important to consider the role of land cover and use changes in the regional climate change. Changes in the surface cover, associated with deforestation, agriculture and irrigation and construction of major water reservoirs, may induce significant changes in the water, energy and carbon fluxes between the surface and the atmosphere with potentially significant impacts on the regional climate and, in some cases, even on the global climate.

There are several research centers in the world conducting climate studies with long term simulations of the climate scenarios associated with the increase of the greenhouse gases as well as aerosols. Most of these studies need substantial computer power, in general beyond the capability of the currently available potential in the developing countries in the tropical region. However, there are several studies which can be conducted with the available computer power, using the available long term simulations as well as simplified climate models which are useful for understanding climate processes and testing hypothesis. In addition, substantial knowledge can be learnt from studies of the natural climatic variability and its impacts on the human activities.

The Brazilian Academy of Sciences is currently heavily committed in the support of major national and international research programs which have been devised to answer several relevant scientific uncertainties in the understanding of the impact of human activities in the tropical region on the regional and global climate. In particular, the Brazilian Academy of Science supports the Large Scale Biosphere Atmosphere Program in Amazonia – LBA (Nobre, 1996) which is a Brazilian initiative conducted in partnership with the international scientific community, primarily in the USA, under the support of NASA, and in Europe. The LBA was devised to explore the functioning of the Amazon basin from an integrated point of view, considering the hydrological, meteorological and ecological aspects of the problem.

II - Effect of aerosols and gases produced by biomass burning

Biomass burning does not directly produces ozone. However, a observations indicate an enhancement of the tropospheric ozone concentration during periods of biomass burning in South America and Africa (Kirchhoff et al., 1992, Fishman et al., 1996). Biomass burning produces large amounts of trace gases which are precursors of the ozone under the complex photochemistry of the process.

Radiation measurements in the Rondonia area (southern Amazon) indicates high values of aerosol optical thickness during the biomass burning season (Longo et al., 1998). The plume of aerosols leaves the burning belt circling the southern and eastern Amazon towards different regions during the winter season. Part of the atmospheric flow takes the aerosols towards the northern part of the Andes, eventually reaching the higher parts of the mountains towards the Pacific Ocean. The other branch of the atmospheric circulation takes the aerosol load towards Bolivia, Paraguay, southern/ southeastern Brazil. There are indications that the air parcel trajectories eventually rise to the middle and upper troposphere, primarily under the interaction with a cold front (Freitas and Silva Dias, 1996). Under other typical meteorological conditions, the smoke produced by the biomass burning in the tropical region may be transported towards northern Argentina. In any case, there are indications that the smoke plume eventually raises to the upper troposphere, reaching the subtropical jet stream which quickly disperses the aerosols to the South Atlantic and around the globe. Thus, the impact of the aerosols and gases seem to be detectable in remote areas.

Some scientific questions need to be explored concerning the effective importance of biomass burning in global and regional balance of radiation, carbon and other trace gases are:

- What is the amount of CO_2 and ozone precursors effectively produced by biomass burning?
- What is the typical aerosol load produced during the average burning season?
- Is the life cycle of the ozone precursors sufficiently long to effectively impact the ozone balance?
- What is the impact of clouds in the vertical transport of biomass gases and aerosols? Does the complex chemical processes within the cloud alter these constituents?
- Once in the atmosphere, what is the relative role of the biomass burning aerosols on the long and short wave radiation balance?
- Are the aerosols produced by biomass burning efficient cloud condensation nuclei with significant impact on cloud formation?
- What is the role of the natural climatic variability on the production of biomass burning gases and aerosols?

III - Carbon Balance

The conversion of forest to agriculture in a large portion of the tropics is still a major source of carbon to the atmosphere. On the other hand, recent Net Ecosystem Exchange (NEE) measurements indicate that undisturbed forest systems may be a net carbon sink (Grace et al. 1995). Moreover, abandoned farmland usually undergoes a regrowing process of the natural vegetation which constitutes a further carbon sink, although the extent of this sink (its area and intensity) is uncertain. Similarly, over-logged forest and disturbed areas associated with logging have not been evaluated. Studies are required to determine both the areal extent of different land uses and the associated changes in carbon.

One approach to the regional carbon balance emphasizes the natural carbon cycle, including net primary production (NPP) and respiration. Fluxes in the natural vegetation will reflect two processes. The first of these involves metabolic processes of photosynthesis, growth, and decay, affecting individual trees, and very short time and spatial scales. The second process, over somewhat larger scales, is succession, which affects the number, age and species composition of stems, as well as the amount, nature and turnover rate of soil organic matter.

Some important scientific questions on the carbon balance which are related to the role of tropical forests and savanah and are considered in the LBA program are:

1) How large are the carbon pools in vegetation and soils of intact forests, including *savanah (cerrado),* pastures, cultivated lands, secondary and logged forests?

2) What are the rates of carbon exchange between vegetation and atmosphere, and how are these rates altered by natural and human disturbance?

These questions imply a general need to assess carbon pools and fluxes in a variety of land-cover and land-use types. More specific research questions are:

- What is the seasonal and interannual variability of the CO2 flux between the atmosphere and different land-cover/land-use types and from the Amazon region as a whole? What factors influence the balance of photosynthesis, respiration, plant recruitment and mortality that give rise to these net fluxes at the ecosystem scale?

- What are the relative contributions of fluxes from natural and disturbed ecosystems to the net basin-wide flux? (To what degree do natural sinks and sequestration of carbon in regrowing forests balance/offset sources associated with forest conversion?)

- How do pools and fluxes of carbon and nutrients in soils of pasture/cropland change over time; what factors (soil properties, management practice) determine carbon gain or loss? Changes in carbon pools in soils are thought to be small compared to those of vegetation, but rather little is known of decomposition rate of the so-called recalcitrant forms of carbon, and the elemental carbon resulting from biomass burning.

- What are the biologically-mediated influences on carbon sequestration in abandoned pastures and croplands? The importance of species biodiversity and biodiversity of life forms is unclear. Studies are need to identify critical roles of species groups (for example, deep rootedness, capacity to fix nitrogen, capacity to break down and decompose recalcitrant forms of carbon).

- How does selective logging change the storage and cycling of carbon in forests? This includes influences on microclimate, decomposition, ecosystem structure, and probability of future disturbances (i.e., fire) that will further influence carbon dynamics. Recent data on timber harvest intensity and wood production indicate that selective logging of otherwise intact stands of forest contributes significantly to the area of forests altered in Amazonia. Selective logging may result in decreased carbon storage in living biomass and increased emissions of carbon through decomposition processes for the region affected. The removal of stemwood to long-term storage pools together with regrowth following harvest may lead to a net carbon sink. The net flux of carbon from forest end-products needs investigation. There is evidence that logged forests may become more prone to fire because of the large fine fuel loads left behind and a drier microclimate near the litter layer. It is difficult to estimate the total area subject to selective logging, and it is even more difficult to quantify the changes in carbon storage and emissions.

- What factors (land-use history, soil properties, etc.) control the rate of carbon sequestration in biomass and soils of regrowing forests? There are major uncertainties in our understanding of the carbon dynamics of re-growing forests. It has been suggested that secondary forest re-growth following pasture or crop land abandonment may be responsible for much more carbon accumulation than previously estimated. This suggestion needs to be investigated. There is also evidence in some regions that secondary forests are cleared and re-converted to agriculture after only a few years of re-growth. Thus, better information on the ages of secondary forests and the rates of carbon accumulation at various ages is desired.

- What portion of the basin wide flux of CO2 is from fire? How do ecosystems recover from fire? Are there statistical relationships between fire occurrence/frequency and land management (e.g., selective logging)? Some management practices include fire as a way of concentrating nutrients in available soil pools. Other practices, such as selective logging, may increase the flammability of forests and affect fire frequency. Considerable work on fire is already in hand, both for humid forest and *cerrado*, but there are a number of unanswered questions about the decomposition of uncombusted organic matter remaining in the soil over months and years following the burn, and also on the rate of carbon accumulation of the regrowth.

IV - Impact of land use change and cover on regional and global climate

The hydrological cycle is the integrated product of the climate and the biogeophysical aspects of the surface. The climate determines the characteristics of the surface in view of its importance in the soil formation, type and characteristics of the vegetation, topography and drainage structure. At the same time, the surface exerts a marked influence on the climate through physical and biological effects. The topography clearly impacts of the atmospheric flow, temperature and, ultimately, on the precipitation regime. The biological effect occurs through the vegetation and soil physical properties. These physical and biological effects determines the interaction between the atmospheric humidity, the precipitation, the surface drainage and the energy balance in the form of sensible and latent heating (i.e., evapotranspiration). Recent research suggest a strong interaction between climate and surface processes (Shukla e Mintz, 1982; Sud et al., 1990; Nobre et al , 1991; Wood, 1994, Betts et al, 1996).

Changes in the vegetation parameters and other surface properties (such as albedo, soil type and roughness) modify the water and energy fluxes from the surface to the atmosphere through the following arguments: (a) The absorption of solar energy at the surface depends on the canopy structure and the vegetation fractional coverage; (b) The surface temperature is a function of the net energy available at the surface (both long wave and short wave) and of the fractioning of heat transfer from the surface to the atmosphere as sensible and latent heating (i.e., evapotranspiration); (c) Higher and denser canopies exert substantial aerodynamic drag, reducing the wind speed near the surface which enhances the turbulent diffusion of water vapor and heat in the planetary boundary layer.

The interaction between the soil type and vegetation is more important for the hydrology through the infiltration of water available at the surface in the form of rainfall and surface and/or sub-surface flow. While the vegetation represents an important control on the infiltration and interception of rainfall, it also exerts an important control on the extraction of water from the ground through the root system.

The tropical rainforest in Brazil occupies an area of the order of $3.5x10^6$ km^2 in the so called legal Amazonia. Deforested areas cover approximately 15% of the total area in the legal Amazonia, primarily in the states of Rondonia and Para. The *Cerrado* area is of approximately $1,39x10^6$ km^2 and there are at least 4 different subdivisions (*Campo Cerrado, Cerrado Sensu Stricto* and *Cerradão)*. The tropical rainforest is responsible for a intense water vapor and CO2 exchange with the Atmosphere. The measurement of the evapotranspiration over the pasture areas in Amazonia and the Cerrado show large spatial and temporal variability as shown in Table 1.

Table 1: Evapotranspiration (E) and net radiation (Rn) expressed in mm/day in the tropical rainforest (Central Amazonia), Cerrado and other agricultural environments in different seasons. (From Rocha and Silva Dias 1994)

	Dry Season		Wet Season	
	E	Rn	E	Rn
Tropical Forest (Central Amazonia)	3.9	4.4	3.5	3.9
Pasture (Central Amazonia)[2]	2 - 3	4	(3,5	3,9) *
Cerrado (Central Region of Brazil)	1,5	4,4	2,6	4*
Other cultures [3]				
Rice		4,3		
Sunflower		5,6		
Soya		5,4		
Wheat		4,4		
Eucaliptus		6,0		

The CO2 and water exchanges between the vegetation and the atmosphere are also strongly coupled and dependent on environmental factors and biologic processes. The stomatic control at the surface of a leaf is influenced by hydroactive controls associated to the ionic transport, influenced by the amount of available radiation , air temperature and humidity, CO2 partial pressure and soil moisture.

In spite of the general public awareness and worldwide efforts for the conservation of natural resources, tropical forests continue to disappear at alarming rates. It is crucial to establish management techniques which are compatible with sustainable development for the tropical forests . It is vital to understand the impact of the human intervention on the natural capabilities of forest regrowth and how to preserve the basic ecological processes which are vital for the biological productivity and the water and energy recycling. The conversion of natural forests and of the *Cerrado (savanah)* to agricultural areas poses a major change in the environment.

More specifically, the following scientific questions addressed in the LBA program are closely related to climate change issues in the tropical area:

- What are the surface controls in the water and energy fluxes at the surface and do these fluxes vary in time and space, between seasons and from one year to the next (the interannual variability)?
- What is the role exerted by the natural forests, regrowth areas, pasture and different types of *cerrado (savanah)* in the hydrological cycle?
- What are the changes in the surface water and energy fluxes associated with land surface changes including deforestation and regrowth of natural forests?
- What is the time scale associated to the adjustment of the water and energy balance during regrowth towards the typical behavior of unperturbed forests?

- What is the relative role of the feedback processes between the surface and the atmosphere and the atmospheric forcing in the development, maintenance and decaying of large scale climatic anomalies?
- How is the coupling between the climatic regime in Amazonia with neighboring regions and is there any remote/global impact of changes in the Amazon precipitation?
- What are the atmospheric mesoscale mechanisms (of the order of a few hundred km) associated with surface cover changes which interfere with larger scale climatic anomalies?
- What is the role of dry and wet convection in the water, energy and redistribution of trace gases in the atmosphere and how are these processes modified by land cover changes and use?
- What limits photosynthesis and respiration in the undisturbed, natural vegetation?

V - Detection Studies of Climate Change and Impact studies of climate variability on human activities and health

Detection of human derived climate change is a major challenge in view of the large natural climatic variability. Thus, a first step is to improve our knowledge of the observed variability and to understand the natural causes. Finding long term and reliable climatological data is the tropical region is not an easy task. Most of the data is in printed form, frequently in deteriorating conditions. Substantial effort should be oriented towards improving the climatological data base and on the detection of possible changes in measurement systems as well as location of the observing stations.

The role of anomalous tropical precipitation in generating atmospheric circulation anomalies has been quite well established during the last 20 years, based on observational and theoretical studies which became feasible in direct response to the improvement of the computer power and the expansion of the data basis. The El Nino/Southern Oscillation phenomena (ENSO) is a clear example of the cooperative role between the ocean and the atmosphere. The relatively large variability of the model estimates of the global warming due to the increase in the concentration of the greenhouse gases can be another clear example of the impact of the interaction between the ocean and the atmospheric circulations.

The importance of the oceans in controlling the natural climatic variability has been explored in the context of the observed cooling in certain parts of the globe, notably near the Arctic region in northern Europe where some climate models tended to produce large warming in association with the CO_2 doubling experiments. These studies shows that the proper simulation of the warm tropical water which feeds the Arctic Ocean in the northern Atlantic Ocean is responsible for the slowness of the arctic temperature response. The model studies show that the tropical and extratropical low level wind response changes the strength and position of the subtropical high pressure cells which have an impact upon the low level winds, which modify the upper oceanic currents. Thus, the atmosphere and the ocean react in a coupled mode and a tropical interactions may have remote effects at higher latitudes through the process of energy propagation in the atmosphere and ocean.

Given a sea surface temperature anomaly at a certain area of the tropical oceans, there is not a clear cut atmospheric remote response. The fact that there is no clear relationship between the ENSO phenomena and the climate anomalies at higher latitudes in the northern hemisphere (but fairly good relationship in the tropics) is also an indication that atmospheric energy propagation from the regions of warm sea surface temperature (SST) to higher latitudes can not be explained in terms of simple purely linear dynamics. The impact of anomalous SST in the Atlantic Ocean have been shown to be important for understanting the natural variability of the tropical sector of South America as well as Africa. Similar studies have also indicated the potential role of the Indian ocean in generating climate anomalies in Asia and Africa.

Substantial improvement in our knowledge of the role the ocean/atmosphere interactions can certainly be accomplished with relatively modest computer power but with access to the modern data basis available in several research centers all over the world.

The natural variability of the climate provides us with a unique opportunity to study their impact on human activities. The large magnitude of the tropical impact of the El Niño phenomena has been associated to heath problems (malaria outbreaks), drought and flooding which have been associated to huge material and life lost. The 1982/83 El Niño episode was responsible for approximately US$8 billion damage in the tropical area. The more recent event had a significant impact as well but several initiatives were taken in advance in view of its prediction. Thus, it is quite clear that the tropical countries have the means to take advantage of the predictability of at least part of the natural climate variability.

VI - Conclusions

The vast extension of the tropical forest areas in the Amazon and other tropical areas imply a potential impact on the global energy, water and carbon balance. We need to understand what are the possible climatic impacts associated with changes in the natural vegetation coverage in the future. The energy, water and carbon exchange as well as other trace gases and nutrients, through the atmospheric , ecological and fluvial systems need to be quantified and understood, in different spatial and temporal scales. We need to understand how these exchanges are altered by the conversion of forest areas to pasture and agricultural areas. We must know how to predict the impact of deforestation in the ecological, climatological and hydrological functioning of the tropical areas and to what extent these changes will affect the long term sustainability. We must also be able to predict the impact of these changes in remote areas.

The potential role of vegetation in fixing carbon should be studied in detail. The FLORAN project is an initiative which needs to be quantified and possibly explored in other parts of the tropical region. Reforestation may play an important role in the carbon balance and its impact on climate should be more extensively studied.

It is important to observe that some current scientific uncertainties, pointed out in the IPCC/1996 are specifically treated in the scientific planning of LBA supported by the Brazilian Academy of Sciences. The exchange of carbon between the surface and the atmosphere, the role of natural aerosols (e.g., the isoprenes) and the biomass burning aerosols on the radiation balance and their role as cloud condensation nuclei, the role of clouds in the energy, water and carbon balance, the long range transport of gases and aerosols produced in the tropical areas are important scientific issues which are in the LBA scientific agenda.

Impact studies of the natural climate variability on different sectors of the human society are needed. The example of the reduction of the impact of the recent El Niño episode in view of its prediction clearly indicates the importance of further work. Understanding the impact of the ocean/atmosphere interaction in the Atlantic and Indian oceans are another important research issue in the tropical countries. The biophere/atmosphere interaction and climate variability is another important issue for tropical countries. The Brazilian Academy of Science is heavily committed to the support of national and international projects related to the biosphere/ atmosphere/ocean interaction and climate impacts.

VII - Summary and Recommendations

(a) The main variables that affect the climate in the tropics are reviewed and considerations made of their effect on global climate;

(b) The more relevant issues that are in need of additional research are identified;

(c) The objective is to increase the value of our predictive models with an eye to collaborating with the sustainability effort;

(d) Sustainability requires a better knowledge of the natural ecosystems hability to exchange carbon with the atmosphere. Recent observational results indicate that the tropical wet forest in Amazonia has been fixing carbon at a rate of the order of 1 to 5 kg/ha/year. Carbon fixation at significant rates have been also observed in the savanah region of Brazil and in sugar cane fields over the annual cycle;

(e) Biomass burning poses important questions for sustainability in view of the possible impact on the energy balance of the atmosphere/surface balance. There are growing indications of a significant impact of the aerossols produced by biomass burning on the atmospheric and surface temperatures;

(f) The impact of land cover changes have been detected in observational studies in forest and pasture areas in the Amazon. Simulation results suggest possible impacts on the precipitation regime. Sustainability studies should consider the impact of land cover changes in the regional climate.

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Biodiversity, Sustainability and Drug Development

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Which Class of Antihypertensive Agents Arose from the Tropical Rain Forests of South America?

ACE inhibitors. In the 1960s, Ferreira discovered that venoms of the South American pit viper (Bothrops jararaca) contained peptides that inhibited angiotensin converting enzyme. The molecular structure of these natural peptides provided the starting point for the design of the commercial ACE inhibitors used today.

This was a Today's Question of the Medscape website. The answer conveys right and wrong notions. The term "rain forests" immediately evoke the idea of a forest around the equator like the Amazon forest. In fact it is little realised that the Mata Atlântica is much rich in biodiversity than the Amazon forest, which it is now almost destroyed due to the expansion of the agriculture and urban areas. The venom used in those pioneer experiments was original of a family of snakes abundant in the Mata Atlântica.

It is correct, however, to call attention for the fact that a great majority of synthetic medicaments were based in prototype molecules extracted from natural product, like snake venom or a plant extract. The crucial moment for the development of a drug is the discovery of the prototype. This prototype has the expected activity of the drug, but usually requires further development because of its low potency, short biological life, high price, difficult synthesis, undesirable side effects, etc.

The text gives a wrong notion, because it implies linearity between the discovery of the prototype and its use as an inhibitor of the angiotensin-converting enzyme. Drugs are generally developed by the industry. Prototypes nevertheless can be discovered in the Academia and in general there is a long way to be made for the drug to reach the hands of the clinician.

At present, scientific knowledge is crucial for the development of new inventions, which guarantee industrial profit (1). However, the recognition of the academic contribution to the development of a new drug is, in general, very controversial.

"From *Bothrops jararaca* bradykinin potentiating peptides to angiotensin converting enzyme inhibitors" is a story which illustrates this point. Scientists who were doing non-task-oriented research, in academia, hospitals, and other non-industrial institutions produced the basic scientific knowledge up to the drug-prototype of the converting enzyme inhibitors. In effect, the discovery of the rennin-angiotensin and bradykinin systems and their possible contribution to cardiovascular homeostasis was pioneered by academic scientists such as Tiegersted and Bergman in Sweden, Werle and his collaborators Kraut and Frey in Germanyh, Braun-Menéndez in Argentina, Gold, Page and Helmer in the U.S., and Rocha e Silva in Brazil. Our own contribution to the development of the converting enzymes was mainly made at the University of São Paulo, Brazil. Progress, however, was only possible with the collaboration of several other scientists, such as L.J. Greene and J.M. Stewart in the USA, J. R. Vane and Y.S. Backle in England, and E.M. Krieger in Brazil (see 2).

When we discovered the bradykinin potentiating peptides in the venom of a Brazilian snake, *Bothrops jararaca,* we had no idea that the enzyme responsible for the major inactivation of bradykinin in the body was the same as that which converted the inactive e angiotensin I to the active hypertensive molecule angiotensin II.

Nonetheless, the bradykinin potentiating peptides were instrumental in this demonstration (see Ref. 2).

Our main contribution to the area can be summarised as follows: A) the demonstration of the inhibition of bradykinin destruction by metal chelating agents (3); B) the discovery of the bradykinin potentiating peptides in the venom of the Brazilian snake *Bothrops jararaca* and the demonstration of its pharmacological profile (4-7); C) the use of the bradykinin potentiating factor (BPF) as a methodological tool to detect the participation of bradykinin in physiopathological processes (8,9); D) the isolation of nine peptides possessing bradykinin demonstration of parallelism between bradykinin potentiating activity and inhibition of angiotensin I conversion (10,11); E) the elucidation of the structure, synthesis and definition of the pharmacological profile of the smallest active *Bothrops* peptide, PCA-Lys-Trp-Ala-Pro, BPP_{5a} F) the first demonstration that the synthetic pentapeptide was effective in controlling blood pressure was in angiotensin-dependent models of hypertension (15). Later, one of the *Bothrops* venom peptides synthesised by the Squibb group was successful in testing the hypothesis that converting enzyme inhibitors were effective in lowering blood pressure in hypertensive patients (16). It is intriguing that, at this point in the sooty, the family of bradykinin potentiating peptides (BPP) was rather unethically renamed "angiotensin converting enzyme inhibitors" (17), probable because of marketing objectives. The awareness that the converting enzyme could be inhibited by metal chelating agents (3), that BPP_{5A} was split by the converting enzyme in the carboxyterminal amino acids, together with the new concept of making non-peptidic drugs from peptides (18), allowed Squibb reconcept of making non-peptidic drugs from peptides, in particular BPP_{5a} , could be considered as the drug-prototype since they were instrumental for the development of this first member of a new class of antihypertensive drugs. The clinical success of Captopril and the other "me too" angiotensin converting enzyme inhibitors popularised the concept that the only mode of action of the renin-angiotensin system. However, mounting evidence has been obtained over the last few years that the beneficial effects of this group of drugs on the reduction of cardiac insufficiency and myocardial infarct lesions is mainly due their bradykinin potentiating activity (20-24).

Thus it is not unfair to say that most of the relevant basic knowledge used ion the invention of Captopril was the result of non-task-oriented academic research. We know very well that there is no typical inventor since, in the process of inventing, developmental scientists frequently make scientific discoveries. But it is well recognised that drug development is heavily supported intellectually by academic research (1).

The question to be asked is: why doesn't new scientific knowledge have intellectual property rights?

As academic scientific discoveries are published (which does not happen to a great deal of industrial scientific discoveries), they become of public domain. There is a tacit international consensus that public domain prevents the authors from participating in the patent rights of any invention resulting from their scientific discoveries. This may be acceptable for developed countries, whose industries are capable of transforming the new scientific discoveries into inventions. For the third world, however, the system is unfair, since third world countries lack industries strong enough to develop new products. Even in developed countries, however, scientists working in universities are now under fire and their survival is frequently linked to their industrial development or task-oriented projects. Alternatively, scientists now frequently withhold their scientific findings and offer them to the industry before any publication. This pattern of behaviour will eventually sterilise the scientific creativity, which used to flourish in the intellectual freedom of academia.

At present, at the University of São Paulo, in Brazil, we are repeating the BPF story by developing prototypes of new analgesics based on new knowledge regarding the physiopathology of inflammatory pain which has been discovered in our laboratories. It is obvious that I will get recognition from my academic and industrial colleagues for those discoveries. But without recognition from of the intellectual property rights, my country and university will never profit from the investment that was made in my education and research. I am hoping that my colleagues intellectual understand the importance of fighting for the international recognition of the intellectual property rights for scientific discoveries in order to participate in a fraction of the value of the patents. This recognition will certainly protect scientific research in the university not only in undeveloped countries but also around the world, which is now on the brink of collapse.

Biodiversity is a very broad concept involving all nature's living entities and basic principles of its preservation and protection including principles of sustainability, intellectual property rights and transfer of new technology for the native population etc.

Degradation of the ecosystem certainly was not due to the research and production of new drugs. Drugs like rutine and pilocarpine, which are still extracted from plants, are produced in dedicated farms. The research of new drugs profit immensely of the biological diversity and the knowledge of its native population. In the year of 1988,for example, among the twenty drugs introduced in USA the market, seventeen had their prototype directly originated from plants.

Brazil like may other countries have its biodiversity threaten by globalisation. We stand in the international market as cheap exporters of our flora, soil and our ethnobotanic and **ethnopharmacological** knowledge of our biodiversity. In fact to the native knowledge of the medicinal use of the plants added those of the African slaves and Europeans. Brazilian laws that "protect" our biodiversity are frequently meaningless either because the rain forest belongs to several countries or the sampling of materials for drug development can be made without social noise and in general with the cooperation of a Brazilian research associate.

We have recently evaluated the effort that the Brazilian made in the investigation of medicinal plants. In part, this effort was stimulated by the controversial idea of substitution of standard therapy by cheaper herbal therapy. But there was also the sensible idea of determining the active principle and the toxicological profile of the plants in popular use.

Most of these studies, however, took us no where, but allowed in the last thirty years the formation of a great number of postgraduate students and a few qualified clinical and experimental laboratories. Brazil to profit from our immense biodiversity must organise a strategic plan for drug development in charge of the coordination of national and international groups interested in natural product research. A detailed description of a strategic planning was described elsewhere.

Finally, we would like to point out that there is a general recognition of the importance of biodiversity for the development of drugs. However, we also recognise that the total sustainability of biodiversity is improbable with the presence of men in forest regions. Men actively adequate the environment for their security. They actively decimate aggressive or predatory animals and apparently inutile plants, which entails the destruction of their ecological partners. Scientists also know that they can only invent drugs with the screening tests available to them. Future screening tests will be developed with the new understanding of diseases or pathological processes. It is obvious that we cannot use now the screening tests of the future. Thus, if we do want to preserve biodiversity for future research and for the discovery of new drugs, we cannot just organise its sustainability. It is crucial to preserve a certain number of sanctuaries, inaccessible to any kind of exploitation and representative of the biodiversity of the various ecological regions around the world.

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Sustainable Agriculture in the Tropics

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Unfortunately there is no a vaccine against hunger. People need to be adequately fed every day, hence the importance of a well developed agriculture that rationally utilizes available natural resources together with the technological improvements resulting from scientific research

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I - The Struggle to Survive

For most of the 1.5 million years of the **estimated** existence of mankind on this planet, human beings had to face all sort of adversities, competing with animals more apt to live in a hostile environment. A major concern was always an adequate food supply. Hunting and collecting plants provided food, although irregularly. Several times the human species came close to extinction as pointed out by 1970 Nobel Peace Prize laureate, Norman Borlaug , the father of the Green Revolution. During that long time, acting essentially as a hunter, there was little social progress. The Sole concern was survival. No significant increase in population took place, with a tendency to stabilize at around ten million individuals (Borlaug 1972).

About 10,000 years ago plants began to be cultivated. It is believed that this initiative was pioneered by women, who are less apt at hunting and having to take care of domestic tasks, had more opportunities to observe plants, to develop knowledge on their properties and eventually on their reproduction. Agriculture is a quite recent activity in the history of humankind. This can be easily visualized using a scale of 365 days to represent 1.5 million years, where man appears on January 1st and agriculture is initiated at four thirty P. M. on December 29.It is of interest to point out that agriculture was invented at least twice independently, in the Old and in the New World. Both types differ in many respects, such as animal vs. human work, selection for uniformity in the Old World vs. selection for variability in colors and shapes in the New World, as can be appreciated in many crops such as maize, beans, squashes and so on. Besides, inhabitants of the New World never discovered the wheel as a means of transportation, and even though they succeeded in developing some animal husbandry in North America, no animal domestication to work in agriculture took place. In this short period in historical perspective, agriculture had a significant development as can be seen on Table 1. A primitive husbandry improved by a factor of ten the results of hunting. But, no doubt, subsequent advances in agriculture were much more spectacular. Subsequent improvements in agriculture made possible the development of communities and later on of cities. Also fewer people were necessary to produce food, so that many could dedicate their time to other activities such as commerce, arts, politics, waging war , religion and so on.

In spite of the progress achieved, there has been a recurrent concern on the prospect of hunger due to limitation of food production. The catastrophic prediction made by the Rev. Robert Malthus in 1798 is well known, stating that hunger would be inevitable, for while the population increases hardly in a geometric progression, food production increases scarcely in an arithmetic progression. Such "prophecies" have been repeated more recently by Paul Ehrlich in his book "The Population Bomb" published in 1966: a "prediction" was made to the extent that in the sixties and seventies hundreds of millions would die of starvation. Thanks, however, to technological progress applied to agriculture such disasters did not occur, although many still believe that such predictions have been merely postponed.

Food is the most pressing need for human beings. Besides improvement in agriculture, food availability depends on social and economical conditions of the communities. In 1913 the Rockfeller Foundation was created with the goal to improve the quality of life. The first 20 year emphasis was on health. Then an assessment of the program reached the conclusion that the five basic needs for a satisfactory quality of life are Food, Health, Shelter, Education and Opportunity, in that order:

II - Plant Domestication

Changes due to domestication

The enormous plant diversity has not been evenly utilized for food production. From the known 350.000 species, man employed during all his history less than 3000 and today about 300 are cultivated. The fifteen most important, contributing with more than 90% of all food production in the world are rice, wheat, maize, soybean, sorghum, barley, sugarcane, sugar beet, beans, peanut, potato, sweet potato, cassava, coconut and banana. These species are the result both of the selection among many originally used as well as of the selection within each species to increase its efficiency in providing adequate quantity and quality of food.

Many characteristics were changed in the process of domestication from the original wild species. The most evident are the following:

a) Loss of natural seed dispersion, so that the grains remain attached to the spike, helping the harvest.

b) Loss of seed dormancy, so that all seeds germinate uniformly.

c) Change from alogamous to autogamous reproduction in many species.

d) Change from perennial to annual life cycle in several species, which increases yielding ability per unit of land

e) Change from dioecism (male and female plants) to monoecism or hermaphrodites (both sexes in the same plant).

f) Increase in the size of fruits, grains and general yielding ability, besides several characters such as quality, flavor, and so on.

All these changes, including domestication, are the result of empirical selection carried out by rural communities during hundreds or thousand years, indicating the skillfullness of ancient cultivators and also the great amount of genetic variability within species. Also, it should be emphasized that all present day cultivated plants were domesticated by ancient people. Modern man received from their predecessors all domesticated plants showing the mentioned changes. By applying the knowledge obtained especially in the present century, man continues the improvement, achieving highly significant gains in food production.

Vulnerability of domesticated plants

Although plant domestication assured the survival of human species, it also raised some unexpected problems. The most serious are represented by the vulnerability of the cultivated plants to diseases caused by microorganisms, especially fungi and bacteria. When in the wilderness, plants were dispersed in the environment mixed to other species, which conferred them some degree of protection. Although some could be infected, most escaped and remained healthy. Besides, a great genetic variability of the wild species was an additional asset favouring the occurrence of genetically resistant plants. Under domestication artificial selection during many generations increased uniformity, resulting in a reduction of genetic variability. Also, plants became cultivated in more compact and denser populations, favouring still more the spread of diseases.

Since biblical time reports can be found on disasters in food production due to diseases. In ancient Rome, Plinius considers "the wheat rust the greatest curse for crops". Perhaps the most dramatic example was the potato blight appearing from 1830 to 1840 in Western Europe and Northeastern USA, reaching catastrophic proportions on 1845 in Ireland. Being the staple food, the blight was so violent that about one million people died of starvation and another million emigrated to US. Later on the fungus called *Phytophtera infestants* (from the Greek Phyto = plant and phthera = destructor) was identified as responsible for the disease. This disease also affected the German crops during the First World War, what might have contributed to abreviate its end.

III - Tropical vs. Temperate Climate Agriculture

Regions of the Northern Hemisphere most of them belonging to the First World, have a more temperate climate and are more developed than most tropical countries on the Southern Hemisphere. Furthermore, frequently, there is a tendency to make comparisons with the most developed nations. Regarding agriculture, this would imply compairing temperate to tropical environments. This is highly inappropriate because the climatic differences between these two areas are markedly different, with the tropical regions being much more adverse regarding agriculture. Table 2 based on Brewbaker (1985) with some additional items (Paterniani 1990) summarizes the main characteristics of these two climates for maize production that can be applied also to other summer crops. Most of the characteristics are self-evident and need no further comment, except maybe to acknowledge the usually more adverse factors in the tropics. Unpredictable rainfall variation, certainly, is one of the most important constraint, as can be seen on figures 1 and 2 that compare monthly rainfall variations between a temperate location (Ames, Iowa, USA, 42° N, 93 ° W) and a sub-tropical place (Piracicaba, SP, Brazil, 22° S, 47° W) for a period of about 70 years. Some other items can also be highlighted to show the more adverse conditions for the tropics, such as the longer day length in temperate areas (15 to 16 hours of sunlight in summer) while in the tropics the summer has considerably shorter day length, i.e. about 13 hours. In this way, higher CO2 fixation due to photosynthesis is the rule in temperate climates in relation to the tropics. Besides, shorter and cooler nights are more favourable in temperate areas, since less CO2 is lost due to respiration, while the opposite is true in the tropics where longer and warmer nights prevail. Another important constraint refers to the soil: in temperate regions, the soils are usually less acid, more fertile, have a higher primary mineral reserve and more active clay, and are less apt to leaching and to erosion. Last but not least many of the technological developments that could improve tropical agriculture, although available, are not used due to poor social and economic conditions in most tropical countries or, in brief, due to lack of "sustainable" agricultural policy in most cases.

Plants are dependent on climate, so that species or varieties are adapted to specific climatic environments . This renders even more inappropriate the comparison between tropical agriculture with the temperate one, since plants need to be adapted and improved to specific conditions, which is not the case regarding industrial appliances for example. The technology must be developed in the area where it is going to be used. Agricultural practices, plant nutrition, fertilizing, plant breeding, disease and insect control, all these items need to be developed in the tropics, for most of the technology adequate in temperate areas are of no use in the tropics. In agriculture, transfer of technology is usually an inadequate option. It is quite obvious that the assessment of the agricultural efficiency should be done between regions of similar climatic conditions. In this regard, Brazil has been able to carry out important basic and applied research, that resulted in a well developed and reasonably efficient agriculture, superior to most other tropical countries. Many of these technical achievements are available for immediate employment or adaptation to other tropical countries a high probability of promising results.

IV - Improved Technology in Modern Agriculture

Although some know how relative to plant cultivation, such as notions on mineral nutrition, sexual reproduction and other agricultural techniques were already available in the 19th century, agriculture as an applied science is a development of the 20th century. Being an applied science, it is only natural that investigators in agriculture tried to use as much as possible the advances in basic science to improve agriculture efficiency. The following scientific landmarks are pertinent:

a) The start of the fertilizer industry as early as 1840 with the production of simple superphosphate by Lawes in England, shortly after Liebig in Germany established that plants are fed by air, water and a handful of minerals.

b) Mendelian inheritance, due to the work of Mendel in 1865, and its rediscovery in 1900 by De Vries, Correns and Tschermack.

c) Heterosis or hybrid vigor in maize (East 1908 and Shull 1909), later on extended to other crops, which might be the greatest contribution of the present century to agriculture.

d) The contribution of Thomas Hunt Morgan, around 1910, showing the role of chromosomes in inheritance.

e) Genetic basis of complex characters, called quantitative (Nilsson – Ehle 1908 and Fisher 1918), which led to the development of new and more efficient methods of plant breeding.

f) The development of statistical methods by Fisher in 1917 (Fisher 1936), that led to the development of experimental designs to achieve greater precision in field work evaluations.

g) The effect of ionizing radiations for the production of mutant genes by J. H. Muller around 1930.

h) The finding that the resistance and the susceptibility of plants to diseases caused by fungi are controlled by genes and, in sequence, Flor´s theory (Flor 1955) that for every gene for virulence in a fungus, there is a corresponding gene for resistance in the host plant.

i) Several methods for plant breeding, such as methods for obtaining evaluating inbred lines for hybrid production, recurrent selection schemes (both intra and inter-population) and methods for improvement of autogamous and asexual reproduction species.

j) A series of discoveries related to the genetic material (DNA) that led to Molecular Genetics and Genetic Engineering with the production of transgenic plants.

k) The development of the concept of Integrated Pest Management (IPM), where pests are controlled using a combination of techniques such as: chemical, genetic resistance, environmental control, cultural practices and biological control.

l) A number of agricultural practices, resulting from improvements on mechanization and equipment, also played an important role to increase efficiency in agriculture, such as better irrigation systems like "Central Pivot" no-till farming and equipments to improve land preparations, plant cultivation, protection and harvesting.

There has been world-wide increase in the productivity per unit of land, thanks to the use of the improved available technology. It is currently estimated that about 18 million km^2, an area equivalent to South America, is cultivated throughout the world. If crop yields would be at the level of 1950, there would be the need to plow about 48 million km^2 (Avery 1994). Thanks to modern technology developed countries are increasingly going to "high-yield farming", a combination of techniques to provide higher yields per unit of land. Since 1968 Sweden shifted more than 5 million hectares back into forest, without decreasing crop productivity (FAO 1969, 1991), while Chile, with no increase in cropland, has been able to feed a population growing at 1.7 % annually and at the same to time expand the export of its fruits and vegetables. Ecuador with yields not rising due to low-yield agriculture, is cutting its forests and expanding its cropland at a rate of about 2% annually (Avery, 1994).

Many reports indicate a need to increase food and fiber production to satisfy the needs of a growing world population. Cultivable land per capita is being reduced significantly, from near 1 ha in 1960 to 0.5 in 2000 and 0.30 in 2040 (Krattiger 1998). Although not all countries are in the same situation, for many countries like Brazil still have plenty of land to be cropped, the rational use of available techniques to improve efficiency in agriculture should help to protect land devoted to wild life, helping in this way to improve the environment, an end of the sustainable approach.

Although the techniques for high–yield farming are widely known, they are not employed everywhere, specially by poorer countries, in view of their socio-economic conditions.

V - Some examples of Brazilian Agriculture

General aspects

Considering the constraints of the tropical environment, together with other limiting factors of infrastructure, it is significant that currently Brazilian agriculture lies at the front in comparison to other tropical areas of the world with respect to efficiency and productivity. Besides this advanced position, Brazil is experiencing a continuous progress in production per unit of land. In the period 1970/1995 productivity of 16 important crops was doubled, thereby "saving" about 50 million hectares of land from cultivation. The following factors are responsible for this condition: the development of new improved varieties of the most important crops; techniques of integrated pest management (IPM), where biological control plays an important role especially reducing the use of agrochemicals; the conquest of the "cerrados" (savannas) a type of soil considered several years ago inappropriate for agriculture. In addition, techniques for soil conservation, no-till farming, more efficient use of fertilizers and enhanced nitrogen fixation by strains of Rhizobium sp. have also played their role.

No-till farming, clean air and clean water, is now used in about 10 million hectares in the South, West and Center of this country.

Many tropical countries have benefited with the improvements achieved by Brazilian agriculture, including the use of improved varieties. Much more can still be adapted abroad, for instance, the improvement of savanna like soils.

Agricultural research in Brazil has been carried out both by official institutions and by the private sector. Official institutions, corresponding to public universities, state institutes and the Brazilian Enterprise of Agricultural Research (EMBRAPA), contributed to basic and applied research. These institutions receive support from several financing government institutions as National Research Council (CNPq), Financing of Studies and Research (FINEP), Coordination to Improve University Professors (CAPES) and also State Foundations for the Advancement of Science. Important contributions from the private sector resulted in improved varieties, like hybrid maize, vegetables and other crops, and in the area of fertilizers, agrochemicals and mechanical equipments.

Genetic Improvement

Nothing is more essential for agriculture than the seed. Seeds here are understood in the broad sense, comprising the true botanical seeds, as well as any propagating material used commercially such as vegetable parts employed for assexual propagation. One must realize that the value of a seed is a function of its genetic potential. Agricultural productivity of good quality and quantity is achieved only by a proper combination of genetic quality with the more advanced agricultural practices. Some examples of genetic improvement are provided below.

Coffee: Coffee breeding was initiated in Brazil in 1933 at the Instituto Agronômico de Campinas, São Paulo. Fundamental basic research on taxonomy, cytogenetics and biology of flowering paved the way to improve coffee breeding. Table 3 shows the improvement achieved by selecting progenies of the Mundo Novo variety over previous ones. Subsequently new varieties were obtained with higher yield and important characteristics like resistance to rust (*Hemileya vastatrix*).

Maize. Maize is the major crop in Brazil with respect to cultivation area. Several official institutions have devoted a great amount of effort to maize research, both basic and applied. Studies on germplasm characterization, utilization and preservation have resulted in substantial knowledge of the genetic potential of races and varieties, both local and introduced. New breeding schemes, especially related to population improvement, have been developed employing methods of recurrent selection and reciprocal recurrent selection. Improved varieties have been obtained that were used per se by farmers and also as basic material to develop better inbred lines to produce superior hybrids. Table 4 gives the results of the evaluations of genetic improvement for grain or ear weight conducted by several investigators. It can be seen that the yearly progress is continuous. Besides grain yield, substantial improvements have been obtained in agronomic characters, such as reduction of plant and ear height, resistance to lodging, resistance to diseases, among others.

In the last 15 years, farmers started planting maize off season, sowing around February. This started in the State of Parana State, in substitution to wheat. This type of cultivation gave satisfactory results, so that, nowadays maize is grown almost all year round. In consequence, new breeding programs had to be created do develop cultivars, especially hybrids, adapted to the new season that includes winter.

Soybean. Until 1970 Brazil was planting very little soybean, representing only 2% of the world production. In 1998, due to the increasing economic importance and breeding programs, Brazilian soybean represents about 20% of the world production. Breeding programs were able to improve yields per unit area approaching those of the U. S. A. Although most soybeans are grown in Southern Brazil, genetic research developed varieties adapted to Central West and the North in Maranhão State. The progress achieved can be easily assessed, by the following figures: in 1961, grain yield was 1, 127 kg/ha, in 1980, 1,727 kg/ha and in 1998, 2,367 kg/ha. This corresponds to an annual increase of 31.6 kg/ha/year or a gain of 1200 kg/ha in 38 years of research. Besides grain yield, improvement was achieved also for protein and oil content and quality, and resistance to diseases.

Bean. Bean (*Phaseolus vulgaris*) is the main staple food and source of protein for Brazilian people. In Northern States cowpea (*Vigna unguiculata*) is also quite popular. A variety of *P. vulgaris*, Carioca, is the most cultivated and has been selected to obtain new strains. Improvements both in cultural practices and in genetic gain have been observed. Evaluation along 20 years have shown a total gain of the order of 42.6 kg/ha/year with the genetic progress being of the order of 14.5 kg/ha/year. (Abreu et al. 1994)

Rice. Rice (*Oryza sativa*) is the most consumed food in Brazil, about 75 kg per capita per year. Three kinds of cultivation are used:

a) irrigated with controlled flooding; b) humid lowland without controlled irrigation and c) dryland. In dryland cultivation areas with low levels of water deficiency and adequate soil fertility and areas where low dry periods are frequent are used.

Rice breeding programs are underway by official institutions, both for irrigated and for dry land cultivation. Evaluations made by Soares and Ramalho (1993) and Rangel *et al*. (1996) have shown, for a period from 1974 to 1996, a genetic gain of 33 kg/ha/year for dry land and 44 kg/ha/year for irrigated rice.

Wheat. In Brazil *Triticum aestivum* is the most cultivated type of wheat, and in small scale *T. durum*. Some areas of triticale are also found. Even though Brazil imports most of the consumed wheat, programs for wheat improvement have been conducted with satisfactory success. From 1970 to 1996, a continuous trend in yield of the order of 38 kg/ha/year has been estimated, from which the genetic contribution is 17 kg/ha/year (Nedel 1994).

Temperate fruits. Several fruits of temperate climate are grown in Brazil, namely: apple, peach, nectarine, pear, plum, fig, strawberry and European nuts. Quite successful breeding programs have been conducted especially with apple, peach, pear and plum. Originally these species were not adapted to Brazilian climate, since they needed large periods of very low temperature to induce flowering. Genetic improvement was realized essentially through the evaluation of a great number of progenies, selecting the ones that require only a moderate period of cold to flower. In sequence, fruit quality like flavor, acidity, and other attributes are taken into consideration. Apple production in Brazil rose from 16,000 ton in 1977 to 495,000 ton in 1995. Productivity estimated from 1984 to 1995 showed a gain of 0.6 ton/ha/year. The country has become an exporter for very demanding markets. Varieties of the other mentioned temperate fruits adapted to Brazilian climate have been obtained, especially, peach, nectarine, pear and plum.

Eucalyptus: Introduced from Australia in the second decade of this century, eucalypt found a good environment in Brazil. It became the most important wood for general use. The area planted with eucalyptus rose from 700.000 ha in 1960 to 3.500.000 ha in 1998. Selection of genetic material has been done both by official and private institutions, resulting in significant improvement, as can be seen by a productivity of 20 m^3 /ha/year in 1960 that increased to 40 m^3/ha/year in 1998. About 50% of this gain is attributed to genetic improvement (Ferreira and Santos 1997). Liming phosphate fertilizers as well micronutrients, mainly boron and zinc, play a major role in the productivity of Eucalyptus and the quality of wood and fiber.

Vegetables. Until the forties most vegetables grown in Brazil were imported varieties that were more adapted to the local winter season. Almost no adequate adaptation existed for the summer, when vegetables become more important. Subsequent breeding programs were able to develop better adapted varieties both for the local winter and more importantly for summer. Main vegetables are: lettuce, carrot, brassicas (cabbage, cauliflower, broccoli), onion, eggplant, tomato and cucumber.

Citrus. Brazil is a leader in orange and the major exporter of orange juice. Several varieties are available and significant improvements were made regarding disease resistance. The production of nuclear clones to obtain stocks free from virus represented a significant advance in citrus production. Improvements of grafting techniques, including micrografting, further contributed to improve citrus production.

Integrated Pest Management

Pest control evolved to the point that a balance of different techniques has to be made: i.e. protection of environment, biological control, chemical control, genetic resistance of the plants, cultural practices. Depending on the pest intensity of infestation, local conditions and other factors, the most appropriate techniques or combination of techniques are employed.

In sugarcane the borer *Diatraea saccharalis* is the most important pest. In the past native flies have been used as parasitoid such as *Metagonistylum minense* and *Paratheresia claripalpis*. A parasite introduced from Trinidad Tobago *Cortesia flavipes* was shown to be much more efficient and is widely used . In the seventies with 10% infestation there was a loss of 100 million dollars annually. Today, thanks to the new parasites, the infestation is of the order of 2%, in spite of a much larger sugarcane area that is twice the as previous one (Macedo et al 1993).

In soybeans the worm *Anticarsia gemmatalis* is efficiently controlled by the *Baculovirus anticarsia*. In many other crops, like pastures, wheat, tomato, cotton, citrus, pests are being controlled using a combination of techniques representing Integrated Pest Management.

Plant Nutrition and Fertilizing

No adequate plant development can be obtained without an adequate supply of nutrients. A considerable improvement on plant nutrition and fertilization was responsible for most of the increase in productivity obtained for many crops in Brazil. It is proper to quote the later great P. R. Stout from Berkeley: “There is no miracle seed without fertilizer”.

Malavolta (1999) presented a review of plant nutrition and adequate fertilization of the most important crops in Brazil, together with the needs to correct poor soils like the “cerrados”. The use of new areas to increase food and fiber production have been the general rule in many developing nations, including Brazil. This strategy represents a significant cost, even in money, compared to the rational use of fertilizers, besides the area that is saved.

The Conquest of the Cerrados

About 24% of Brazil is “Cerrado”, a soil type of savanna. Due to many deficiencies, “cerrados” were considered, several years ago, completely inappropriate for agriculture. Although there are different types of “cerrados” with regards to levels of nutritional defficiencies, the main constraints are high acidity, aluminum toxicity, and unavailability of most phosphorus for the plants. Thanks to basic studies to identify and understand the soil limitations, it has been possible to develop strategies to improve these areas, resulting in satisfactory productivity as can be seen on Tables 5 e 6.

The following point should be highlighted: the present generation inherited “cerrado” soils inappropriate for agriculture, since they were degraded by Nature. Due to scientific findings and proper management it delivering to the next generation a soil with good agricultural potential, which represents a significant sustainable approach.

Agriculture in the Amazon

Alvim (1999) presents an excellent report of the main factors related to possible and potential utilization of the Amazonian area in Brazil. Climate, vegetation and soil limitations are considered. Regarding the potential utilization for agriculture, Table 7 presents the condition for Continental Amazon. It can be seen that there is not a single environment typical of the Amazonian area, but different physical, biological, climatic and socio-economic aspects should be taken into consideration to indicate the most appropriate system for agricultural activity. The main systems for agricultural utilization of the Amazonian region is presented by Alvim (1999), identifying the following: perennial crops, forestry, pasture and annual crops. All these systems, if employed in the appropriated areas and using adequate techniques are quite sustainable.

VI - Conclusion

There are a number of agricultural systems, activities and managements. Scientific research evolved to the point where a substantial productivity can be obtained on various environments. High technology in agriculture should not be viewed as something against nature but, once properly applied, as a provider for enough food and fiber without the continuous need to use additional areas and clearing of forests. The examples reported show the benefits of scientific research and its applications to improve productivity, and at the same time providing a sustainable agriculture.

A World Commission on Environment and Development stated some time ago (York 1989): “Sustainable agriculture is to increase agricultural productivity and thus insure food security, while enhancing the productive capacity of this natural resource base in a sustainable manner”. Another similar statement made by York

(1989) considers: "Sustainable as the successful management of resources for agriculture to satisfy changing human needs, without degrading the environment or the natural resource base on which agriculture depends".

The following statement by York (1989) is pertinent as a final comment:

"But the challenge of achieving sustainable agricultural systems around the world cannot be solved by agricultural interests alone. Indeed, sustainability is threatened far more by forces outside agriculture than from within".

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TABLE 1: COMPARATIVE CAPABILITIES OF VARIOUS TYPES OF AGRICULTURE IN RELATION TO HUNTING. (ADAPTED FROM STORK AND TEAGUE 1952 AND BORLAUG 1972).

System	Area required (ha)	Number of people fed
Hunting (1)	2500	1
Foraging (2)	250	1
Hoe Agriculture (3)	250	3
Plow Agriculture (4)	250	750
Modern Agriculture (5)	250	3600

(1) Indians of the North American plains (before European influence)

(2) California Indians (before European influence)

(3) Eastern wood-land Indians of North America (before European influence)

(4) Ancient Egyptian agriculture

(5) Highly developed modern agriculture of the USA (based on 1970 yields).

Table 2: Comparison between temperate and tropical climate for maize production.
(Adapted from Brewbaker 1985 and Paterniani 1990).

Characteristics	Temperate	Tropical
	GROWING CONDITIONS	
Yearly climatic variation	Relatively stable	Variable, unpredictable
Yearly rainfall variation	Relatively uniform	Variable, unpredictable
Rainfall among locations	Relatively uniform	Variable, unpredictable
Photoperiod	Longer days	Shorter days
Night temperature	Cooler	Warmer
Soil conditions	Usually favorable	Frequently adverse
Sowing period	Very restricted (few days)	Very broad (Several months)
Growing period	Well defined	Variable, broad
Germination constraints	Cold soil and fungi	Soil insects
Weed infestation	Medium	High
Insects of stored grain	Low infestation	High infestation, frequently started in the field
	TYPES OF MAIZE PLANTS	
Maturity cycle	Uniform adapted to the growing season	Variable, to adapt to climatic and socioeconomic situations
Plant height	Medium to short	Usually large
	INFRASTRUCTURE	
Distances among locations	Shorter	Larger
Transportation and communication	Usually satisfactory	Usually unsatisfactory
Number of researchers	Adequate	Inadequate

Table 3: Comparison among original varieties of coffee Arabica with improved and selected materials in São Paulo, Brazil. (Adapted from Carvalho and Fazuoli 1993).

Cultivar	Yield	
	kg / há	%
Arabica	745	100
Red Bourbon	1333	179
Yellow Bourbon	1745	234
Mundo Novo (no selection)	1360	182
Mundo Novo (with selection)	2340	314

Table 4: Average gain in grain yield of maize due to genetic improvement according several evaluations.

Period	Yield increase kg/ha/year	References
1946 to 1986	60[1]	Paterniani 1990
1964 to 1983	72 to 109[2]	Vencovsky et al. 1986
1970 to 1990	31 to 51[1]	Araújo 1995
1964 to 1993	123[2]	Fernandes and Franzon 1997

[1] *Weight of grains*

[2] *Weight of ears*

Table 5: Grain and coffee production and Productivity in Brazilian Cerrados (EMBRAPA/CPAC 1996).

Crops	Production in 1000 ton (% Brazilian Production)		Increase	Productivity ton/ha		Increase
	1975	1993	%	1975	1993	%
Soybean	2.3 (3.1)	9.4 (41.5)	309	1.32	2.2	67
Maize	1.8 (17.3)	7.0 (23.2)	289	1.57	2.7	72
Rice	2.2 (42.8)	1.9 (19.1)	-.16	1.03	1.2	16
Bean	0.3 (13.1)	0.5 (19.9)	63	0.48	0.7	48
Coffee	0.08 (3.2)	0.5 (21.2)	575	0.82	1.3	62

Table 6: Production of main crops and beef in Brazilian "Cerrados" (Macedo 1995)

Activity	Area (10^6 ha)	Productivity (t / há / year)	Production (10^6 t)
Crops (no irrigation)	10.0	2.0	20.0
Crops (irrigation)	0.3	3.0	0.9
Beef (pastures)	35.0	0.05	1.7
Total	45.3		22.0

Table 7: Potential utilization of Continental Amazonian soils for agriculture. (Sanchez *et al* 1982).

Potential Use	Million hectares	%
Soils with no limitation	32	6
Usable soils with fertilizers	280	58
Soils practically not usable (1)	176	36
Total	488	100

(1) Due to topography, drainage and other physical limitations

The Role of Biological Nitrogen Fixation to Bio-Energy Programmes in the Tropics

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Introduction

The "Proalcool" programme initiated by the military regime after the two oil crises in the Seventies prompted a search for other renewable resources and their potential uses. Four million cars, vans, and small trucks in Brazil use ethyl alcohol produced by the fermentation and distillation of sugar cane for fuel. This is even mixed (22 percent) with petrol without damaging engines. On the other side, global society is based on oil which has been accumulating as subsoil reserves for thousands of years and will be finished soon (estimates 2050). In tropical regions, there is much more sun energy and therefore, chances of replacing petrol by biofuels are better potential alternatives. Progress made in all areas of biomass energy production, has been much greater per unit expenditure than progress achieved in the pursuit of nuclear fusion (Rosillo-Calle et al. 1994).

Sugar cane has been grown in Brazil for many decades with low or zero applications of nitrogen fertilisers. There are many areas in the country where sugar cane has been grown for decades, even centuries, and neither cane yields, nor soil N reserves, appear to fall with time, despite this apparent deficit in N supply. These results have led to research concerning the contribution of biological nitrogen fixation (BNF) to the maintenance of cane productivity. Recent results have shown that contributions up to 150 kg N ha^{-1} yr^{-1} can be obtained from the biological reduction of atmospheric nitrogen. Several nitrogen fixing bacteria colonise the hole plant and some of them live inside the plant which can fix the nitrogen and transfer it direct to the plant tissue. The screening of plant genotype for higher contributions of BNF has been cited to be the key to the replacement of N fertilisers in several important crops like sugar cane, rice, wheat, maize and others. Also diesel can be mixed with oil palm (around 20%) without any engines modification. African oil palm is the best alternative for the replacement and also is colonised by several nitrogen fixing bacteria. Biofuel are much more compatible with environmental preservation and as a renewable resource must be stimulated by the government.

The Brazilian Bio-Ethanol Programme

The elimination of N fertilisers for biofuel crops represents the key to high energy balances because these fertilisers are produced by the reduction of atmospheric N_2 to NH_4, using petrol or gas. The Brazilian ethanol programme is the best example of biofuel (Dobereiner, 1994). Sugar cane grown in Brazil for centuries, never received high N applications and therefore the genotypes grown today obtain significant contributions from biological N_2 fixation (BNF). When grown with ample P and K fertiliser and foliar application of molybdenum (500 g ha^{-1}) this crop may obtain more than 50 g N/m^2 during three years from BNF which means by extrapolating from the plot size of 2.7 m^2, the mean annual contribution to some commercial hybrids of sugar cane CB 45-3 and SP70-1143 a range from 170 to 210 kg N ha^{-1} (Table 1). These data confirm the differences between plant genotypes.

Sugar cane is now planted on 5.0 million ha in Brazil, 9% of the land under agriculture. With mean yields of 64 tons per ha, in addition to sugar, 10-12 billion litres of ethanol are produced per year, equivalent to 200.000 barrels of petrol per day (present situation). Although petrol prices all over the world currently are relatively low, the government of Brazil is convinced of the social and ecological impacts of the biofuel programme and plans to support it further. The key to the success of the Brazilian bio-ethanol programme is the high energy balance obtained in Brazil as shown in Table 2.

Table 1: Contributions of Biological N_2 fixation (BNF) to different sugar cane genotypes, evaluated by N Balance and ^{15}N dilution methods during tree years (Urquiaga et al.1992).

Cane Genotype	Total N accumulation in kg N/ha (3 yr)	BNF contribution in kg N/ha (3 yr)	
		N Balance	^{15}N dilution
CB 47-89	614 bc	397	348 c
CB 45-3	843 ab	626	526 b
NA 56-79	578 c	361	326 c
IAC 52-150	596 bc	379	338 c
SP70-1143	775 bc	558	519 b
SP71-799	569 c	352	333 c
SP70-2312	636 c	419	354 c
Chunnee	330 d	113	169 d
Caiana	11.6 d	- 101	67 d
Krakatau	1028 a	811	718 a

Nota: Differences between means significant at P = 0.001. NS, no significant differences between means at P = 0.05.

Due to the high N contributions the Brazilian sugar cane genotypes obtain from BNF, it is now recommended to the farmers to plant certain plant genotypes, CB 45-3 or SP70-11-43 without any N fertiliser and to use the money otherwise used for N fertilisers for increased phosphate applications, foliar spraying of Molybdenum, the key minor element for BNF, and irrigation. Elimination of leaf burning before harvest also increases the sugar cane yields and reduces the N applications as the leaves can contribute to the maintenance of the N in the system (Oliveira et al. 1994; Boddey, 1995). In addition it increases soil fertility and reduces irrigation needs. The higher labour need for cutting unburned sugar cane provides more jobs in the interior and costs are compensated by further increased yields.

The Brazilian Alcohol programme has already created more than one million jobs, decreasing the over-populations in large cities. Elimination of cane burning also will further reduce air pollution in addition to the negative greenhouse effect, by removing more CO_2 from the atmosphere. The use of biofuels has already reduced the lead content in the atmosphere of large cities by 75% and vehicles running on ethanol have zero lead emissions. Cars running on ethanol also emit 57% less CO, 64% less hydrocarbons and 13% less NOx than cars running on gasoline (Bohn, 1986). The only pollution problem is the smoke and soot produced by burning off the sugar cane trash (senescent leaves) before harvesting. Nowadays, more and more producers are using machinery's to harvest the sugar cane and around the cities it is already forbidden to burn, reducing further the pollution problems.

Ethanol production increased to 11,900 M litres by 1985 and by 1988, 88 per cent of the new cars being sold were powered by ethanol engines. It reduced drastically in 1995 to 3%. Unfortunately, with the decline in price of petrol, there were no interest of the government to continue this program (Figure 1).

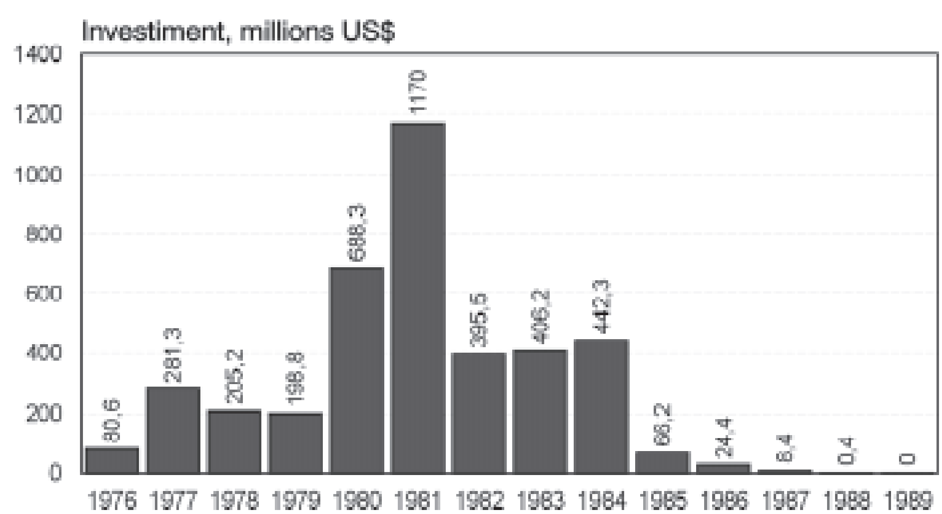
TABLE 2: ENERGY BALANCE OF ETHANOL PRODUCTION FROM SUGAR CANE UNDER BRAZILIAN CONDITIONS (BODDEY, 1995).

	ha^{1} year^{-1}
a. Mean crop yield	65 t
b. Mean ethanol yields	3,564 litres
Energy produced	
c. Ethanol	18,747 Mcal
d. Residue (bagasse)	17,500 Mcal
e. Total (c + d)	36,297 Mcal
Energy expended	
f. Agriculture	4,138 Mcal
g. Factory	10,814 Mcal
h. Total (f + g)	14,952 Mcal
i. Energy gain (h - e)	21,345 Mcal
j. Overall energy balance ratio (e/h)	2.43
k. Net energy balance ratio assuming all factory power derived from bagasse[a] (c/f)	4.53
l. **Net energy balance ratio (k) but assuming** zero nitrogen fertiliser use[b]	5.79

[a] *Virtually all distilleries derive all heat and electricity from bagasse. Some sell excess bagasse as fuel to other neighbouring industries.*

[b] *Present mean N fertiliser use 65 kg^{1}N ha^{-1} year^{1}. Estimated energy cost 902 Mcal*

FIGURE 1: TOTAL BRAZILIAN GOVERNMENT INVESTMENT IN THE NATIONAL ALCOHOL PROGRAMME (PRO-ÁLCOOL) 1976 TO 1989 (BODDEY1993).



The key to the success of the Brazilian alcohol programme was the continuous selection of plant genotypes with N fertiliser applications much below the plant needs. With this approach, sugar cane genotypes were selected which associate with N_2 fixing bacteria using sun energy products of the plant to reduce the atmospheric N_2 into NH_4. N fertilisers are produced from atmospheric N_2 using petrol for the reduction process. High N applications, as recommended by the "Green Revolution" make any bio-energy programme senseless because the same amount of energy is used to make the biofuel as is obtained. For this reason, so far, Brazil is the only country in the world where biofuel programmes are energetically viable. The overall energy balance of ethanol production on Brazil is 2.5. If bagasse is used to produce all factory power, the energy balance increases to 4.5 and if in addition all N fertilisers are eliminated, it increases to 5.8 (Boddey 1993) With all these practices Brazil has been using the lowest N applications among all other countries (Dobereiner, 1997).

Palm Oil as an Alternative for Diesel Oil

The African oil palm (*Elaeis guineensis*) was introduced in Brazil, South of Bahia State in the XVI Century by the African slaves. Only in the 70´s, a stimulus in the production of this oil occurred due to the increase of its price in the world market and Pará State turned to be the highest producer in Brazil. Malaya is the biggest producer in the world contributing with more than 50% of the world production and also is the highest exporter country (64%). Brazil is responsible for only for 0.6% of the world production although palm oil the second one in production (18.49%) and consumption (20.40%) in the world.

The African oil palm seem to be the most interesting crop from the point of view of yield production. It may produces 4.0 - 8.4 t oil $ha^{-1}yr^{-1}$ and it has the highest energy yields (Table 3).

Another promised crop is peachpalm (*Bactris gasipaes*) that is also grown in the wet tropics and is already exploited commercially for palm hearts and its high yields of edible fruits. Besides oil, the starch meal can be converted into alcohol. This crop can also produces all over the year as the African oil palm with yield of 4.8 t oil $ha^{-1}yr^{-1}$ corresponding to 57 kcal $ha^{-1}.yr.^{-1}$ (Purseglove, 1968). In contrast, soybean produces only 0.6 t oil $ha^{-1}yr^{-1}$ during its crop cycle (120 days). Palm trees like African oil palm, can maintain a permanent large leaf area and root system and continuously produce, if well managed, for more then 20 years. This crop can also be harvested continuously throughout the year, requires a simple pressing process to produce the final fuel and release much less effluent to dispose of. It can also be grown on extremely poor soils and it is well adapted to wet tropic climate and represents a desirable tree alternative in forest areas. The main disadvantage is the high costs to establish the crop (1,866.21 US$/ha until the first harvest – Agrianual 97) and the long period of time (4 years) it takes until the first harvest.

Attempts have been made to convince the Brazilian government about the advantages of replacement of diesel oil by palm oil, which could create thousands of jobs for the poor population in the North and Northeast of the country. If the African oil palm would be planted in 30% of the area already deforested in the Amazon region, it could produce enough palm oil to replace all diesel oil used in Brazil which means around 460.000 barrels of diesel per day (Boddey, 1993).

Table 3: The agricultural and energy yields of the most promising crops (Dobereiner et al., 1981)

	Crop yields t/ha.yr			Fuel yields [a]		Energy yields
	Actual means	Estimated potential	Type	L/t	L/ha.yr	TOE/ha.yr [a c]
Sugar crops						
Sugar cane	60	90	ethanol	67	4020	2.1
Sugar beet	30	56	ethanol	67	2010	1.0
Sweet sorghum (stems)	35	50	ethanol	55	1925	1.0
Starch crops						
Sweet sorghum (grains)	3	5	ethanol	30	1080	0.6
Cassava	13	40	ethanol	180	2340	1.2
Sweet potatoes	15	30	ethanol	125	1875	1.0
Maize	3	6	ethanol	360	1080	0.6
Babassu palm nuts	3[b]	25[b]	ethanol	80	240	0.1
Oil crops						
Babassu kernels	0.6	5	oil	37	22	0.02
African oil palm	18	38	oil	210	3780	3.7
Wood crops (25% H_2O)						
Eucalyptus or others	16	30	ethanol	159	2544	1.3
Eucalyptus or others	16	30	methanol	330	5280	2.7
Fire wood	16	30	wood	-	-	4.8

[a] *Calculated from present mean yields*

[b] *Present means are from extraction of native trees and potential are from cultivated plants.*

[c] *Calculated on the basis of: ethanol 5,120, methanol 5,034, oil 9,723 kcal/L and wood 3,000 kcal/kg and 10^7 kcal = 1 TOE.*

The possibility of running diesel motors on vegetable oil has been known since the work of Rudolf Diesel in 1911. The replacement of diesel oil by palm oil, which is used mainly in trucks and tractors would be of a tremendous beneficial effect to the environment, because oil palms take out more CO_2 from the atmosphere than would be returned by trucks, causing a negative greenhouse effect. Diesel oil can be mixed with up to 20 % palm oil without any need of change to the motor of trucks and buses. However, a further increase would require considerable modifications to the engine design, that are already available and have been sold by a German company Eslsbett Elsbett. Vusof Basiron and Ahmad Hitan estimated the cost of the use of oil palm in a car Mercedes 190 D using an Eslsbett Elsbett motor. A car powered with this engine runs 35,000 km without any technical problem using 6 litres of fuel per 100 km in urban area and 7 km on the road, with 30% superior performance than the normal diesel. The cost were estimated as 4.80 cents per km for oil palm fuel versus 5.87 cents using diesel.

Like in sugar cane, no high N fertiliser doses were applied on palm trees. The reason might be because commercial plantations of oil palms are mainly carried out in the poorest regions of the country that is, the North East and the Amazon region and because of the very little commercial use of these palms.

Species from the complex Orbignya-Attalea-Maximiliana are observed naturally in 16 million of hectares in Brazil and is normally called Babassu, which is actually the palm which also has a high extractive potential in the continent. Under natural conditions the productivity reaches around 150 litres of oil ha^{-1} and has a potential of up to 1 ton of oil per hectare after domestication. Babassu is exploited for the oil rich kernels and also the whole nut can be used as an energy source (IPT, 1979). There exists approximately 3,000 species of palm trees around the world of which about 1,600 occur in the American tropics region.

N_2 Fixing Bacteria Colonizing Sugar Cane and Oil Palms

Sugar Cane

During the 1950s two species of diazotrophic bacteria were found in high numbers in the rhizosphere of sugar cane. One of them was a new species called *Beijerinckia fluminensis* (Dobereiner and Ruschel 1958). These bacteria however only occur in soil and therefore the N_2 fixed by them is only partially available to the plant. In the 1970s a new genus, *Azospirillum* was described which also survives in soil and is enriched in the rhizosphere of various Gramineae including maize, rice, forage grasses, sugar cane and palm trees and which contains some specific strains which are able to infect the plant and multiply within plant tissues (Schloter et al., 1994).

Only at the end of the 80´s, aerial parts of plants, specially sugar cane that has a lot of carbon in the stems, was used for isolation and quantification of diazotrophic bacteria. This new habitat enabled the discovery of new species that colonise the plant interior without exhibiting any symptom of disease. In 1988, a new species of the Acetobacter family was found inside the sugar cane and was called *Acetobacter diazotrophicus* (Cavalcante and Dobereiner 1988, Gillis et al., 1989). Recently, these kind of organisms that live inside the plant tissue residing latently or actively colonising locally or systematically and do not showing visibly harm the plant and in some case improving plant growth and reduce disease symptoms caused by several plant pathogens, which do not survive in soil and which are transmitted within plant cuttings or seeds (Kado, 1992; Chen et al., 1995; Frommel et al., 1991; Kloepper et al., 1992; Pleban et al., 1995, Halmann et al., 1997). More recently however, two new species of N_2 fixing were reclassified as endophytes, (Dobereiner et al., 1994; Baldani et al., 1997) such as *Herbaspirillum seropedicae* (Baldani et al., 1986) and *H. rubrisubalbicans* (Gillis et al., 1990) and another new species was described colonising rice, maize and also sugar cane and was named *Burkholderia brasilensis* (Baldani, 1996).

A. diazotrophicus was first isolated from sugar cane and since then it was only isolated from *Pennisetum purpureum*, sweet potato and recently from coffee plants (Reis et al., 1994; Jimenez-Salgado, 1997). Comparing the survival outside the plant tissue from these endophytic bacteria, *A. diazotrophicus* was never found in the soil and inoculations of sterile and natural soil failed to isolate the bacteria (Baldani et al., 1997). It means that this organism needs the sugar cane tissue to survive and to pass to the next crop. In sugar cane, *Acetobacter diazotrophicus* was found colonising the roots, stems, leaves, trash (Reis et al., 1994) and internally was found in the xylem (James et al., 1994) and in the apoplast space in Cuba (Dong et al., 1994).

Using a model system to study the transference of the N fixed by this bacterium Cojho et al., (1993) used a mixed culture with a yeast and observed that more than half of the N_2 fixed by the bacteria could be liberated to yeast and suggesting that the plant also can obtain this amount of N. *Acetobacter diazotrophicus* seems well adapted to these sugar cane tissue as it shows the best growth with 10% sucrose and at pH 5.5. In addition, this bacteria does not poses a nitrate reductase, being able to fix N_2 in the presence of high levels of NO_3 (Cavalcante and Dobereiner, 1988). In the presence of 10% sucrose the NH_4 assimilation by this bacteria is only partially reduced (Boddey et al., 1991; Reis et al., 1998). This bacterium has also its nitrogenase activity only partially inhibited by ammonium (Stephan et al, 1991) and in the presence of 10% sucrose, the enzyme continues to fix nitrogen (Reis et al., 1998). Also, in the presence of high sucrose, the inhibition by oxygen, which damage the nitrogenase system, is less sensitive, maybe by the osmotic protection as the diffusion in the level of sucrose (10%) is reduced (Reis et al., 1998). These characteristics enable the bacteria to fix N_2 in complementation to N assimilation by the plant from soil.

In addition, two new species of *Herbaspirillum* were also found colonising endophytically sugar cane roots, stems and leaves (Baldani et al., 1996a). *Herbaspirillum seropedicae* was originally isolated from rhizosphere soil, washed roots and surface sterilised roots of maize, sorghum, and rice (Baldani et al., 1986), but not from uncropped soil (Baldani et al., 1992). *H. seropedicae* was originally thought to be a new species of *Azospirillum* by its similar growth characteristics in the semi-solid, N-free media. However, further analysis showed that it was a new genus (Baldani et al., 1986). Until now, this bacterium has been reported in 13 members of the Gramineae, normally colonising roots (Olivares et al., 1996) but was also found in the aerial parts of rice and maize as well in stems of sugar cane, but not in leaves (Olivares et al., 1996). In 1990, Gillis et al. reclassified *Pseudomonas rubrisubalbicans*, which causes the mottled stripe disease in sensitive sugar cane varieties, as *H. rubrisubalbicans*. With this new reclassification, another group was identified as "species 3" but includes only non-diazotrophic bacteria and is mainly isolated from clinical material, such as wounds and feces, although a few strains have been isolated from sugar cane, sorghum and maize (Baldani et al., 1996a). This two species of diazotrophic bacteria have very similar physiological characteristics and they can differ only in the utilisation of meso-erythritol (as sole carbon source) by *H. rubrisubalbicans* and N-acetylglucosamine by *H. seropedicae* and these characteristics are used to separate them. Also the optimal growth temperature (30°C, *H. rubrisubalbicans*; 34°C *H. seropedicae*) and by the use of oligonucleotide probes (Baldani et al., 1996a). *H. rubrisubalbicans* is less common, and could be isolated mainly from sugar cane and in less frequency from sorghum, (Hale and Wikie, 1972 a,b) rice, palm trees (Baldani et al., 1997) and *Miscanthus* (Kirchhof, et al., 1997).

Microscopy studies were performed to compare mottled stripe-disease susceptible variety of sugar cane (cv. B-4362 – Barbados) and the resistant one (cv. SP70-1143 – Brazil) and the difference was great. In the susceptible plant, the xylem vessel was completely blocked, intercellular spaces and substomatal cavities by the growth of *H. rubrisubalbicans.* In the resistant variety SP70-1143, bacteria were restricted to microcolonies encapsulated within polymeric material (Olivares et al., 1997). James et al., (1997) inoculated this two species of bacteria in sorghum leaves and observed that both posses the same behaviour, forming microcolonies in sorghum leaves. A complete review of this two endophytic bacteria was done by James and Olivares, (1997).

Recently, another new endophytic N_2-fixing bacterium, *Burkholderia brasilensis* which grows best at pH 4.5-5.5 was described by Baldani et al. (1996b). This species was also isolated from sweet potato, rice and cassava. Also, a few strains of another species of *Burkholderia* were isolated from sugar cane plants collected from Pernambuco. These strains are very close related to *B. brasilensis* and any the physiological testes could differentiate them until now. The only way is to use the probes produced for each type strain using 23S rRNA variable sequence. This result suggest that these strains belong to two different species (Kirchhof et al., 1997).

The endophytic occurrence of these diazotrophs may now explain the high contributions sugar cane can obtain from BNF observed by Lima et al., (1987), Urquiaga et al., (1992) and Yoneama et al., (1997). The amount of N obtained from BNF and the difference between cane genotypes is shown in Table 1.

Palm trees

Until now, only two reports showed the presence of diazotrophic bacteria belonging to the *Azospirillum amazonense* species were found colonising roots of palm trees (Magalhães et al., 1983; Magalhães and Dobereiner, 1984). Recent, attempts were carried out to isolate similar endophytic diazotrophs from palm trees at various sites in Brazil including Amazon and South Bahia (Table 4). Numbers of diazotrophic bacteria were higher in roots as compared to the other part of the plants. Also the endosperm of the seed is colonised by these microorganisms. Oil palm (*Elaeis guineensis* - Dendê) and Peachpalm (*Bactris gasipaes* - Pupunha) are colonised by *Azospirillum brasilense*, *A. amazonense*, *A. lipoferum*, *Herbaspirillum seropedicae* occurred in oil palm while *Azospirillum brasilense*, *A. amazonense*, *A. lipoferum* and *Beijerinckia* spp. were found colonising peachpalm. Also other as-yet-unidentified N_2-fixing bacteria were present in these two palm trees. These unidentified bacteria are present in the roots, stems, leaves and in the endosperm of the fruit. Preliminary results suggest that a new *Herbaspirillum* species is present in roots, stems and leaves of these palm trees (Ferreira et al. 1995). In the literature, there is only one report showing occurrence of *Azospirillum* spp. in oil palms grown in Malaya (Shamsuddin et al., 1995).

Table 4: Occurrence of diazotrophic bacteria in tree different genotypes of oil palm collected in the South Region of Bahia State (Numbers of cells per gram fresh weight) (Carvalho and Dobereiner, in preparation).

Genotype	Washed Roots		Sterilized Roots		Leaves	
	JNFB	LGI	JNFB	LGI	JNFB	LGI
Dura	1.3 x 10^5	2.0 x 10^5	6.2 x 10^3	n. d.	n. d.	1.0 x 10^2
Tenera	4.1 x 10^6	1.5 x 10^5	1.4 x 10^5	1.9 x 10^4	1.0 x 10^2	1.0 x 10^2
Native	5.3 x 10^6	5.6 x 10^4	n. d.	n. d.	9.0 x 10^2	n. d.

JNFB semi-specific media used for isolation of Herbaspirillum *species.*

LGI semi-specific media used for isolation of A. amazonense.

Carvalho, (1997) used a mixture of strains including *H. seropedicae* (Z67), *Burkholderia brasilensis* (M130) and *A. lipoferum* (Sp260) in an inoculation experiment with African oil palm and peachpalm plants. The author also used a mixture of 3 isolates from African oil palm including 2 strains of *Herbaspirillum* (8A and 7C) and one strain of *A. brasilense* (23B). These experiments also included a treatment using mycorrhizae fungi *Glomus clarum* alone or in a mixture with the diazotrophic bacteria. These plants were dependent on N fertilisation during the first 6 months and the AM fungi increased N assimilation by the peachpalm and the African oil palm. The inoculation with diazotrophic bacteria alone or with AM fungi showed a better effect than the uninoculated control without nitrogen but it was lower than the N fertilisation for all parameters analysed.

The author also applied the same treatments to oil palm plants replacing one treatment by a mixture of 3 species of arbuscular mycorrhizal fungi and a mixture of strains: *A. lipoferum* Sp260 and Br 17; *H. seropedicae* Z67 and *B. brasilensis* M130 and the isolates from palm trees. An increase in stem height, stem diameter, height of the first leaf, leaf area and weight of the dry shoot and total N in roots was observed with inoculation of a mixture of all bacterial strains. It suggest that a better combination of diazotrophic bacteria must be tested.

Perspectives for the Future

All these new findings open perspectives for a replacement of diesel oil as well as gasoline by bio-energy sources which are much more compatible with environmental preservation and are renewable resources. The substitution of these derivatives of petroleum is necessary to overcome these problems and the solution is renewable energy sources which are clean and originate from biomass. This is only possible in countries which possess sufficient reserves of land for the expansion of crop production along with a suitably warm climate and an abundance of rainfall as observed in Brazil and Nigeria

In the Conference held in Brazil in 1992 (ECO-92), the developed countries made several promises to reduce the global effects of the use of fossil fuels but this has not been done. Of course is not easy to change the society as the cost of petrol does not provide the necessary motivation. Also, the countries which are localised in temperate region have their lands are fully occupied. The Brazilian government must stimulate the use of these natural energy sources and also sell this technology or the product (ethanol) for the others, especially to cities where the air pollution is too high, such as Mexico city. Of course, the government must invest money to maintain the progress and reduce the global alterations in America. The use of oil palm oil as a fuel is the best option to reduce the use of imported oil as it is the requirement for diesel oil that is mainly responsible for the high demand for imported crude oil. Palm oil would be an ecological solution to replace diesel oil imported to the Amazon region.

In any case, a energy balance must be positive otherwise it is not viable. Biological nitrogen fixation can reduce the use of N fertiliser which is the most expensive and also needs fossil energy for its production. In sugar cane, even not replacing nitrogen fertiliser by BNF, the cost of production in Brazil are already the lowest in the world,. Here, the N fertilisation adopted by the farmers averages 60 kg N/ha and the productivity in the State of São Paulo (where 60 % of Brazilian sugar cane is grown) is around 80 ton fresh stems per ha. In United States, Australia, Mexico, India (maybe others) the N fertilisation is around 200-300 kg/ha. In Australia, using 200 kg N/ha and irrigation in much of the area, the productivity is only slightly above that of São Paulo (84 ton/ha). In these countries, the energy balance is much less favourable, even negative in some cases, and ethanol production from this crop is not viable (Pimentel et al., 1988).

In Brazil alcohol has been used as a fuel to replace gasoline in cars and light vehicles for almost 20 years and the air pollution of São Paulo city was considerably reduced (Bohm, 1986). Another important reason that we can not forget is that the oil from the African oil palm can be produced in the northern region were the cost of transportation of fuels is high. The PROALCOOL program together with the "DENDIESEL" program need political support.

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The Role of Biological Nitrogen Fixation in Land Reclamation, Agroecology and Sustainability of Tropical Agriculture

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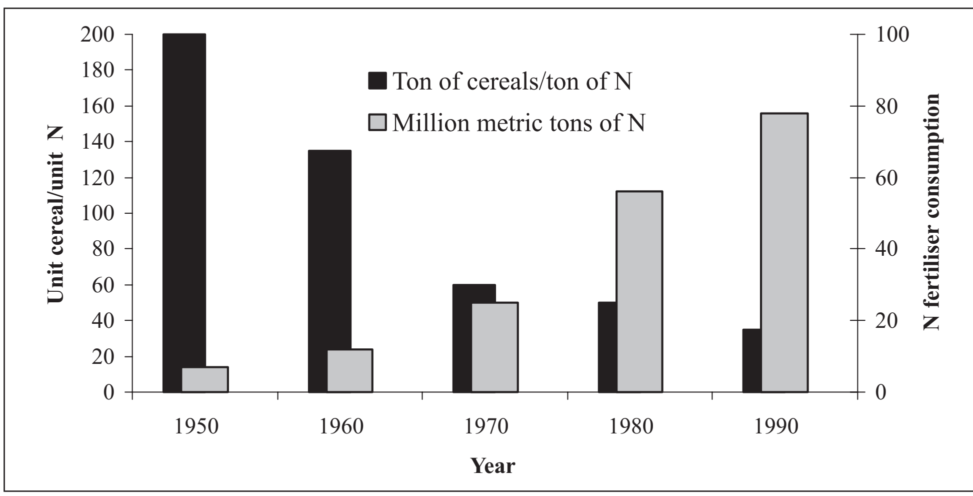
Introduction

The great worries about the population growth of the last half century has been beaten by the increase of food production, not only on acreage but also on productivity. By mid 1990's, total food supply reached 2,740 calories per person per day, far beyond the 2,200 calories per day generally accepted as the nutritional bottom line to maintain human life. The United Nations predict that supply will continue to grow faster than population at least through 2010.

The increase in fertiliser use, especially nitrogen, has played a major role in these productivity gains. However, increasing the amount of nitrogen applied decreases its use efficiency (Figure 1) and a large amount of it is left causing environmental problems. This will add to the wastes left from intensive animal production already the biggest source of pollution.

Figure 1 – Use and use efficiency of Nitrogen fertiliser (World Bank, 1992).



Plant products constitute 93% of the human diet and 66% of the world food supply is provided by about eight species of cereals (maize, wheat, rice, barley, sorghum and millet). The demand for cereals for the year 2025 as projected by Bourlaug & Dowswell (1997) (Table 1) is likely to be around 4.0 billions metric tons, although this may be an overestimation since they have based their predictions on the demographic growth of the preceding decade.

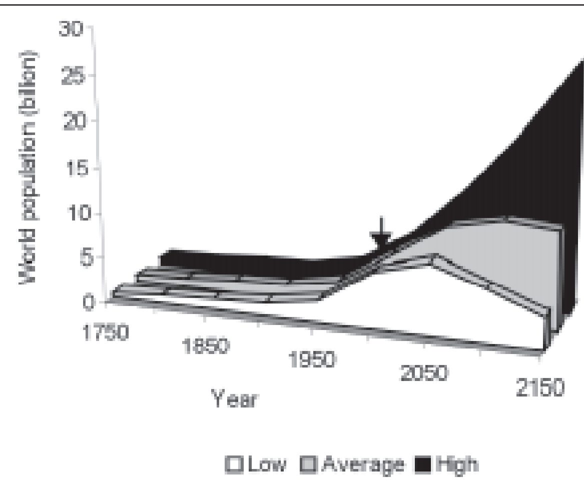
Table 1 – Population and world cereal supply of the world.

Year	Population[1] (Millions)	Food supply[2] (Million t)	Productivity[2] (t/ha)
1990	5,284	1,970	2.5
2000	6,185	2,450	2.9
2025	8,303	3,970	4.5

[1]*World Development Resort (1992);* [2]*Borlaug & Dowswell (1997)*

This decade the population rate has decreased world-wide below what had been projected a few years ago, and may decrease even more than previously expected as shown in the bottom line of figure 2. Considering the lower rate of demographic growth, food demand will not increase much more than is produced today. Hunger today is not caused by lack of food but mainly as a consequence of lack of proper distribution and for political reasons. Preventing losses during harvest, post-harvest handling and storage also may contribute to increase the availability of food. In Brazil more than 300 million dollars are lost annually during the soybean harvest and storage. The Brazilian farmer has the capacity to storage only 5% of the total harvest, while in Argentine they may store 50% of the harvest and in the United States twice the amount harvested (Pavan, 1998).

FIGURE 2 - WORLD POPULATION – PRESENT AND PROJECTED.



Contamination and degradation of the environment, atmospheric CO_2 accumulation and lack of clean water may be foreseen as the main problems of the next century. Therefore, the focus on feeding the people of the world must be changed to the production of clean food on a clean and sustainable environment.

The remaining frontiers for crop acreage increases have predominantly acid soils and low natural fertility. The combinations of toxicity (Al, Mn, Fe and H) and deficiencies (N, P, Ca, Mg, K and some micronutrients such as Zn, Mo, B, Fe etc.) are serious plant growth-limiting factors. To maintain high crop yields on these soils with chemical and mineralogical characteristics that still impose strong limitations to phosphorus availability (Muniz et al., 1985; Ruiz et al. 1988; Villani et al., 1990; Novais & Smith, 1998) represents a great challenge. Selection and development of crops species and cultivars that grow and produce well at lower levels of available soil nutrients (high nutrient use efficiency) seems an important strategy for sustainability in tropical soil systems (Bernardo, 1995; Barros & Novais, 1996; Grespan, 1997; Baligar & Fageria, 1997; Novais & Barros, 1997).

The enhancement of soil productivity is a combination of appropriate tillage practices, crop rotations and planting time, the application of soil conservation measures to reduce loss of nutrients, the strategic use of organic matter and mineral fertilisers in doses tailored to match farmer's combination of crops, availability of organic materials and market opportunities.

Soil organic matter has a very important influence on soil physical and chemical properties, on biological activities (Fassbender, 1987), and as a source of plant nutrients, especially nitrogen. The only exception to crops that are able to grow in soils depleted of organic matter, are those associated with diazotrophic bacteria, if nutrients other than nitrogen are available. Thus, instead of productivity alone, tropical agriculture in the next century must favour biodiversisty, the preservation of soil organic matter and efficient cycling of nutrients. BNF may play an important role on restoring fertility and sustainability under those conditions.

Nitrogen, even though its abundance in the atmosphere, is the most limiting nutrient for crop yields in many soils, while phosphorus is the most limiting nutrient under natural conditions in the tropics and the second most limiting plant nutrient for farmers. Considering that the production of nitrogen fertiliser is the most costly both economically and energetically, that less than half of the nitrogen applied is recovered by the first crop under tropical conditions and that it strongly contributes to pollution, thus nitrogen availability must be a priority in any attempt to increase clean food in a clean environment. In this context BNF by micro-organisms free living in the soil or associated with plants have a great potential to contribute to food production. BNF uses energy derived from photosynthesis and does not accumulate excess nitrogen to cause pollution. The use of fertiliser has been increasing and is already higher in developing than in developed countries that are also using less fertiliser since 92/93 (Figure 3). This may be a consequence of an excess supply that is projected to increase even further in the next few years (Figure 4). The high surplus of nitrogen fertiliser will certainly result in price decline.

Figure 3 - Consumption of fertiliser in the world (FAO 1998).

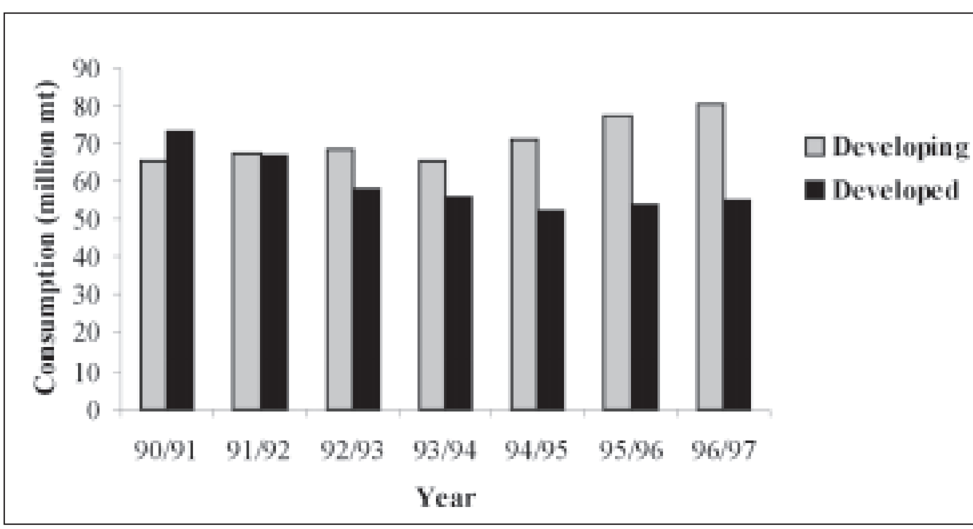
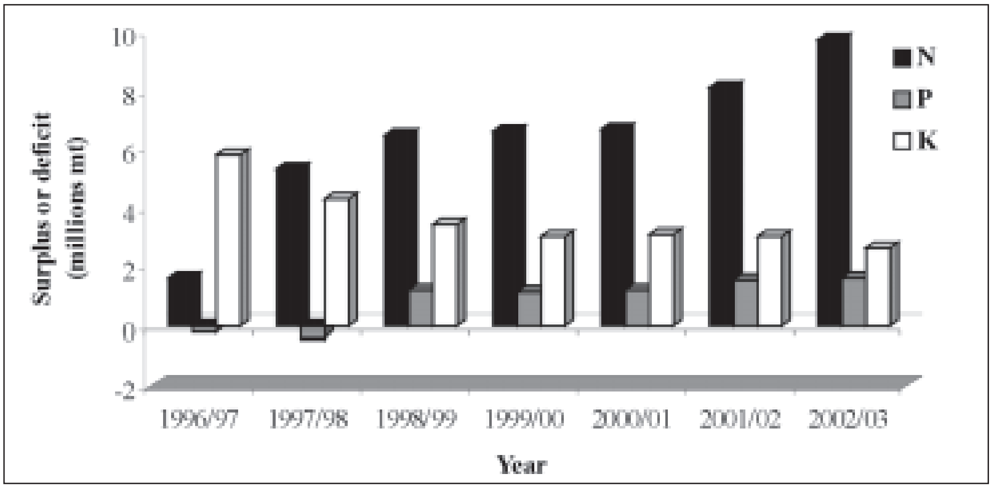


Figure 4- World N, P_2O_5 and K_2O supply and demand balance (extracted from FAO, 1998).



Yamada et al. (1998) estimated that, from 1993 to 1996, 1.05 million tons of nitrogen (=US$ 680 millions) were used per year in Brazil while BNF in the soybean crop alone has contributed to an estimated saving of US$ 1.5 billions every year in replacing N that would be required in nitrogen fertilisers. Even though the soybean crop in Brazil may be used as the best example of the contribution of BNF to food production and the country economy, the total nitrogen acquired is still insignificant when compared to the estimated total BNF contribution in natural ecosystems. The annual contribution of BNF in terrestrial environments has been estimated around 175 million metric tons. At present costs this would be equivalent to 148.5 billion dollars in nitrogen fertilisers (Elkan, 1992).

Biological Nitrogen Fixation in Agriculture

Many agronomic plant species associate with diazotrophic microorganisms able to fix atmospheric nitrogen. Among the legume species are the crops with highest potential for BNF already available to be used in the productive systems. Blue green algae, free-living in the soil or associated with the fern Azzola and endophytic associations between diazotrophic bacteria and gramineous and starchy species have also potential to be used in agriculture (Dobereiner et al., 1999). Table 2 presents some values on BNF in some crops. Even though the variability of conditions and methods where these values were obtained, they indicated the great potential of BNF already available. There are also experiments showing BNF contribution of 30 kg of N/ha.year in free-living cyanobacteria and up to 3 kg of N per ha per day in the symbiosis Azzola with cyanobacteria (Watanabe & Roger, 1984).

Biological Nitrogen Fixation in the Soybean Crop in Brazil

Last year, 153 out of 274 million tons of oil-producing crops were soybean. Of this total 30.6 million tons were produced in Brazil, the second largest world producer. In spite of high taxation, inefficient structure of storage and transport, that reduces

Table 2 – Amount of nitrogen fixed (kg/ha/year or cycle) by some leguminous crops and tree species

Plant specie	BNF kg/ha/year or cycle	%Ndda	Days	Country
Grain crops				
Soybean (*glycine max*)	114-188	84-87	66	Nigeria[1]
	85-154	70-80	110	Brasil[1]
Beans (*Phaseolus vulgaris*)	25-65	37-68	60-90	Brazil[1]
	3-32	15-72	61	Brazil[1]
	11-53	19-53	-	Brazil[2]
	18-36	32	47	Colombia[2]
	92-125	69-73	-	Guatemala[2]
Pigeon pea (*Cajanus cajan*)	68-88	88	-	India[1]
	168-208	-	-	[3]
Cowpea (*Vignia inguiculata*)	9-51	32-74	110	Brazil[1]
	73-354	-	-	[3]
	66-120	54-70	57	Nigeria[1]
Mung bean (*V. mungo*)	119-140	95-98	66	Thailand[1]
Chickpea (*Cicer arietinum*)	60-84	60-80	160	Australia[1]
Forage legume				
Leucaena (*Leucena leucocephala*)	500-600	-	-	[3]
Centrosema (*Stylosanthes pubescens*)	80-280	-	1 ano	Several[1]
Stylo (*Stylosantes spp.*)	20-263	-	1 ano	Several[1]
S. capitata	3-46	-	1 ano	Brazil[1]
Kudzu (*Pueraria phaseoloides*)	-	-	-	Colombia[1]
Tree species				
Acacia (*Acacia mearnsii*)	200	-	-	[3]
Gliricidia (*Gliridia sepium*)	-	26-75	-	Several[1]
A. auriculiformis e mangium	-	52-66	-	Several[1]

[1]*After Giller e Wilson (1991);* [2]*After Hardarson (1993); Franco & Dobereiner, 1994;* [3]*After Greenland (1985); Kang and Duguma (1985)*

the value of Brazilian soybean by about 20% on the international market, it is still competitive (Silva, 1998; Pavan, 1998), mainly because it is grown with BNF.

The early history of the introduction of soybean in Brazil and the research that made it possible is described by Myasaka and Medina (1981), with the collaboration of most scientists that contributed to the success of the crop. The first attempt to introduce soybean in Brazil at the end of last century in Bahia State was a failure. Later an attempt was made in S. Paulo State, also without much success and finally in Rio Grande do Sul State where the lower latitudes had favoured the varieties available that were more sensitive to photoperiodism. The first export of 150 tons occurred in 1938. The official records started in 1941 with the production of 457 tons of grain in 702 ha. By 1947 the cultivated area had increased to 7,651 ha with a yield of 6,396 tons, with productivity of only 836 kg of grain per hectare. From this point on the soybean cropping area expanded throughout Rio Grande do Sul, Paraná and S. Paulo States. In 1960 was released the first cultivar bred in Brazil: cv. Pioneira, adapted to lower latitudes.

This expansion has been due to three main factors: a) the incorporation of the Central West region to cropping system; b) replacing of rice, *Phaseolus* bean, cassava, potato, onion, maize and coffee cropping areas in Central South areas, increasing 88% the soybean cropping area from 1970 to 1973 and mainly to c) the support given by a net of breeders, agronomist, soil scientists (soil fertility, plant nutrition and rhizobiologists) all over the country integrated by the National soybean cultivar trials and the National soybean versus inoculant trials. This network of research was co-ordinated by the Departamento Nacional de Pesquisa Agropecuária, later on transformed in the Brazilian Agricultural Research Corporation (EMBRAPA) from the Ministry of Agriculture and Food Supply. At the early seventies soybean crop gets into the cerrado region and up closer to the equator.

Together with breeding and adaptation of the plant to lower latitudes, studies on BNF on soybean were conducted in Rio Grande do Sul, S. Paulo and Rio de Janeiro States, not only to obtain *Bradyrhizobium* strains adapted to the new cropping areas but also to identify the main limiting biotic and abiotic limiting factors (Oliveira & Vidor, 1984a,b,c; Myasaka & Medina, 1981; Peres et al., 1984). At the same time several experiments were conducted in the cerrado region with the objective to test the effect of starter nitrogen and *Bradyrhizobium* strains adapted to the Cerrado soils and inoculum concentration (Vargas & Suhet, 1980; Vargas et al., 1982a; Vargas et al., 1982b, Scotti et al., 1993, 1997). It was again demonstrated that if soybean is well nodulated with efficient bradyrhizobia, even under low nitrogen availability, there is no response to nitrogen fertiliser with grain yields up to 3192 kg/ha.

Commercial inoculum was already available in 1949, at first in agar slants and from 1955 on using peat as carrier. Today the Brazilian inoculum industry has a turnover of US$15 million annually. More than 95% of inoculant production is for soybean alone (Araújo, 1998).

The total amount of bradyrhizobia inoculum necessary for the 1997 crop was 600 metric tons, very little if compared with the amount of nitrogen fertiliser that would be required to meet the plant needs. Considering a 50% use efficiency of the fertiliser, 6 million tons of urea would be necessary to supply the crop demands. The figure 5 illustrates the annual economy in nitrogen fertiliser in relation to the total value of the crop, the value for internal use and the export. It is astonishing that BNF represents between 30 and 50% of the exported value, contributing in this way for the reduction of the ecological debt if all nitrogen used by the crop were from nitrogen fertilisers. To this should be added the costs of transport and application of the fertilisers and the costs derived from the problems caused the environment by the N not used by the crop. Other important point derived from this figure is that more that 50% of the soybean value is exported and greater effort should be made for soybean to contribute more to increase the availability of the protein to the population. In spite of the criticism about the precision in which those estimates of BNF were obtained, considering only the case of soybean, the economy derived from BNF represents much more than what has been invested in all research in agriculture in Brazil.

Last year the soybean cropping area was over 13 million hectares, with a productivity of 2,365 kg/ha and an export of 1,885 million metric tons of nitrogen (Table 3). In spite of the large expansion of the crop into harsh environments there was an increase of 182,8% in productivity since 1941, as a result of the technology that had been developed in Brazil during this period.

Figure 5 – Annual contribution of BNF on Brazilian soybean crop in relation to the total production and export in the last two decades compared to that of 1998.

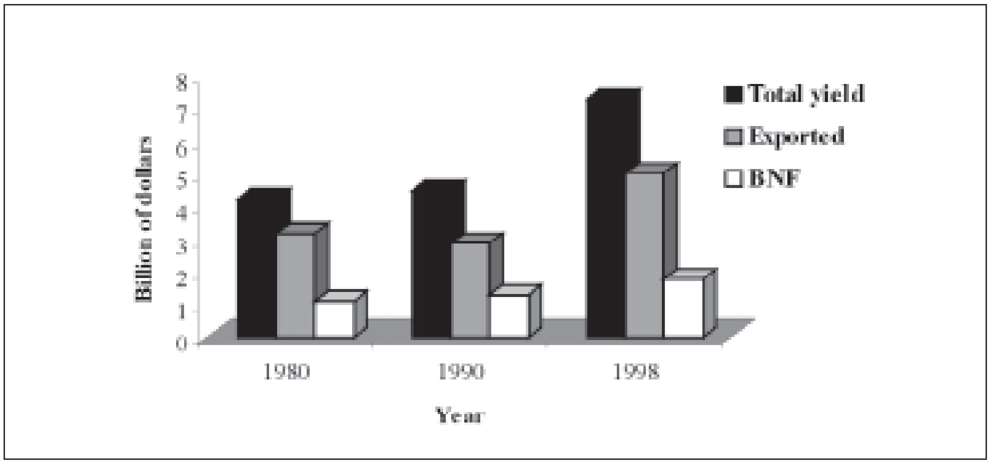


Table 3 – Planted area, total production, productivity and total nitrogen exported in the grains from 1970 to 1998 in Brazil.

Year	Cropping area (ha)	Total grain yield (t)	Productivity (kg/ha)	N exported[3] (thousand t)
1970-71[1]	1,716,420	2,014,291	1,174	121
1980-81[1]	8,501,169	15,007,367	1,765	900
1990-91[1]	9,583,000	15,522,000	1,620	931
1997[2]	11,540,330	26,508,030	2,297	1,591
1998[2]	13,285,610	31,419,144	2,365	1,885

[1] IBGE (1992); [2] IBGE (October 97, July 98), FIPE AGRÍCOLA (1997,1998); [3]N Estimates considering 6% of N in the grain.

Today the Brazilian productivity, without using transgenic material, is higher than in USA and this represent an advantage for markets that restrict transgenic food. Not considering the other environmental and human harzard potential, for pure economical reasons, it is difficult to accept the present trend to introduce transgenic soybean in Brazil.

Biological Nitrogen Fixation and *Phaseolus vulgaris*

The *Phaseolus* bean represents an important source of staple food protein to Latin America. Most of it is cropped by small farmers with very low productivity. In Brazil, the mean productivity has been around 500 kg/ha for decades (Table 4), even though, under some conditions it may be higher than 3,000 kg/ha. In contrast to soybean the nitrogen economy of beans is more due to nodulation with native rhizobia than by inoculation with selected rhizobia. Beans nodulate with many native rhizobia - three species have already been described *(Rhizobium leguminosarum* bv. *phaseoli, R. tropici* and *R. etli)* and possible new ones currently under study (Mercante, 1998). A few data on biological nitrogen fixation in *Phaseolus* bean are presented in table 4. Even though it may obtain rates of BNF similar to that of soybean, the inoculation with selected rhizobia strains by farmers is not a guarantee of yields above that of the native populations. This constitutes an additional difficulty to convince extensionists and the farmers about the contribution of BNF to this crop.

TABLE 4 – CROPPING AREA, TOTAL YIELD, PRODUCTIVITY, TOTAL NITROGEN EXPORTED AND VALUE OF THE N THAT WOULD BE DERIVED FROM BNF IN *PHASEOLUS* BEAN FOR 1996 AND 1997, IN BRAZIL.

YEAR	AREA (HA)	TOTAL YIELD (T)	PRODUCTIVITY (KG/HA) (T)	TOTAL N IN THE GRAIN	VALUE[2] US$ x 10^6
1996[1]	2,707,890	1,334,830	493	53,393.2	45.3
1997[1]	2,474,720	1,396,420	564	55,856.8	47.4

[1] *FIPE AGRICOLA (1997);* [2] *Considering US$ 848.54 per metric ton of nitrogen.*

Due to the short plant cycle preferred by the farmer, the delay for the crop to start benefiting from BNF and the decline of BNF in the early stages of grain filling stages (Franco & Dobereiner, 1994), what seems most important today is to work the plant genome for better performance as nitrogen fixers. Unfortunately, *Plaseolus* bean plant breeders have relegated BNF in their breeding programs and few effort have been made to increase BNF in this crop (Bliss et al. 1989, Bliss, 1993). For the *Phaseolus* bean cultivars in use or that are been released nowadays, the most import for improving BNF is to find the best nodulating cultivars and to remove the biotic and abiotic limiting factors to the symbiosis of the crop (Franco & Dobereiner, 1994).

Among the rhizobia that nodulate *Phaseolus* bean, *Rhizobium tropici* are the most tolerant to soil acidity (Vargas & Grahan, 1988) and to high temperature Mercante, (1993), some strains are competitive for nodulation (Vlassak, 1997) and have been recommended for the commercial inoculant production in Brazil.

Phaseolus bean is cultivated in the tropics even though it does have several characteristics of a temperate crop. It is sensitive to soil acidity and high temperature, and requires high levels of nutrients, especially P and Mo, especially when dependent on BNF (Franco & Dobereiner, 1994). The crop is also sensitive to several crop diseases and pests, including a larvae of an insect, identified as *Cerotoma arcuata* that eats nodules of several legumes but is especially detrimental to the *Phaseolus* bean crop because its short cycle (Teixeira et al.,1996).

The experiments conducted in Brazil with well nodulating type II and type III cultivars, with a cycle around 90 days, may yield up to 1,500 kg of grain per hectare in nitrogen poor soils, inoculated with selected strains of rhizobia but without nitrogen fertilisers. Yields above that may be obtained combining inoculation with rhizobia and nitrogen fertiliser applied 3 weeks after germination as demonstrated by Franco et al. (1979).

Results from Vidor et al., (1992), who conducted 64 experiments over 3 years in bean cropping areas in Rio Grande do Sul State, have indicated, that for a well nodulating cultivar, there was, on average, an increase of grain yield of 12%. For similar increases over the whole bean cropping area in Brazil, that would generate a net additional 19 million dollars in grain yield increase.

BNF and Forrage Crops

As early as the 1940s the Australians started on a program to develop mixed pastures based on grasses and legumes of the tropics. In the 1960s and 70s considerable success was achieved at selecting suitable grass/legume combinations suited the soil and climate of different regions of tropical and sub-tropical Australia such that animal performance was increased above that of the grass-only swards. This success encouraged Brazilian and other South American scientists to try to introduce these combinations of tropical grasses and legumes to the savannas and areas of cleared forest in their countries. These attempts met with little success as the legumes did not persist for more than a year or so and it became a general belief that mixed grass/legume pastures were not viable in South America. The main causes of failure were bad management of pastures and nutritional constraints to the legume species.

In recent years a large scale screening of many species and accessions of forage legumes was undertaken in many South American countries under the program RIEPT (Rede Internacional de Evaluación de Pastos Tropicales) organised by the Centro Internacional de Agricultura Tropical (CIAT) in Colombia. Many hundreds of accessions were screened and together with soil amendments some materials have shown a good ability to persist in mixed swards. A trial in the Atlantic forest region in the South of Bahia have shown that beef cattle grazing on mixed pastures of *Brachiaria dictyoneura* with the forage legume *Arachis pintoi* can make daily weight gains of over 500 g per head per day and yields per hectare of over 2 kg liveweigth per day which compares to maximum yields recorded of 1.2 kg ha^{-1} day^{-1} for other grass-only *Brachiaria* pastures at the same site (Table 5).

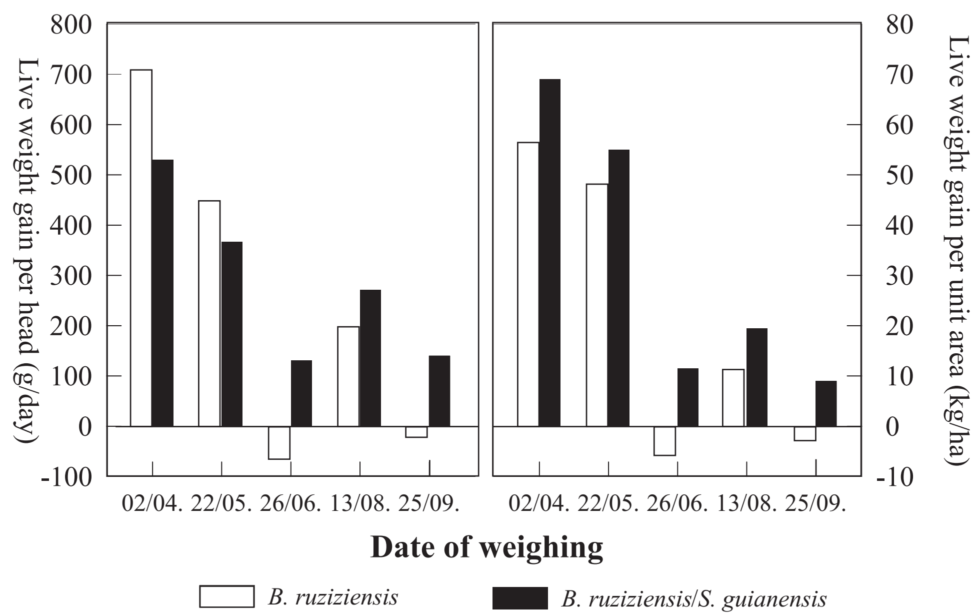
Table 5. Live weight gains of Nelore cattle grazing on a mixed pasture of *Brachiaria dictyoneura* and *Arachis repens* in the Atlantic forest region, Southern Bahia, Brazil. Data from *Santana and Pereira (1995).

Period	Stocking rate animal/ha	Live weight gain g/aninal/day	g/ha/day
Nov. 92-May 93	1.6	549	879
(182 days)	2.4	571	1,368
	3.2	575	1,841
	4.0	494	1,978
May 93-Feb. 94	1.6	499	797
(286 days)	2.4	590	1,416
	3.2	509	1,629
	4.0	502	2,010
Oct. 94-May 95	1.6	688	1,100
(205 days)	2.4	697	1,674
	3.2	688	2,201
	4.0	798	3,194

Recent studies on nutrient cycling and degradation of pastures have shown that in the Cerrado region the principal cause of pasture decline is overgrazing which causes a reduction in the proportion of nutrients recycled via the plant litter to the point where it becomes too low to support further forage growth (Boddey et al., 1996). Nitrogen has been shown to be the most critical nutrient followed by phosphorus (Oliveira et al., 1997), and the introduction of a strongly persistent N_2-fixing legume, such as those cited above, should not only increase animal yields but also increase the resistance of the pasture to decline in productivity.

One serious problem in the Cerrado region is that cattle generally lose weight during the severe dry season. Recent results using the legume *Stylosanthes guianensis* (cv Mineirão) have shown that as the legume is of low palatability compared to *Brachiaria* in the wet season the cattle leave considerable quantities of legume for forage in the dry season. Data from a trial conducted near Uberlândia (MG), showed that where this legume had been introduced into a *B. ruziziensis* sward, the cattle continued to gain weight throughout the dry season in contrast to the weight loss experienced in the neighbouring grass-only sward (Fig. 6).

Figura 6. Comparison of live weight changes of Nelore cattle grazing a pure *Brachiaria ruziziensis* and a mixed *B. ruziziensis/Stylosanthes guianensis* sward during the dry season in the Cerrado region near Uberlândia, Minas Gerais. Data from Ayarza et al., 1998.



BNF Associated with non-legume Crops

Since the fifties it has been shown that the N_2 bacteria *Beijerinckia* were associated with grass roots (Dobereiner & Ruschel, 1958). In the seventies several species of *Azospirillum* were found to infect roots of maize, wheat, rice and other grasses (Boddey & Dobereiner, 1988). Even though the acetylene reduction assay has given indication of nitrogen fixation in these systems only in the last twenty years more reliable data from nitrogen balance and isotopic dilution technique experiments, was it possible to quantify with more confidence the contribution of BNF on these systems. Since then, it has been observed that between 10 and 50% of the nitrogen incorporated were derived from the atmosphere in wetland rice, sugar cane and forage grasses (Boddey & Victoria, 1986, Miranda & Boddey, 1987, Boddey & Dobereiner, 1988, Urquiaga et al., 1992).

Soil core experiments in the field with *Brachiaria humidicola* and *B. decumbens* indicated that 30 to 40%, respectively 29 and 45 kg N/ha, of the nitrogen accumulated in the plant were derived from the atmosphere (Boddey & Victoria, 1986). Using similar procedure, Miranda and Boddey (1987) studying 10 *Panicum maximum* ecotypes, observed during the plant active growth rate, up to 30% of total nitrogen accumulated (10 kg of N/ha per month) were derived from the atmosphere. All these studies, even though indicated a good potential of BNF to be exploited in the long run, were obtained under low to median productivity conditions.

Approximately 20% of the fertiliser commercialised in Brazil is for the sugar cane crop, even though it receives less than 100 kg of N per hectare per year. Without water stress, sugar cane seldom responds to nitrogen fertiliser, especially after the first cutting. Urquiaga et al. (1992) in a three year experiment, where it was compared several cultivars of *Saccharum officinarum* with *S. spontaneum* growing in large tanks filled with 85 metric tons of soil containing 0.09% of ^{15}N labelled N: Two varieties of *S. oficinarum*, CB 45-3 and SP 70-1143 presented high yields up to the last harvest, accumulating, respectively 164 and 148 kg N/ha from the atmosphere. The other cultivars also accumulated significant quantities of nitrogen during the three successive harvests. These results are convincing evidence of the great importance of BNF in the sugar cane under high productivity conditions, at least three times the Brazilian current productivity.

If all cane sugar cultivars planted in Brazil were replaced by the two cultivars with high BNF, the economy in nitrogen fertiliser for this crop would be approximately half billion dollars per year (Table 6).

Table 6 – Yield, copping area, potential of nitrogen fixation and estimated economy in nitrogen fertiliser of cane sugar planted in Brazil.

Year	Area (ha)	Total yield (thousand t)	BNF[2] (thousand t)	Value[3] U$ (million)
1996[1]	4,827,320	325,929.07	596.17	505.9
1997[1]	4,852,740	333,649.82	599.31	508.5

[1] FIPE AGRICOLA (1997); [2]BNF: total nitrogen derived from the atmosphere considering the levels of fixation (123,5 kgN/ha) obtained by Urquiaga et al., 1992; [3]Assuming US$848.54 per metric ton of N.

BNF and Agroecology

Nitrogen fixing legume trees (NFT) and agroecological systems

Nair et al. (1984) attributes two important functions for the trees in mixed cropping systems: production and protection. Cellulose, food, energy, wood, dyes, medicine, forage, poles, etc., are few of the products of N_2-fixing legume trees. Erosion control, wind-breaks, shade, water quality, landscape stabilisation, nutrient storage and timing of release are some of the important attributes of protection of N_2-fixing trees (NFT) in mixed cropping.

Several articles have stressed the importance of NFT as a way to insert BNF into productive systems (Peoples & Craswell, 1992; Budowiski & Russo, 1997). Kass et al. (1997) have reviewed the importance of BNF on agroforestry systems indicating the several systems, natural or developed by men, where a combination of a NFT and other cash crops are used as source of nitrogen and sustainability. Alley cropping has been studied extensively but as yet has limited use.

The amount of N incorporated by the NFT is variable with plant species and growing conditions but may be as high as 231 kg N/ha.year in 3 months (Table 7).

Table 7 – N_2-fixed and proportion of total N accumulated in legume tree species derived from the atmosphere[1].

Legume species	Country	Proportion	N_2 fixed Amount (kgN/ha)	Duration
Acacia spp.	Australia	-	12	annual
	Philippines	0.52-0.66	-	
	Senegal	0.3	3-6	6.5 months
	Mexico	-	34	annual
Falcataria moluccana (=Albizia falcataria)	Philippines	0.55	-	
Cajanus cajan	Australia	0.65	-	90 days
Calliandra calothyrsus	Australia	0.14	11	90 days
Gliricidia sepium	Australia	0.75	99	90 days
	Mexico	-	13	annual
	Philippines	0.6	-	
Leucaena leucocephala	Malasia	0.58-0.78	182-231	3 months
	Nigeria	0.34-0.39	98-134	6 months
	Tanzania	-	110	annual
	Thailand	0.59-1.00	-	
Sesbania cannabina	Phillipines	0.93	119-188	45-55 days
S. grandiflora	Indonesia	0.79	-	2 months
S. sesban	Senegal	0.13-0.18	7-18	2 months

[1] *Peoples & Craswell (1992)*

The use of a nodulating legume, however, is not a guarantee of high rates of BNF. Beyond good conditions for growth, it is necessary to appropriate conditions that favour the establishment of rhizobia in the soil, in the rhizosphere and the functioning of the symbiosis. It is also necessary to conform the land occupation with the main crop within the farmers social conditions and culture. This seems in reality the main difficulty to increase the participation of BNF as soil conditioner agent in farming systems. Pasture arborization with NFT seems a great possibility to increase BNF under tropical conditions (Carvalho, 1997, Carvalho et al. 1997).

The use of nodulating legume tree as live stakes is an example of a technology that may support sustainability. It is cheap to implement, in addition may produce wood for energy, forage, honey, incorporate N to the system, but above all, it does have a strong ecological appeal importance as it substitutes native hard wood depletion and deforestation (Kass et al.,1997). Fast growth and ease of rooting from cuttings are two important characteristics of nodulating legumes species for fast and simple establishment of the plant in the presence of animals, today restricted to only two genera. Special strategies must be also developed to allow establishment of these species from seedlings in the presence of animals to allow a greater diversity of species to be used.

BNF and Land Reclamation

It may be considered that at present at least 50% of all cultivated land has some degree of degradation and at current rates of land degradation a further 2.5 million km^2 of farm land could became unproductive by 2050. The build up of organic matter in the system is the main factor for land rehabilitation, especially in the tropics with prevalence of acidic soils, with high aluminium saturation and low phosphorus availability. However, the quality of the organic matter is important for nutrient cycling and availability for succeeding or intercropped species on these substrates. Nitrogen, lignin and polyphenols content present good relationships with the rate of mineralization and seem the most important indicators of organic matter quality (Fox et al., 1990; Palm & Sanches, 1991; Thomas & Asakawa, 1993).

Nodulating and mycorhizal legume species have been found as the best colonisers of substrates without organic matter (Franco et al., 1992; Franco & Faria, 1997, Dommergues, 1997). The data summarised on table 8 were from several studies on land reclamation conducted in greenhouse and in the field and indicates the best species used on land reclamation under tropical conditions in Brazil.

Identification of nodulating legume species and isolation and screening of rhizobia to be used for inoculation in land reclamation projects have been done at Embrapa Agrobiologia since the eighties (Faria et al.1984, 1989). Franco & Faria (1997) summarised the results of more than 50 experiments listing the rhizobial strains most efficient for several legume species, including the species indicated for land reclamation: *Acacia mangium, A. auriculiformis, Sesbania exasperata, A. holosericea, M. caesalpiniifolia, M. tenuiflora, Sclerolobium paniculatum, Albizia saman, A. lebbeck, Pseudosamanea guachapele*, among others.

Table 8 – Nutritional requirement and tolerance to acidity and soil compaction of some fast growing N_2-fixing trees used in land reclamation. Numbers represent arbitrary values, 5 lowest requirement or highest tolerance and 1 the highest requirement or least tolerance.

Species	Nutritional requirement P	K	S	Tolerance to: Acidity	Soil compactation
Acacia mangium[2,7,8]	3 – 5	2	2	4	5
A. auriculiformis[2,7]	3	2	2	3	5
A. holocericea[3,7]	3	3	3	4	5
Sclerolobium paniculatum[5]	4	3	2	4	3
Mimosa tenuiflora[6,7]	5	3	3	2	2
M. caealpiniifolia[7]	-	-	-	4	4
Enterolobium contortisiliquum[7]	-	-	-	4	5
Leucaena leucocephala[7]	-	-	-	2	2
Samanea saman[1]	-	-	-	4	5
Stryphnodendrum guianensis[1]	-	-	-	4	4
Acacia angustissima[1]	-	-	-	3	4
Acacia crassicarpa[1]	-	-	-	-	3
Falcataria moluccana[1]	4	-	-	4	4

[1]FRANCO et al. (1996); [2]DIAS et al.(1990); [3]BALIEIRO et al. (1995); [4]BALIEIRO et al (1999); [5]DIAS et al. (1991); [6]PAREDEZ et al. (1996); [7]FERNÁNDES et al. (1994); [8]FARIA et al. (1996).

Another factor that increases the potential of these species for land reclamation is its symbiosis with arbuscular mycorrhizae fungi (AMF). The main function of the fungi is to increase de acreage of the plant roots to harvest nutrients and water (Siqueira, 1996). The effect of inoculation with rhizobia or arbuscular fungi varies with nitrogen or phosphorus availability and plant species, and frequently show a synergistic effect. An example of this response may observed in table 9 for *Leucaena leucocephala* growing in greenhouse in a latossol where the responses to mycorrhizae was greater than to rhizobia, indicating that plant growth was more limited by P than N (Table 9).

Table 9 - Response of Leucaena leucocephala to inoculation with rhizobia and mycorrhizae[1,2].

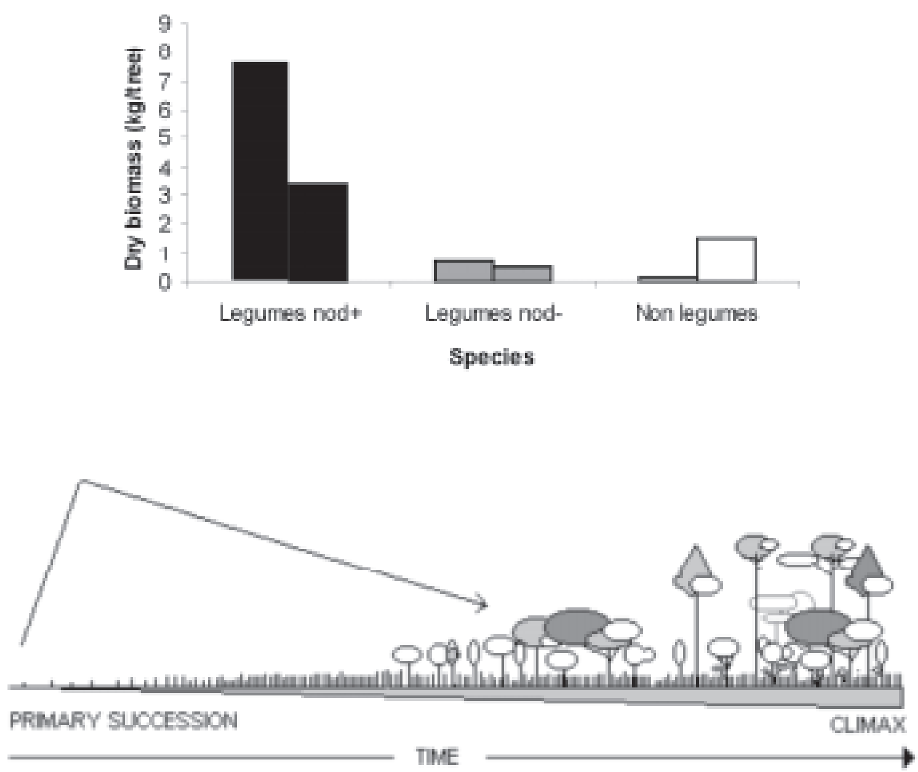
Inoculation treatments	Nodule dry weiht	Root infection AMF	Plant dry weight	Accumulated in the shoot N	P
	(g/pot)	(%)	(g/pot)		(mg/pot)
None	0	0	4.3 d	116 d	5 c
Rhizobia (R)	81.7	0	5.7 c	200 c	8 c
Arb. Mic. Fungi (AMF)	0	55b	8.1 b	243 b	14 b
(R) + (AMF)	143.2	70a	10.4 a	406 a	25 a

[1]From Costa & Paulino (1992).

[2]Values in the same column followed by different letters differ at 5% by Tukey test. different

The inoculation with AMF also increases water uptake and the survival of the seedlings transplanted to the field (Awotoye et al., 1992: Santos et al., 1994). This is critical in land reclamation projects where the substrates are frequently devoid of organic matter and have poor structure. The addition of two litters of cow manure on an acid substrate devoid of organic matter and poor in nutrients (0.4 $cmol_c/dm^3$ Ca+Mg; 3 mg/dm^3 K; 0 mg/dm^3 P and pH=4.6), favoured the establishment of nodulating legume, non nodulating legume and others species (Franco et al., 1996). However, even without addition of organic matter, the two best fast growing NF-species accumulated, 22 months after transplanting to the field, more than 8 metric tons/ha of dry matter. These results indicated that the period of land reclamation could be considerable abbreviated by using nodulating and mycorrhizal NF species as indicated in figure 7. The top figure represents the biomass accumulated in 22 months of two nodulating and two non nodulating legume, and two non leguminous tree species growing in a substrate without detectable nitrogen and carbon (Franco et al., 1996). By using the nodulating and mycorrhizal species the time of land recovery could be substantially reduced without much investment.

FIGURE 7 - COLONISATION OF A SUBSTRATE DEVOID OF NITROGEN – NATURAL X USING NF-SPECIES. INSERT EXTRACTED FROM FRANCO ET AL. (1996).



Nitrogen availability is of utmost importance for plant colonisation, however, the organic matter quality may affect the intensity and quality of the colonisation plants. Legumes, in general, present litter fall with higher nitrogen content than non legume species. Table 10 presents some data on litter analyses of *Acacia mangium* compared with *Eucalyptus pellita* in land reclamation of a latossol sub soil in a bauxite mining in the Amazon (Dias et al. 1994). The results indicate the superiority of the legume species over *Eucalyptus* in dry matter and nutrients accumulated in the litter.

Table 10 – Dry matter and nutrients accumulated in the litter of *Acacia mangium* and *Eucalyptus pellita*, grown in an exposed substrate in bauxite mining site in Porto Trombetas-PA

Plant species	Litter dry matter	Nutrients accumulated in the litter (kg/ha)					Ratio
		P	K	Ca	Mg	N	C/N
Eucalyptus	4,664.4	0.56	2.75	45.86	4.86	27.45	93.41
Acacia	7,844.6	1.37	4.90	29.43	5.46	94.47	38.72

From: Dias et al. (1994)

The chemical composition of the litterfall will determine the velocity of decomposition and the cycling of nutrients regulating the growth of the succeeding species. The legume species may also increase the action of the soil fauna, but there are differences among species. Correia et al., (1995), observed a greater increase of saprophagous group under *Mimosa caesalpiniifolia* than under *A. mangium. The M. caesalpiniifolia* litter contained higher levels of lignin and nutrients (N, P and K) while the levels of soluble polyphenols and C/N ratio were lower than that of *A. mangium* litter (Table 10). Froufe et al., (1999) have also observed higher rates of decomposition of *Pseudosamanea guachapele* than under *A. mangium* that was superior to *Eucalyptus grandis*.

Table 11 – Chemical characteristics of litter of *Acacia mangium* and *Mimosa caesalpiniifolia*

Plant species	C	N	P	K	Ca	Mg	Lignin	Polif.
				dg/kg				
A. mangium	42.61	1.399	0.023	0.22	0.91	0.28	12.28	5.21
M. caesalpiniifolia	43.94	1.655	0.048	0.36	0.68	0.13	18.84	4.66

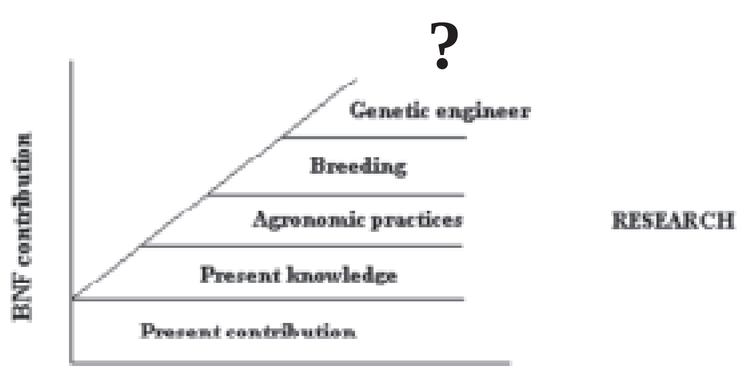
From: Correia et al. (1995)

This approach of land reclamation by using BNF and using minimum quantities of fertilisers has been showing good results in the field. Franco et al., (1994) are recommending the application of 100g rock phosphate per plant with success in several soils of Brazil while Dart (1995) is recommending 200g of rock phosphate per plant. Gypsum, potassium sulphate and a mixture of rock phosphate and superphosphate or any local cheap fertiliser may also be used as a source de P, K and S, according to soil analysis and fertiliser availability. The application of small amounts of organic matter close to the seedling at planting may replace, in same situations the need of adding micronutrients, however the application of 10 g per seedling of a mixture of fritted trace elements (FTE) will guarantee the micronutrients during the colonisation of the land. This technology has already been used with great success in several municipalities and mining areas in Brazil.

In absolute terms N_2 fixation is small compared with total soil N reserves (105,000 x 10^6 t N), but it is at least several fold greater than inputs of N from N fertiliser (65 x 10^6 t N/yr).

There is no doubt about the importance of BNF for soybean, other grain legumes, forage legumes and land reclamation. Plant sources commonly provide 90% of the calories and up to 90% of human dietary protein in tropical regions (Peoples & Craswell, 1992) There are also several agroforestry systems, in use or under study, in which BNF may be of economic importance (see reviews of Bohlool et al., 1992, Peoples and Craswell, 1992, Giller & Cadisch, 1995 and Kass et al., 1997). Nitrogen fixing trees are an important component of the production systems for coffee and cacao, two very important cash crops. Studies in the Amazon with fallow-rotation systems incorporating fast growing nodulating legume trees have shown great advantage over the traditional fallow-rotating systems (Brienza et al., 1997). Agrosilvicultural systems are have also been studied in the Amazon region (Wanderlli et al., 1997). Incorporating the knowledge already available and by a little of research efforts the present BNF levels may certainly be more than doubled. With more research removing the limiting factors and on the genetic of the bacteria and the plant, it is difficult to predict the limit of BNF contributions (Figure 8).

FIGURE 8 - PRESENT AND FUTURE POTENTIAL OF BNF (MODIFIED FROM GILLER AND CADISH, 1995)



A good example of a combined sustainable production system has been developed at CATIE in which *Erythrina*, a nitrogen fixing tree, associated with the non-nitrogen fixing *Morus spp*. and King grass. The *Erythrina* trees are pruned periodically and the foliage applied to the soil. Goats are fed a combination of only King grass, *Morus spp*., mineral salts and water. The goat manure is applied to the shrubs and grass associated with *Erythrina*. Over three years, 1,200 m^2 of land that contained 800 trees of *Erythrina beteroana* and two goats supported production of an average of 12,000 kg of milk per year with the mineral salts fed to the goats as the only input from outside the system. Profit was US$4,800 per hectare per year (Oviedo et al. 1994). The productivity in this system was high, profit was high, whereas the principal input of nitrogen to the system was through BNF and the system sustainable.

Comparing benefits and constraints in favour of BNF or the use of nitrogen fertilisers (Table 12) may favour either sources depending on the scenario of the moment which can not be predicted due to the uncertainties of the next century.

Table 12 – Benefits and constraints in favour or against BNF and the use of nitrogen fertilisers.

Nitrogen fertilisers (NF)	Biologiacal Nitrogen Fixation (BNF)
-Plants prefer combined nitrogen	- BNF occurs under low N availability
- Use fixed energy for production and distribution: increase atmospheric CO_2 and global heating	- No fixed energy necessary, no atmospheric CO_2 increase no global heating
- May generate acidity or alkalinity, depending on source	- Generate acidity: may be used for rock phosphate solubilization on the rhizosphere
- Crops less sensitive to biotic and abiotic stresses	- Crops more sensitive to biotic and abiotic stresses
- More prone to cause euthrophication, HNO_3 in aerosols in the rain, ozone layer destruction (NO_x) from denitrification	- Equilibrated system less prone to cause problems to the environment
- Health problems: Methamoglobin caused by excess NO_3 and NO_2; Cancer caused by nitrosamines; and Respiratory diseases caused by NO_2 and HNO_3	- No known health problems – possibly produces a more equilibrated food
- Expensive	- Less expensive

Even though, as less agricultural land became available, pressure increases toward higher yields and the use of nitrogen fertilisers, the understanding and development of more efficient NF-systems may favour BNF. Unfortunately, the increasing nitrogen surplus will certainly be pushing toward adding nitrogen fertiliser to the production systems. It is certainly the quality of food and the problems caused by excess use of nitrogen fertiliser the driving forces that in the next century may increase the use of BNF in crop production.

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Water for sustainable development: the Brazilian perspective

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I – Introduction

The availability of water is fundamental for the maintenance of the functioning of the natural ecosystems, as well as to sustain human activities such as food and energy production. Water has been and will be always a limiting factor for sustainable development. To maintain an adequate level of development it is necessary an investment in the preservation and recovery of water resources and of the quantity as well the quality of the water. Human activities produce considerable changes in the quality and quantity of water and water resources and economy are always inter-related. These is also a direct relationship between water quality and human health; poor water quality and bad sanitation contribute with a great deal to infant mortality and to lower life expectancy in general.

The quality and quantity of water of a given hydrographic basin, in natural conditions, is dependent on climate and the physical and biological characteristics of the aquatic and terrestrial, ecosystems. The seasonal fluctuations and the availability of water, are dependent upon these natural conditions which have cycles that can be changed by episodic events, periodic or not.

Superimposed to these natural conditions, there is a number of human activities which, vary in amplitude and in temporal and spatial scales.

The availability and water budget should be considered at national, regional and local levels.

In this paper the authors describe and discuss the availability of water in Brazil, its water budget, the main problems with water conservation and the impact of human activities. The recent developments in water management and legislation with perspectives for sustainable development based on water resources are discussed .

II – The water resources and water balance of Brazil

Brazil is a federal republic of 8.5 million km2, located between the Equator and the tropic of Capricorn. Its extension, from both north to south and east to west is approximately 4.400 km. Eleven hydrographic zones have been established for water resources monitoring and management which corresponds to the major watersheds of the country (Fig. 1 and Fig. 2). Brazil has 16% of the available fresh water of the planet. (Rebouças et al, 1999) A balance of these watersheds is presented in Table 1.

A demand/supply balance including demands for domestic, industrial and irrigation uses is presented in Table 2. (Braga et al, 1998) From these tables, it is possible to identify four major regions of Brazil which have interest for sustainable development:

a – Amazonia

b – The northeast of Brazil

c – The center west of Brazil

d – The degraded urban and rural watersheds in the south and southeast.

TABLE 1: WATER BALANCE FOR THE MAJOR BRAZILIAN WATERSHEDS

Basin		Area (km2)	Average Rainfall (m3/s)	Average Discharge (m3/s)	Evapotrans-piration (m3/s)	Disch/ rainf. (%)
(1)	Amazon	6112000	493191	202000	291491	41
(2)	Tocantins	757000	42387	11300	31087	27
(3A)	Atlantic North	242000	16388	6000	10388	37
(3B)	Atlantic Northeast	787000	27981	3130	24851	11
(4)	S. Francisco	634000	19829	3040	16789	15
(5A)	Atlantic East	242000	7784	670	7114	9
(5 B)	Atlantic East	303000	11791	3710	8081	31
(6 A)	Paraná	877000	39935	11200	28735	28
(6B)	Paraguai	368000	16326	1340	14986	8
(7)	Uruguay	178000	9589	4040	5549	42
(8)	Atlantic South	224000	10515	4570	5949	43
	Brasil including Amazon Basin	10724000	696020	251000	445020	36

From Braga et al (1998)

FIGURE 1: MAJOR HYDROGRAPHIC BASINS OF LATIN AMERICA.
FROM TUNDISI (1994)

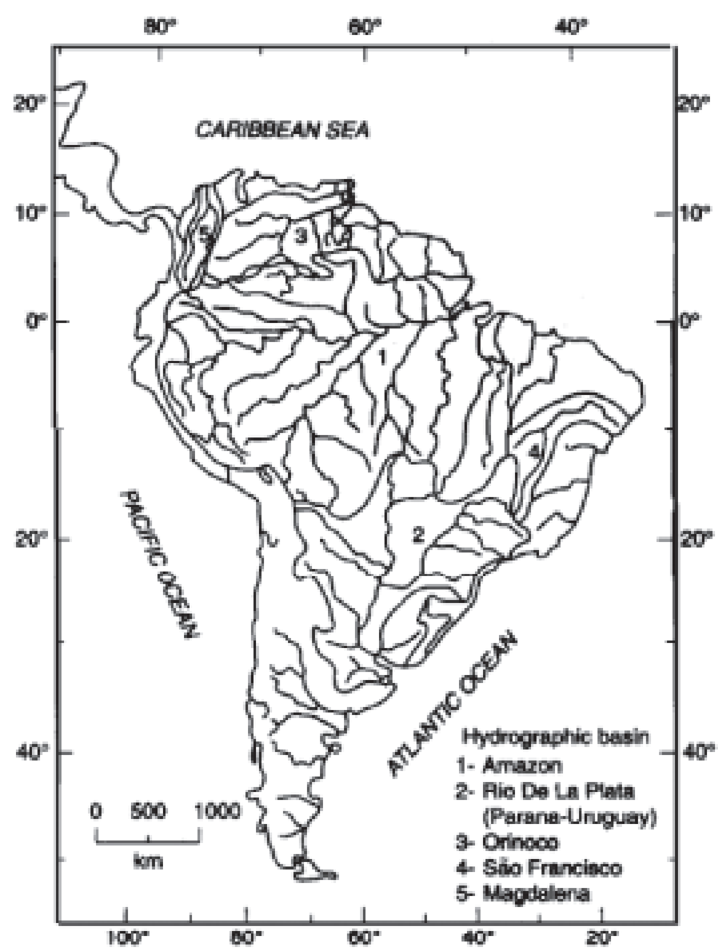

TABLE 2: SUPPLY/DEMAND WATER BALANCE FOR BRAZIL

STATE /REGION	TOTAL DISCHARGE (KM3/Y)	URBAN DISCHARGE (KM3/Y)	IRRIG. (KM3/Y)	INDUST. DISCHARGE (KM3/Y)	DEMAND/ AVAIL. (%)	URB. IND. AVAIL.-IRRIG. (%)
Rondônia	150.2	0.03	0.00	0.01	0.03	0.03
Acre	154.0	0.02	0.00	0.00	0.00	0.01
Amazonas	1848.3	0.10	0.01	0.03	0.00	0.01
Roraima	372.3	0.01	0.00	0.00	0.00	0.00
Pará	1124.7	0.19	0.05	0.06	0.00	0.02
Amapá	196.0	0.01	0.00	0.00	0.01	0.01
North Region	3845.5	0.36	0.06	0.10	0.00	0.01
Maranhão	84.7	0.22	0.01	0.02	0.20	0.28
Piauí	24.8	0.12	0.09	0.01	0.89	0.53
Ceará	15.5	0.29	0.96	0.09	8.65	2.61
R.G. Norte	4.3	0.14	0.23	0.05	9.77	4.67
Paraíba	4.6	0.15	0.27	0.04	10.00	4.39
Pernambuco	9.4	0.45	0.98	0.16	16.91	7.24
Alagoas	4.4	0.11	0.18	0.04	7.50	3.55
Sergipe	2.6	0.06	0.12	0.02	7.69	3.23
Bahia	35.9	0.52	1.07	0.12	4.76	1.84
North-east region	186.2	2.06	3.91	0.55	3.50	1.43
M. Gerais	193.9	1.22	1.63	0.59	1.77	0.94
E. Santo	18.8	0.18	0.22	0.08	2.55	1.40
R. Janeiro	29.6	1.03	0.63	0.73	8.07	6.08
S. Paulo	91.9	2.74	1.81	4.16	9.48	7.66
South-east region	334.2	5.17	4.29	5.56	4.49	3.25
Paraná	113.4	0.70	0.28	0.35	1.17	0.93
S. Catarina	62.0	0.33	0.65	0.40	2.23	1.19
R.G.Sul	190.0	0.71	6.32	0.70	4.07	0.77
South region	365.4	1.74	7.25	1.45	2.86	0.89
M.G. Sul	69.7	0.10	0.13	0.03	0.37	0.19
M.Grosso	522.3	0.08	0.03	0.02	0.02	0.02
Goiás	283.9	0.28	0.25	0.06	0.21	0.12
D. Federal	2.8	0.13	0.04	0.03	7.14	5.80
W. Central region	878.7	0.59	0.45	0.14	0.13	0.08
Brasil	5610.0	9.92	15.96	7.80	0.60	0.32

From Braga et al (1998)

Figure 2: Political division and major watersheds of Brazil. From Braga et al (1998)

III – Multiple uses of water resources and its impacts on Brazil's freshwaters

The general uses of water are:

– Function of support: creating conditions for life and productive activities such as water as a natural habitat, water in soil, water for transportation or water for food production;

– Function of regulation: when it cleans, dilutes, dissolves or neutralizes residues; self-depuration capacity;

– Function of production: for human consumption and production: water for irrigation for animal use;

– Function of information: when water is used as indicator of a environmental state for example the state of conservation or degradation of watershed.

(Lanna, 1999)

All the human activities and multiple uses fall within these four categories.

The multiple uses of water in Brazil can be summarized as:

- Water supply for general public use (human consumption and all human activities);
- Irrigation;
- Industrial use;

- Navigation;
- Recreation;
- Tourism;
- Hydroelectricity;
- Fisheries;
- Aquaculture.

The number of multiple activities varies accordingly to the population in the watersheds and the economic and social organization of the regional system related to density and distribution of population, intensity of economic development.

All these activities generate impacts and deterioration of water quality as well as interfere with the available quantity of water. The deterioration of water quality and quantity starts with the watershed uses and the impacts of human activities on the soil, vegetation and other components of the watershed.

The impacts on the water resources of Brazil are several, vary in the watersheds and within the watersheds, and can be summarized as follows:

- **Deforestation: As the defore**station progress the impact on the aquatic systems increases. Loss of habitats, of animal diversity, of buffer capacity is associated with this deforestation;
- **Mining: All mi**ning operations (sand, gold, precious stones) produce general impacts on rivers and wetlands;
- **Road Construction**
- **Waste discharge: solid waste dispo**sal or non treated sewage increase the impacts. Industrial activities also increase impacts on the rivers, lakes or reservoirs.
- **Introduction of exotic species: This is now at a dangerous lev**el. Accidental introductions of exotic species or bad management practices, produce disruption of the food chains in natural lakes and rivers;
- **Removal of critical species: Many species, critical to t**he freshwater ecosystem function are removed producing another type of disruption of the diversity in the freshwater ecosystems;
- **Reservoir construction: Many reservoirs have b**een built in Brazil. Reservoir construction have negative and positive impacts. Loss of biodiversity can be expected by reservoir construction, at least in the initial stages of the functioning of the system. (Tundisi, 1999).

As a consequence of these impacts, eutrophication, toxicity of freshwaters due to algal blooms, increasing of suspended material, loss of buffer capacity, hydrological alterations, geographic expansion of water borne diseases are common in many freshwater ecosystems, specially near or in the urban regions.

Therefore as well as conservation, restoration of the freshwater ecosystems in Brazil is one of the key problems to be addressed in the next century.

It is necessary also to consider the interrelation of water quality with human health.

The contamination of the water resources is one of the most important factors for the deterioration of human health, specially in regions of poor sanitation and inadequate water supply. (Biswas, 1996)

In large urban areas of Brazil and also in some rural areas inadequate and inefficient water supply are causes of high infant mortality due to water borne diseases.

IV – New developments in management and legislation

The increasing need for an effective management of water resources in Brazil its quality and quantity – and the urgency to develop new technologies and mechanisms of control has lead to the implementation of new regulatory and institutional mechanisms.

The most effective and important development is the watershed approach to management, with the watershed committees, and the organization of funds to support the research, monitoring and management at watershed level.

This is leading to a integrated planning and management approach and stimulating a shared vision of the water problem with increasing community participation. It is clear now that the basis for sustainable development is the watershed approach with community participation, the integration of planning, management and operation and new local legislation.

The principle of the polluter – payer at watershed level and the large scale decentralization process which is under way will stimulate new and creative ideas for management and for financing the watershed and its conservation and recovery. This change in legislation and institutional framework will be the most important achievement of the brazilian society and certainly will provide a sound template for future improvements. Another fundamental change is the multisectoral and interative approach and the realization that non point source of pollution and degradation is the most important problem to be addressed in the next century and for that education al all levels is necessary.

V – Perspectives for sustainable development: Brazil's water resources and the challenges ahed

Brazil is a country endowed with many natural resources distributed in a wide range of latitudes and with several special ecological characteristics that make them unique in the planet. Such is the case of the Amazon watershed, the Pantanal wetlands where the integration of terrestrial and aquatic ecosystems is intense and extremely important for the conservation of ecological processes and the biodiversity.

Therefore this is an important asset from the ecological, economic and ecological point of view.

When considering the challenges for sustainable development and the role of water resources, the following problems are to be taken into consideration:

- The most effective and economical management of aquatic ecosystems results in a understanding of the complexity and the mechanisms that govern the hydrology, chemistry and biology of these ecosystems. Therefore from the research point of view it is necessary to stimulate an integration of studies on the climatological, hydrological, physical chemical and biological problems. This is already in progress throughout the watershed approach which is in operation in several regions of Brazil, but it is necessary to promote it more intensively. This applies to all major watersheds.

- The integration of research and management is another important topic for the future. Integrated management will have a strong research component and the training of managers and scientists in pilot programs seems to be a major challenge, for effective management.

- The conservation of aquatic ecosystems, their ecological processes and their biodiversity is another challenge that will integrate the economic and social problems with the functioning of the natural ecosystems. The conservation of the Amazon, forests and floodplain lakes is fundamental for Brazil but it has also of planetary importance due to the influence of the Amazon Rain Forest and its major processes in the climate of the planet. The aquatic biodiversity of this region and that of the Pantanal wetlands are of extremely qualitative and quantitative importance. For example for the Amazon River only, the large catfishes use most of the rivers, the lowland areas and the estuary during their life cycle (Barthem & Goulding, 1997). This area is 2.500.000 km2. These large predators, have an important role in the ecology of the Amazon river and its tributaries. Another recent study (Araujo Lima & Goulding, 1997) approached ecology, conservation and aquaculture holistically and described the life cycle the biology, the distribution, the fisheries and the fish farming of the tambaqui – Colossoma macropomum (Luvier, 1818). This study shows how this species is important for the maintenance of the ecological processes in the inundated forest. The Pantanal biodiversity of fishes is also very high but other species of animals such as capybara are very important for the functioning of the systems and for the local economy. Therefore conservation of aquatic biodiversity is of fundamental importance for the future of sustainable development.

- If conservation is fundamental for the natural areas, recovery of freshwater ecosystems in many regions, specially the southeast is of prime importance: several rivers and reservoirs have suffered very high impacts resulting in eutrophication, pollution and contamination with toxic substances.

  It is necessary the development of new and relatively cheap technologies (ecotechnologies) to recover these ecosystems. Most of there ecosystems are located in urban regions, where the need for adequate water supply is urgent and where the aquatic biodiversity has suffered heavy losses; the costs of treatment of water for public use are increasing considerably due to the effects of contamination and pollution. Eutrophication is another major problem and it will be probably the main handicap for sustainable development in the next century. Eutrophication of water bodies has reached dangerous levels in Brazil as well as in many other large countries and regions such as China, India, Southeast Asia and Eastern Europe. In Brazil most of the urban reservoirs and rivers are eutrophic producing algal blooms, massive fish kills, unsuitability of water for human use and in extreme cases human deaths resulting from inadequate consumption of eutrophic water. (Tundisi, 1999, in press).

The economic aspects of the eutrophication problem have to be considered in this integrated picture. Eutrophication management, its prevention and control can provide new job opportunities, and new tools for economic development. (Murdrock, 1999, in press)

Good water quality can improve and maintain the economy with the development of many activities such as commercial and recreation fisheries, touristic activities and the implementation of tourism and recreation facilities that will enhance the local economy.

- Improving management capacity

  The reduction of pollution and contamination as well as the conservation of freshwater ecosystems, all carry significant economic and social costs. Priorities towards sustainable development will have to face cost-benefit, cost effectiveness calculations. Ecological restoration, maintenance of biodiversity and integrated management all are related to sustaining the socioeconomy and environmental integrity. (Tundisi et al, 1999 a, b)

  The public participation in this process is fundamental. Community participation and public awareness will be more critical in the future since sustainable development can be achieved only with continuity and the public provide the necessary support for this continuity.

  The use of all forms of education, mass communication programs, acceptance by the general public of a system of value (ethics) and increasing the sensitivity to environmental problems, will be enhanced with the organization of the society and the implementation of partnerships between private and public sectors the strong participation of the Universities that will produce the conceptual framework, necessary to stimulate new and creative ideas and projects. (Tundisi and Straskraba, 1995)

- Institutional organization

  To improve management capacity and to stimulate and integrate the community participation in this management the institutional regulation at national, regional and local levels is a powerful tool. The water resources administration has, as a new challenge and perspective to a sustainable and rational utilization, to incorporate new legal mechanisms and structures. The watershed approach to management, the participation of the community, thoughout the watershed committees and the principle of the polluter-payer are new developments in this institutional framework that will improve management, conservation and recovery.

- The economy of water-Hydroeconomy

  To maintain an adequate level of sustainability for water resources and to provide tools for integrated management it is necessary to take into consideration the relationship between water quality conservation, water treatment for public use, costs of recovery of freshwater ecosystems and the costs of degradation. Community management with the participation of users, stakeholders should be the best possibility for management (Lanna, 1999). The principle of the polluter-payer for use of water is a fundamental and important step forward. It is necessary to understand the economic relationship existing between water uses the degradation of water resources and the multiple economic activities that can be developed in freshwater ecosystems with good water quality.

  The economic evaluation of water resources is another important quantitative estimate. The economic value of rivers, reservoirs, wetlands, underground waters, is fundamental for future development activities. This can generate a new series of academic studies that will be extremely useful for application and for integrated management. (Straskraba and Tundisi, 1999; Tundisi and Straskraba, 1999)

VI - Conclusions

In the 21st century the "water business" will be an important component of the economy in urban and rural areas. The treatment of water in the rural areas will be developed with great intensity and will be an effective tool for improving quality of life in these regions. On the other hand the privatization of the water treatment, water services distribution and the solid waste treatment, will open new opportunities for employment, services and specialized work in the urban areas. The technological development for dealing with water supply, and water quality will probably enhance new investments in research and the innovation in this field.

The monitoring of water resources and the technologies for remote control coupled with the new management perspectives and approaches will be a powerful tool to control and follow up the impacts of human activities in the water resources. The urgent need for an effective management of rivers, reservoirs, wetlands, will stimulate a series of regulatory processes at the institutional level, federal, state and municipal levels. The watershed committees will have a important role in the monitoring, regulation and control of the water quality. The organization of society to manage these problems is vital for the integrated management of water resources.

In the next decades the hydrographic basin will be a major unit for research, management and monitoring .

To all these problems it must be added that preparation of qualified human resources is of prime importance in this sustainable development. Scientists and managers should be adequately prepared for this new approaches and initiatives and this implies in a revitalization of training with an inclusion of ecosystems perspective and interdisciplinary instruction.

Education of the general public in water problems will play a fundamental role in sustainable development.

All the problems discussed above have been considered in the process of sustainable development of Brazil. New programs, new training activities, monitoring, public participation, and education, the watershed as a unit for management, research and education have been discussed at several levels of national, state and municipal decision making. Many universities are discussing programs of training at undergraduate or graduate levels. The main challenge is the articulation of all these projects and ideas, and for that local, state and federal levels have to be integrated. It seems that the most successful projects for sustainable development are obtained at local (municipal or watershed) levels and this may be one of the important developments for the 21st century. The large diversity and latitudinal distribution of Brazil's water resources call for a regional and local approach to management and sustainable development and the research and search for integration of all management approaches is also a challenge for public and private organizations.

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The sustainable development of the coastal marine Brazilian areas

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Introduction

In early 1990, the GESAMP (United Nations Joint **G**roup of **E**xperts in the **S**cientific **A**spects of **M**arine **P**ollution) concluded that the chemical contamination and litter of the oceans could be observed from the poles to the tropics and from beaches to abyssal depths. Of greatest concern is that the trend is toward more pollution and a global deterioration in quality and productivity of the marine environment. According to GESAMP, the major marine contaminants by order of importance are: nutrients from urban sewage and rural runoff, microbial contamination from sewage, plastics from land and sea disposal, synthetic organic compounds, such as pesticides and industrial chemicals, and oil from routine transport and spills.

Most of the wastes produced by human activity reach the oceans. Every year, billions of metric tons of silt, sewage, industrial wastes, chemical residues, oily runoff from urban areas pour into the world's oceans. Rivers alone carry 9,3 billion metric tons of silt and waste to coastal waters annually. Storm-drain and outfall pipes, direct dumping in oceans, and the settling of airborne pollutants, such as particulate matter from smoke and engine exhaust, contribute additional contaminants.

The GESAMP concludes that the most widespread and serious sources of pollution are not large spills or toxic-waste dumping; they are sewage disposal and sedimentation from land clearing and erosion, both exarcebated by growing coastal populations coupled with the lack of sewage treatment and erosion control.

They concluded also that the alterations of the coastal habitats, through both pollution and mechanical destruction of wetlands, mangrove, coral reefs, beaches, and sand dunes for the sake of coastal development, is a serious threat. Destruction of feeding and nursery areas has imperiled and reduced fish and wildlife populations in many areas.

Close to 3 billion people live within just 60 kilometers of the shoreline and 60% of the larger cities in all the countries are located in that zone, and still the majority of tourists, especially in tropical regions, wants to spend vacations at the seaside. The sea, the sun, the beaches, the marine foods, the sporting fisheries, the nautic sports, are the most important characteristics of coastal tourism. The reduction of the quality, the destruction of natural characteristics, results in an immediate decrease in the number of tourists visiting a particular area (OECD, 1986). The increase of the population during tourist season usually results in sea pollution, especially in developing countries where there is considerable direct waste disposal on the beaches. Due to this, pollution of the sea in tourist areas, especially in developing countries, is usually in the form of microbial pollution.

We can classify the coasts in tourist areas in **five** groups: 1. Coasts used only for swimming and recreational purposes, located away from inhabited areas; 2. Coasts used simultaneously for dwelling, swimming and recreational purposes, often with houses, hotels, resorts and commercial facilities; 3. Coasts along which only **dwellings** exist (considered unsuitable for swimming), presenting houses, hotels, resorts, restaurants, nightclubs, and others facilities; 4. Natural and man-made harbors and petrochemical terminals and coasts used as shelters, and many times, unsuitable for swimming; 5. Coasts used for sea dumping, submarine industrial outfalls and sewage outfall dispositions, frequently unsuitable for swimming. It's also possible to find intermediate beaches with characteristics in between.

The principal environmental problem of the coasts of the first three groups is deposition of silt and fecal pollution. The others two groups have innumerous problems with oil spills, heavy metals contamination, organochlorides contamination, siltation, biodiversity loss, saltwater wetlands destruction, eutrophication, fish mortality etc.

Saltwater wetlands are part of a changing environment. Sedimentation and erosion provide the framework for a succession environment that starts with seagrass beds in the subtidal zone, passing through the mangrove zone, salt marshlands, freshwater swamps, bush vegetation to the Atlantic forest. Such environments are termed seral and zone within them is not considered static. The underlying geography or human activities may both cause interruptions and irregularities in the theoretically smooth transition of biotypes.

The ability of a wetland to improve the quality of the water flowing through is correlated to both physical and biological factors. A contaminant entering the wetland may variously become diluted or concentrated, chemically transformed into a more inert or more active form, may accumulate or dissipate. A wetland can isolate and transform contaminants entering it, resulting in a cleaner outflow. It may be stored safely in sediments or in the biomass of the wetland. They may also, or subsequently, degrade into less toxic forms or completely disintegrate into their component elements. Eventually it will be recycled as part of the biomass. In the sediment, the reduction oxygenation (redox) reactions control the rate of contaminant mobilization and fixing. If we destroy or damage the wetlands, sudden influx of contaminant results, and consequently, a large export of them to the coastal region.

Although the global fish catch continues to climb, certain fisheries in heavily fished and polluted areas are declining. And microbial contamination from sewage has affected shellfish beds in some areas. Plastics and pesticides have affected marine mammals even on remote islands.

Algal blooms, for instance, appear to be occurring more frequently and are showing up in the waters where they have never been observed before. These are more red-tides episodes induced by eutrophication. There was a bloom off the coast of Guatemala in 1987, which poisoned almost 200 peoples, killing 23. In the USA, in 1987-88, 740 dead dolphins washed up on beaches in the most extensive such kill ever recorded. And the dinoflagellate may be the cause of unexplained fish deaths that have occurred in the various regions of the world over the past 20 years. Changes are, the presence of these blooms can be attributed to human activity. In fact, over 80% of marine degradation can be traced to human activities on land (Remarks by Vice President Al Gore at the Ministerial Level Plenary Session of the UN Environmental Program Inter-governmental Conference on the Protection of the Marine Environment From Land-Based Activities, Washington DC, November 1, 1995).

Climate change would have a marked effect on the world's oceans. The warming of the sea world cause it to expand, thus raising sea levels 30-100 centimeters. Warmer seawater could also change weather patterns resulting in more severe tropical storms. Changing weather and wind patterns could change the locations of currents, and thus of fishery areas.

The approaches to protection of the marine environment

The earliest approach to environmental protection and management of aquatic systems is the use of water quality standards. These are widely used today. But many of them were first established decades ago and imported by developing countries. The use of standards has focused on the analysis of the concentration of potentially harmful substances in the water. However it is not in the water where the impact occurs but in the animals and vegetal that lives in it and in the humans that used it. The system often leads to misperceptions of the problem or, even worse, failure to notice a problem until it is quite serious.

The water quality standards are mainly based on short-term bioassays of acute or lethal effects on test organisms that reside in the water column. The implied assumption is that the major compartment of the aquatic system in which the substance will accumulate, or at least have its impact, is the water column. This because the use of standards usually does not take into account which species is the most sensitive to the contaminant. Furthermore, their use does not allow for the major impact that might arise due to the accumulation of the substance in one species which, although itself is unaffected, is fed upon another (e.g. man) which is affected.

We applied standards ubiquitously to different systems, e. g. freshwater, estuarine and marine waters. This does not take into account the impact of multiple sources, i.e., overall load, nor does it take into account the impact of the substances in the areas of medium and long-term residence (Gray et al, 1991).

Today we understand the biogeochemical behavior of many contaminants and that they accumulate primarily in aquatic sediments. Thus, there has been a change of emphasis away from simply defining water quality criteria to setting criteria for sediments (e.g. Baudo et al, 1990).

Another approach used by some international agreements is the organization of the black and gray contaminant list. The black list consists of substances regarded as so dangerous that they should not be entering the sea. They are persistent, toxic and bioaccumulatable. The second group is considered less dangerous and can enter the sea, subject to certain precautions. The second group is expected to be characterized by low toxicity and low bioaccumulation potential.

Unfortunately there is no clear dividing line between the two groups, especially because the degree or persistence depends on environmental conditions which affect the behavior of the substance and the significance of both toxicity and bioaccumulation, according the target organism. Another problem is that the list does not include many organochlorides and other organic discharged daily in industrial effluents, especially those realized as complex mixtures. For these reasons, the list approach cannot be considered to be a properly developed scientifically, based on environmental management and protections systems, because it ignores particular circumstances that influence the risk that the substances actually pose in a real situation (Gray et al., 1991).

Another approach to marine protection is the water body pollutant assimilative capacity. It means the total maximum allowable load of a substance for a specific water body segment.

In order to protect the aquatic life in these receiving streams, the capacity to assimilate treated wastewater must be determined. For many reasons, the procedure for determining assimilative capacity for coastal waters is not as well established compared to upland, riverine systems. The dynamic, oscillatory nature of flows in estuarine waterbodies makes statistically determined low-flow values very difficult to compute. Critical dissolved-oxygen concentrations may not occur during low-flow periods when estuarine waterbodies are influenced by ocean water, which usually has dissolved-oxygen concentrations higher than those may in the freshwater. Most water-quality standards were written for upland streams and not for coastal waters, where, many times, the waters may not meet the dissolved-oxygen concentration standard due to natural conditions. For these waters, effluent releases are permitted only if the water dissolved-oxygen concentration is minimally affected, which is quantified as less than a tenth of a milligram per liter decrease from the natural condition - also known as the point-one rule.

At the Second North Sea Conference, a new approach to environmental protection was adopted by acceptance of the precautionary principle (North Sea Conference, 1987). The precautionary principle is based on an earlier German initiative but very much-simplified (see Bewers, 1989, for a review). The precautionary principle applies to substances that are persistent, toxic or bioaccumulatable, but in a highly significant departure from previous approaches, states that precautionary action should be taken, even without scientific evidence of cause and effect relationships, if the substance is suspected of having detrimental effects on marine environment.

Nevertheless, in scientific terms the acceptance of that principle poses a number of problems (Gray, 1990). Firstly, the term's persistence, toxic and bioaccumulatable are not defined. In these situations, all elements should be banned from discharges since they are persistent. Likewise, does toxic mean toxic to all marine species, and at what concentration or dose is a substance defined as "toxic", as all chemicals will become toxic at sufficiently high levels? Some chemicals bioaccumulate naturally and yet pose no stress symptoms in the accumulating organism nor do they present health risks for other species consuming them.

Obviously there is necessity of qualitative and quantitative definitions of these terms that will allow proper management of the marine environment and yet maintain the spirit of the precautionary principle (Gray et al, 1991).

Another situation is that the precautionary principle can be invoked by simply arguing that at some future data a given chemical is likely to have an effect and its discharge to the sea therefore should be banned. Since the introduction of most substances to the marine environment will cause at least local disturbances and because the effect is not defined, this argument can and is being invoked in relation to most sources of direct inputs to the marine environment. The precautionary principle does, however, have a role to play in cases where little is known about the chemical concerned or where the biogeochemical cycle and risks for the chemical in the environment are so poorly understood that a reasonably complete hazard assessment cannot be made and the critical load and monitoring targets cannot be identified. A further role is that it could argue against discharges where concentrations approach environmental quality standards and prior to accurate environmental impact prediction have been made (Gray et al, op. cit.).

The best available control technology means a wastewater treatment capable of meeting the effluent limitations of the environmental regulation. Environmental regulation is, theoretically, trying to ensure that ecosystems are sustainable and that we protect public employment health. The employment of the best available technology to minimize discharges of contaminants is another very much recommended alternative. But in some circumstances the use of the best available technology may prove to be overprotective (e.g. the discharge of a small quantity of a contaminant with limited persistence and toxicity in a large receiving environment), or in situations where it proves to be totally inadequate (e.g. the discharge of a highly persistent and toxic substance made in large quantity to a small receiving environment or in smaller amounts but from several different sources in the same area). The use of the best available technology does, however, have a role to play in a fully developed environmental management and protection strategy. In the Montreal Guidelines (UNEP, 1985) a distinction is drawn between the best practicable technology, which takes into account costs, and best available technology, which does not, but which should apply to the most noxious substances (Gray et al, op. cit.).

Until now, the best environmental science available has been funneled into risk assessment. The key scientists involved in that assessment have been toxicologists, chemists and statisticians. Risk assessment has allowed us to predict some outcomes, particularly cancer, when introducing new elements into the environment. Cairns et al (1978) stated that "...a hazard assessment to measure the risk must ultimately be based upon sound scientific judgement applied to knowledge of expected environmental concentration of the material and the material's toxicological properties.... That statement highlights the importance of the exposure and the fact that a toxicological criterion is only part of the pollution control strategy. But it highlights also the difference between the hazard potential of a substance and the actual risk of a problem being caused as a consequence of exposure to the hazard.

The two most relevant conceptual frameworks, not yet fully explored, are the assimilative capacity and the hazard assessment approach, both originally proposed by Cairns (1977) and Cairns et al. (1978).

The hazard assessment approach should yield clear predictions of the transport pathways and rates, the likely environmental compartment (water, sediment and/or biota) where the substance/material is likely to accumulate, the chemical composition and concentration of the substance and the likely impact of the substance/material at a given target site or on a given organism or set of organisms.

Finally we have the monitoring and surveillance programs. Monitoring programs should include both chemical and biological aspects, so that possible measured biological responses can be related to specific chemical expositions. Chemical monitoring should not simply record total concentrations of contaminants but try to assess the bioavailable fraction. However, it needs also the implementation of a strong quality assurance program.

Surveillance differs from monitoring in that predictions are not tested but target sites or organisms are surveyed to ascertain whether or not they are detectable differences between the surveyed site and control sites.

The so-called Brundtland report (Our Common Future, World Commission on Environment and Development, 1987) postulated that a state of sustainable development was the ultimate goal to be reached by development and environment protection measures. The following are some of the principles and responsibilities proposed by the Commission:

1. Conservation and sustainable use: States shall maintain ecosystems and ecological processes essential to the functioning of the biosphere, shall preserve biological diversity, and shall observe the principle of optimum sustainable yield in the use of living natural resources and ecosystems;

2. Environmental standards and monitoring: States shall establish adequate environmental protection standards and monitor changes in environmental quality and resource use;

3. Prior environmental assessment: States make or require prior environmental assessment of proposed activities, which may significantly affect the environment, or the use of a natural resource.

These tasks and challenges, as well the development of the environmental sciences, make it necessary to re-consider existing strategies for the protection of marine environment, and to propose new ones. It is presently clear that in view of a number of global changes in the environment, measures to protect the marine environment cannot be made in isolation but will also have to take into account other environmental compartments.

In a stimulating article, Muul discusses that to make sustainable development acceptable to conservationists and developers alike will require integrating various economic, legal, political, educational, health, cultural social, aesthetic, and ecological issues into a single comprehensive strategy. We will resume in this chapter its *critical mass concept*, and its article published in Ecodecision (1994).

Sustainable development is a politically correct term, widely used but often unclearly defined. In the broadest sense, different interpretations of sustainable development reflect the differences that have separated conservationists from developers. Sustainable development is a concept that proposed to bridge the gap between these two, which were and often still are adversaries: owls versus logs, indigenous peoples rights versus miners rights, global development versus global warming, and so on. Successful demonstration of the concept of sustainable development remains elusive, especially in the tropics. When conservationists talk about sustainable development, they are usually thinking about ecological sustainability.

However, some government officials might say that such a strategy is a form of economic repression of the local people, and, many times, it might be viewed as a way to retard the economic growth of tropical countries, so that the world's rich can continue to drive expensive cars, using cheap fuels and polluting the atmosphere at a rate that would be completely intolerable if the entire population of the Earth were to indulge themselves in such manner.

We must accept the fact that some conservationists will continue to oppose development in any form and proceed with strategies that have a reasonable chance of success. Some developers will continue to change the landscape in ecologically unsustainable ways. We have no choice but to accept this too. But at the same time, we may seek and implement strategies that can reasonably be expected to be ecologically sustainable, while producing sufficient profits to be attractive to developers.

The better approach to making sustainable development acceptable to conservationists and developers is integrating ecological, economic, legal, political, educational, health, cultural, social and aesthetic criteria into a single comprehensive strategy. Such strategy should not give undue emphasis to one issue in detriment of the others, given their interdependence. We need resolve the problems sequentially, one at time, and not give undue emphasis to anyone in particular. Problems have arisen in the past because of our attempts to deal with them separately.

An integrated strategy to save our coastal regions needs to take into account of needs of local people, environmental laws, political factors, education, government officials, environmental leaders, health and sanitation, cultural and social factors, ecological aspects, specially its fragility's, and the effects of various proposed developmental actions. We need to link all those aspects to the proposed development projects.

In an integrated conservation strategy, the "critical mass" concept of Muul (1994) is likely to play a vital role. Critical mass could be defined as the sum of all ecological sustainable development activities in a given area which add up to profits greater than those of one or more ecologically unsustainable activities. This concept is so attractive that such development does not need to be forced or legislated and enforced. People are likely to want to follow this course because it is more profitable. That concept could provide the pull, and in addition to the push, to conserve much larger areas of coastal regions, than can be achieved by political pressure or other means that lack economic incentives.

The critical mass coastal strategy must involve: rehabilitation of degraded coastal areas, habitat conservation and species protection (mangrove, salt-marshes, coral reefs, sand and mud banks, estuarine systems), biological diversity, pollution mitigation, water quality control, balneability control, erosion control, public health and educational programs, sustainable fisheries and mariculture systems and ecological tourism.

Raffensperger, C. & deFur (1997) suggest a biosystem model of the world, very much in the direction of Muul's proposition, as an alternative model for providing regulators with decision-making tools that could protect the environment and public health. A biosystem model sees a different role for humanity than one of dominating nature, i. e. that of participant. A biosystem model of the world uses natural systems with their complex, mutually dependent parts, rather than machine with its instruction guide.

They propose the following parameters of a biosystem model for purposes of policy and regulation: 1. Environmental resources are limited; 2. Humans and the biosphere have evolved together for millions of years; 3. Ecological relationships between species should not be disturbed over large geographies of large time spans; 4. The economy is a subset of the ecological system. It is neither co-terminus nor independent; 5. Pattern is the key question of science; 6. Precaution is the basis for regulation.

They show that risk assessment generally has used very short time frames to determine potential harm for three reasons: 1. Risk assessment uses the very short frame of business rather than biology (consider the speed at which the stockmarket changes); 2. Risk assessment typically focuses on an individual organism rather than on a population, ecosystem, or the biosphere; 3. Scientific certainty decreases over time. Evolutionary biology can give us some clues for time frames that might work for analysis and regulation. Considering the four frames, Wilson (1988) describes biochemical time, organismic time, ecological time, and evolutionary time. They show that if we are truly interested in sustainability we must expand our time frame to at least ecological time. Endocrine disruption and the appearance of damage in later generations demonstrate the need to expand our time frame.

Expanding our time frame has two implications: the first is that to adequately assess the consequences of introducing some new technology, chemical or process into the environment we need to understand the kind of change that will take place over decades if not centuries. And second, not only do we need to know what kind of change will take place, and how change will take place, but the rate at which change that will take place. Is the rate of changing something that is natural in a system? This is a key question for technologies, which dramatically speeds up the rate and kind of change and thus has the capacity, ultimately, to destabilize the entire systems (Raffesperger & deFur, 1997).

The Major International Legal Instruments of Conservation of the Sea

Groombridge (1992) listed 81 international agreements for the protection of the sea. Several involve marine biodiversity. Many of those agreements had large success. We will go synthesize some of those agreements.

The UNEP Regional Seas Program has made a major impact on conservation of marine environment. The UNEP Regional Seas Program gives priority to areas that are vulnerable to human impact and presently provides a framework for some 14 regional agreements. The Mediterranean Action Plan implemented since 1975 and currently involving 21 coastal states, deals with monitoring and research on pollution, socioeconomic (including integrated management) legal and institutional issues.

Fisheries have had varying degrees of success (Norse, 1993), for example the International Whaling Commission. Some countries discuss the competence of that Commission. The whale stocks generally declined, especially up to 1980's.

The Ramsar Convention: Convention on Wetlands of International Importance Especially as Waterfowl Habitat (1971, and 1982 Protocol) has led to the establishment of a world-wide network of almost 500 wetland protected areas, including some coastal areas. But the Ramsar Convention fails to cover protected areas in water deeper than 6m, and there are virtually no marine protected areas for the continental slope and the deep-sea ocean basins. Brazil ratified the Ramsar Convention through the Decree 33/1992. It has in the Oceanographic Institute of the University of São Paulo, a laboratory for the implementation of training and researches in Brazil on wetlands, especially on mangroves.

The International Convention on Biological Diversity is one of the most comprehensive and effective instruments created for the conservation of biodiversity, sustainable use of its components, and firm and equitable sharing of its benefits. It induced two important programs in Brazil, the federal PRONABIO - National Program of Biodiversity (IBAMA), and in the São Paulo State, the BIOSTA – the biodiversity program of FAPESP – Research Foundation of the São Paulo State. The two programs are in implementation stage.

The Part XII of the Montego Bay United Nations Convention on the Law of the Sea (UNCLOS, 1982, came into force in 1994) deals with protection and conservation of the marine environment, sustainable use of its components, and a fair and equitable sharing of its benefits. FAO (1993), biodiversity implications by Kimball (1995), global governance by Jackson (1993) and deep-sea genetic resources revise the marine implications of the Law by Glowa (1995). The Law of the sea has been very effective in moderating the harvest of marine species previously wide open to any fishing vessel. It induces in Brazil, two big programs, the REVIZEE and the LEPLAC.

Various global conventions and protocols have been adopted to control the discharge of oil, chemicals, sewage, and garbage, including plastics, from vessels. While enforcement remains a problem, these international agreements are believed to have curtailed the discharge of pollution from ships.

The Global Programme of Action for the Protection of the Marine Environment from Land - based Activities Convention (Washington, 1995), covered persistent organic pollutants (POPs), sewage, plastics and litter, nutrients, sediments/particulate, heavy metals, oil and polychlorinated aromatic hydrocarbons, pathogens and microorganisms, radionuclids, and physical alteration including habitat destruction.

The Convention for the Prevention of Marine Pollution by Sea Dumping (London, 1972) prevents the discharge of toxic and dangerous materials by in the sea. Brazil agrees with that Convention through the Decrees 87566/1982 and 10/1984.

The Convention on Climate Change (1992) is linked with biodiversity issues. For instance, marine data suggests that coral reefs are already bleaching due to elevated seawater temperatures and that other marine and coastal ecosystems are placed at risk by climatic warming. More frequent storms, induce by climatic changes, could increase coastal erosion, turbidity and coral reef and coastal ecosystem degradation. The rising of sea level could induce coastal erosion, destroy mangrove ecosystems and induce salinization in estuarine systems. That risks are very much important to Brazilian coastal regions because especially of its numerous coastal cities, extensive mangroves systems, and many estuarine and lagoons ecosystems.

The Marpol (1973) International Convention for the Prevention of Pollution from Ships, and its Protocol from 1978, is another very much important instrument to the prevention of pollution of the marine environment. In 1988 Brazil agrees with the annex II and I and through the Decree 2508, with the annex III, IV and V of that Convention.

The 1992 UN General Assembly Moratorium on driftnet fisheries, in force since December 1992, places a moratorium on all large-scale pelagic driftnet fisheries.

Among the regional conferences we have the Antarctic Treaty (1959), the Convention for the Protection of the Mediterranean Sea against Pollution (1976), the CCAMLR: Convention on the Conservation of Antarctic Marine Living Resources (1980), etc. Brazil is a very much active participant of the Antarctic Treaty. It has the polar station. Ferraz, and many researches.

The Agenda 21

The most important of all international treaties is the Agenda 21 (UNCED, RJ, 1992). Agenda 21 is one of five documents agreed upon during the United Nations Conference on Environment and Development (UNCED), in June 1992 in Rio de Janeiro (1).

Signed by 179 Heads of Government, it is a blueprint for sustainable development in the 21st century, aimed at providing a high quality environment and healthy economy for all people.

Specialists point to two major features of this agreement:

a) No longer can social, economic and environmental development be seen as separate issues, their interdependence has become clearly established.

b) It was formulated in negotiations involving an unprecedented number of people and range of organizations, an intensification of the process of global democratization seen as essential for the 21st century.

Agenda 21 is a guide for individuals, decisions-makers in making choices for less environmentally destructive developments, and ultimately a challenge to translate understanding into action in developing sustainable lifestyles. The alternative to this action is unacceptable levels of human suffering and environmental damage, as forecast in the 1987 Brundtland Report, “Our Common Future”.

Agenda 21 sees sustainable development as a way to reverse both poverty and environmental degradation. A major theme is to eradicate poverty by giving poor people more access to the resources they need to live sustainable, including information and skills. It calls upon governments working in collaboration with international organizations, business, regional and local governments and non-governmental organizations (NGOs) and citizens groups to develop national strategies for sustainable development in an ongoing process of consultation and global democratization from local to international levels from 1993/4 - 1997.

The Rio Declaration states that only a global partnership will ensure that all nations will have a safer and more prosperous future. The agreement includes the following ideas:

People are entitled to a healthy and productive life in harmony with nature.

Eradicating poverty and reducing disparities in living standards in different parts of the world are essential to achieve sustainable development and meet the needs of the majority of people.

Nations shall co-operate to conserve, protect and restore the health and integrity of the earth's ecosystem.

Environmental issues are best handled with the participation of all concerned citizens. Nations shall facilitate and encourage public awareness and participation by making environmental information widely available.

The full participation of women is essential to achieve sustainable development.

The creativity, ideals and courage of youth and the knowledge of indigenous people are needed too. Nations should recognize and support the identity, culture and interests of indigenous people.

Peace, development and environmental protection are interdependent and indivisible.

Agenda 21 consists of 40 chapters in four sections of overlapping and interrelated issues involved in sustainable development. We highlight the following:

Chapter 15. CONSERVATION OF BIOLOGICAL DIVERSITY

The essential goods and services on our planet depend on the variety and variability of genes, species, populations and ecosystems. Biological resources feed and clothe us, and provide housing, medicines and spiritual nourishment

The loss of the world's biological diversity continues, mainly from habitat destruction, over-harvesting, pollution and the inappropriate introduction of foreign plants and animals.

This decline in biodiversity is largely caused by humans, and represents a serious threat to our development.

Chapter 17 PROTECTING AND MANAGING THE OCEANS

The oceans are an essential part of the global life-support system. They cover much of the Earth's surface, influence climate, weather and the state of the atmosphere and provide food and other resources for our growing world population. Oceans are under increasing environmental stress from pollution, over-fishing and degradation of coastlines and coral reefs.

Chapter 37. CREATING CAPACITY FOR SUSTAINABLE DEVELOPMENT

A country's ability to develop with more sustainability depends on the capacity of its people and institutions to understand complex environment and development issues so that they can make the right development choices. Governments should use wide public consultation to determine what improvements in capacity their people need to implement their national version of Agenda 21 for sustainable development.

This analysis should be done by 1994, if possible, and should be based upon a broad national consensus. By 1996, the United Nations should recommend what additional measures are needed to strengthen international technical co-operation programs for sustainable development.

In some countries we have had significant progress in implementing Agenda 21. Others are only beginning to make headway against many environmental threats to our global future, and they have a long road ahead to reach the goal of sustainable development.

An interesting example is that of the European Community (EC). They are working hard to keep Agenda 21 high on the list of policy priorities in Europe and in the world. This because no country can reach sustainable development on its own and the global community still has along way to go. They are conscious that Agenda 21 sets out a plan of action to guarantee that life in the next millenium will change substantially for the better. But they are also conscious that it will only be possible to ensure sustainable development by integrating its economic, social and environmental components in a transparent, accountable and democratic framework.

For the EC, coastal and marine environments are no less important than freshwater. Almost half of the European Union population lives within 50 km of the coast, and the coastal environment is often threatened by uncontrolled urbanization and tourism development. The Community's contribution to coastal zone management has been supportive rather than regulatory, but work is presently proceeding rapidly in projects that will achieve sustainable development practices in 26 areas.

The first action was the adherence to international conventions for the protecting of marine environments, including Mediterranean, Northwest Atlantic, North and Baltic Seas. After directives have strengthened controls on pollution from ships and in harbors, these have been supplemented by more strategic measures, as for instance, the Community Action Program to improve Member States' response to major pollution incidents at sea.

The Community is also responsible for the management of fisheries. Over-fishing has long been a growing economic and social, as well as a resource management problem. Substantial limits in fish catches are being introduced which should enable a long-term balance to be achieved between the need to preserve fish stocks and the needs of the fisheries. In this way, and under the Maastricht Treaty and international agreements, the EC is obliged to develop fisheries resources sustainable. Fisheries management shares the same objectives as conservation of the marine environment – safeguarding marine ecosystem and responsible use of marine resources. The priorities for fisheries management of the EC are 1. Greater contribution from scientific research; 2. Better training, information and transparency; 3. Reduced fisheries pressure; 4. Improved nature conservation measures; integrated management of coastal areas.

But most important, is that EC is conscious that to reach the goal of sustainable development means that countries must integrate their environmental policies with economic sectors, including manufacturing industry, transport, agriculture, energy and tourism. They agree that it is time to increase efforts to use development aid to promote sustainable development, especially in the poorest and least developed countries.

The Convention on Biological Diversity

Biological diversity comprehends the variability among are living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic systems and the ecological complexes of which they are part; this includes diversity within species (genetic), between species (organismal) and of ecosystems (ecological).

In marine environments the number of phyla and higher taxa is substantially greater than on land: indeed, 13 animal phyla are exclusively from marine environments (Placozoa, Ctenophora, Gnathostomulida, Kimnoryhncha, Loricifera, Priapulida, Pogonophora, Echiura, Chaetognatha, Phoronida, Brachiopoda, Echinodermata and Hemichordata) whereas only one is exclusively terrestrial (Onychophora).

Probably the ecological requirements of less than 1% of marine species are known. This makes understanding ecosystems and ecological management or resources difficult (Sea Wind, 1995).

Although shallow water marine ecosystems are fairly well known in selected countries, there is no well-established global classification of marine ecosystems. Yet such classification would facilitate marine science and integrated coastal zone management. Marine conservation is hampered without a complete standard ecosystem classification. Hayden et al (1984) described 21 types of oceanic and coastal margin realms and 45 coastal provinces without even considering deep-water realm candidates that could at least double the number of realms and yield more than 300 biotic provinces. Kelleher et al (1995) has developed a global geographic-biogeographic system for representative marine protected areas.

The number of agreements and instruments in place today, which are of relevance to marine and coastal biological diversity, is enormous. For example, a recently published compendium on selected treaties, international agreements and other instruments concerning marine resources, wildlife and environment runs to over 3.500 pages and lists over 500 such instruments (Marine Mammal Commission, 1994).

The Convention on Biodiversity is therefore going to be implemented within the context of many activities, which are taking place under the auspices of a number of legal instruments. Many of these legal instruments and activities are not harmonized and some have targets, which may be less stringent than others. Conventions and other instruments which should receive priority attention are: UNCLOS; the International Convention on the Regulation of Whaling; the Convention on the Conservation on Migratory Species of Wild Animals; the Convention on International Trade of Endangered Species; the Framework Convention on Climate Change; the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter; and the FAO Strategy for Fisheries Management and Development, and the FAO Fisheries Code of Practice.

Article 1 of the Convention gives the objectives of the Convention as: 1. The conservation of biological diversity; 2. The sustainable use of its components; and

3. The fair and equitable sharing of the benefits arising out of the utilization of genetic resources. But much of the negotiation that took place over the objectives and principles of the Convention concentrated on the terrestrial environment. By contrast, there was little, if any, discussion concerning marine biological diversity and its importance to human well being. Nonetheless, the objectives of the Convention provide a framework for addressing all of biological diversity, including marine and coastal components.

The Convention highlights the fact that many human activities are responsible for the degradation of the marine and coastal environment, which in turn can lead to loss of biodiversity and the consequent collapse of marine and coastal ecosystems. But coastal biodiversity is in general poorly known and documented. Nevertheless there are reliable indications that it is being lost at an alarming rate, including in Brazil, mainly due to the degradation of habitats and the unsustainable exploitation of resources.

"The State of the Marine Environment" is a document prepared annually by GESAMP and provides an overview of the extent of human activities affecting oceans and coasts and indicates that the main damages are caused by: 1. Discharge of waste waters; 2. Industrial and urban development in coastal areas; 3. Disposal of dredged material, sewage sludge and other waste directly into the sea and into the marine and atmospheric environment; 4. Disposal of litter, mainly plastics; 5. Manipulation of hydrological cycles; 6. Poor land-use practices; 7. Transport of hazardous substances; 8. Exploitation of non-living marine resources; 9. Exploitation of living marine resources; and, 10. Accidents with tankers, outfalls, ports etc.

The reports show that these effects contribute to changes in the health of organisms, populations, species composition of communities, ecosystems, and landscapes, which in turn can alter or destroy marine habitats. The results have been: loss of approximately 10% of the all world's coral reefs have been degraded beyond recovery and that 20% to 30% may be lost – primary due to human activity – by the year 2010. We have extensive degradation of seagrass beds, and many fishing bank ecosystems, loss of 50% of the world's mangrove habitats; pollution of most of near shore and offshore water column with persistent organic and other pollutants

Article 6 of the Convention on General Measures for Conservation and Sustainable Use requires that each Contracting Party shall, in accordance with its capacity and conditions, develop national strategies, plans or programs for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programs which shall reflect, *inter alia*, the measures set out in this Convention relevant to the Contracting Party Concerned, and, integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectorial or cross-sectorial plans, programs and policies.

For that, it is necessary that the Contracting Parties develop programs addressing the following issues: identification and monitoring of marine and coastal biodiversity components; strategies for conservation and sustainable use, including ecosystem and habitat focussed approaches, instead of single species approaches; bioprospection of marine taxa and genera that might yield new classes of biologically active substances; developed for managing and benefiting access to marine and coastal genetic resources; research and training; education and awareness activities; impact assessment; community approaches to managing marine resources and marine reserves; identification of components of biological diversity under threat and actions that could be taken under the Convention; scientific and technical cooperation; and transference of technology.

The environmental institutional context in Brazil

The SEMA – Special Secretariat (Federal) for Environment was created in 1973. This gives to the issue of environment in Brazil, a legal and institutional situation. A significant step was the Law 6.938/1981, which established the National Environment Policy, and in 1989, the establishment of the IBAMA – Brazilian Institute for Environment and Renewable Natural Resources, and finally, in 1992, the Ministry of Environment.

The National Environment Policy aims at the preservation, improvement and restoration of an environmental quality befitting life, directed at ensuring social and economic development, national security and protection of the dignity of human life.

Among the instruments of the National Environmental Policy are: determining environmental quality standards; environmental zoning; environmental impact assessments; licensing and control of polluting activities; incentives for the production and installation of devices, as well as the creation or acquisition of technologies to improve environmental quality; the establishment of areas especially protected by federal, state or local governments; the national information system on the environment; the national technical register of instruments and activities of environmental protection; and finally, disciplinary or compensatory measures for the non-fulfillment of measures necessary for the conservation of the environment or for correcting inflicted damages.

The 1988 Federal Constitution included, for the first time, a specific and updated chapter, on the environment. The Ministry of Environment has been playing with emphasis, the insertion of the environmental dimension in public policy decisions. In this way and especially important are: 1. The Green Protocol, an institutional instrument for the introduction of the environmental variable as a relevant criteria in decisions pertaining to economic policy and the funding of projects by official agencies, and 2. The involvement of the productive sector and other civil society actors by means of negotiation for the sustainable use of natural resources. An important question is the decentralization of the actions, transferring partial or total responsibilities to states, countries, non-governmental organizations and the implementation of environmental policies to states, public and private entities. The National Environmental Program (PNMA) strengthens the spirit of partnership between the Federal Government and the States and Counties. The States select their projects, incorporating sustainable development parameters, and submit them to the Ministry, that give the funds for their implementation.

The Ministry of Environment is developing four great programs that interest directly the coastal Brazil and its oceanic region:

1. the REVIZEE (it aims at producing an inventory of all marine living resources, their environment, their biomass and the potential sustainable yield),
2. the GERCO – National Coastal Management Program (the environmental management of the Brazilian coastal zone, in an integrated, decentralized and participatory manner, with a view to its sustainable development),

3. the PRONABIO – National Biological Diversity Program (the implementation of the National Biodiversity Project),

4. the PNMA – National Environment Program (it aims at institutional strengthening of the organisms responsible for actions pertaining to the environment at States and local level; establishing and maintaining the National System of Conservation Units; promoting the development of management instruments and actions for the protection of special ecosystems [Pantanal, Atlantic Forest, Coastal Zone]; implementing sustainable development demonstrative projects)

The REVIZEE is being developed, successfully, by a great number of Universities and Research Institutes on the whole national coastal regions. The GERCO suffered a large interruption, for political reasons, but recovered, and some states, like São Paulo, have created specific legislations. The PRONABIO after a period of uncertainties is being developed in some states, like São Paulo, with success.

The PNMA has been developed with a lot of expectation, although it faces serious problems given the Brazilian geographic extension (8.511.996 Km2) and the large biological diversity. Other obstacles include lack of resources and technical competence in some states, political problems, and the deficiencies of IBAMA – Brazilian Institute of Environment - and of the own Ministry, which suffered deep changes on the beginning of the second mandate of the actual President of Brazil, Prof. Fernando Henrique Cardoso.

Unfortunately in Brazil, the sea has not received the attention, and specially, the political priority that it needs, and only recently became part of the national federal policy. As says the environmentalist and composer, Gilberto Gil, "...there is very little focus on the blue on the contrary of the green", much represented and spread through the innumerous entities and projects in our country.

Brazilian projects for the coastal region

Brazil has 7.367 Km of coastal line, without considering the coastal cuttings that amplify significantly this extension, increasing it to more than 8.5 thousand Km. It goes from 04°30N to 33°44S. The Brazilian coastal zone shelters a mosaic of ecosystems with high environmental importance; on it are located the mangroves, coral reefs, and also the largest continuous remnants of the Atlantic Forest in the states of Rio de Janeiro, São Paulo and Paraná. It's highly relevant to remember that this forest shows a larger plant biodiversity than the Amazon Forest.

The average demographic density of the Brazilian coastal zone is 87 inhabitants/Km2, five times above the national average, which is 17 inhabitants/Km2. This is understandable because the national territorial formation was structured from the coast, having the coast as the spreading center of the settling fronts still in movement today. There is, on the national coastal area, state capitals and large cities just in one finds Santista lowlands (Baixada Santista: Guarujá, Bertioga, Santos, Cubatão, São Vicente and Praia Grande), Paranaguá etc. in Santos (SP), the largest seaport of our country.

Unfortunately, there's still today an enormous lack of basic urban services, like sanitation, so that the urban areas constitute the main critical spaces to the environmental planning of the coastal zone, in its corrective action. Only 4,8% of the coastal population are connected to municipal waste pipelines; the population with potable water piping is 79,5%, the population with garbage collection service is 72%. Worse cases are found when there are industrial complexes, seaports, petrochemical terminals, etc. in these areas.

Those large urban centers coexist with great extensions of spread and rarefied population areas, the inhabitants of the communities of fishers who practice the craftswork, "quilombos" leftovers, Indian tribe's etc.

There are also about 400 conservation units on the Brazilian coastal zone, but the difficulties in effectively inspecting places with difficult access encourage many transgressions of the national environmental legislation. The tourist exploration is the basic occupation method that should be disciplined. In reality over16% of the Brazilian territory corresponds to areas of environmental protection: 5,2% federal conservation units, such as ecological parks and reserves, extraction reserves and 11,12% Indian lands. But many of them have important problems like burning, lack of inspection and consequent invasions, lack of interest from the state governments to protect them more efficiently, predatory extraction of wood, predatory fishing and hunting, etc.

Among the federal environmental projects conducted with success on the Brazilian coastal region, we should mention: 1. the TAMAR, and 2. the recuperation of the "Banhado do Taim (RS)", where the Ecological Station of Taim project is located.

Until the end of 1970 there wasn't any marine animals preservation program in Brazil. In 1980 the IDBF (Brazilian Institute of Forestry Development) created the TAMAR project with the objective of saving and protecting the marine turtles of Brazil. The efforts on this project began in Bahia, Espírito Santo and Sergipe, being extended to the entire country, with species identification, spawning places discovery, reproduction period, etc. Today the TAMAR project is on the Ministry of Environment, which incorporated the IBDF. It now counts with 22 research stations between the states of São Paulo and Ceará, monitoring more than one thousand kilometers of coast.

It follows international orientations, in special from the Union for Nature Conservation (IUCN). It receives support from enterprises and national and international institutions, like the National Fund of the Environment, Aracruz Cellulose, TIBRAS, Brazilian Navy, and Interamerican Bank of Development etc. A good part of the resources for the maintenance of these projects come from the selling of products like T-shirts, key rings, adhesives, caps and other materials. These activities represent employment for the local populations.

In 1988 the TAMAR gained a decisive and definitive allied, the Pro-Tamar Foundation, a non-profit organization, created to support, speed up and make possible the development of the conservation works of the marine turtles in Brazil.

In the 96/97 season, the TAMAR reached the mark of 2.500.000 youngest released on the beaches, with almost no destruction of the nests by the men. This is thanks to the involvement of the communities of the preservation area, transforming them in partners of the activities and especially of the ideal of saving and protecting the turtles of Brazil. In exchange, it helped the populations to improve their lives, creating new surviving and cultural preservation possibilities, and offering them, mainly, work opportunity. Today about 300 fishermen work with the TAMAR, in the entire country.

The TAMAR, besides hiring fishermen, developed social programs, like day nurseries and communitarian vegetable gardens and others that offer alternative sources of income, like craftwork, ecotourism, tourist programs and environmental education activities. It offers support to the regional parties, strengthening the local culture.

Today the TAMAR-IBAMA project controls and protects more than 1.000 kilometers of beaches of the Brazilian coast – equivalent to 90% of the whole spawning areas of the turtles.

Another successful action was the recovery of the "Banhado do Taim", in Rio Grande do Sul. "Banhados" are wetland areas, which vary in size during the year. They exhibit in natural condition relatively constant variations of their water level along the years. They consist of environments with high biological productivity, giving support to many plant and animal communities (including marine). They represent an important function in the maintenance of the quality of the waters, purifying them, regulating upstream flow in view of the storage created by its floodable areas and contributing to the maintenance of the ground water level. They are, actually, ecotone, or transition environments between solid land and permanent deeper water.

The Ecological Station of Taim, with 32.963 km2 was in 1991 seriously threatened by hunters, vessels, property owners, rice farmers, contamination by pesticides, lake plumbing, substitution of the natural vegetation etc. There really was a project to drain it entirely. The inspection was inadequate and the working condition of the supervisors precarious. During the period from 1991 to 1996 there was a total reorganization of the Ecological Station, with the construction of plots marking the territory (30-km) and a security wall for administrative headquarters. In 1993 an emergency action plan was drawn out to settle local conflicts. Likewise, educational activities on the environment were undertaken. Today, Taim wetlands were recovered with full proliferation of birds, fish, mammal's etc. Among them, the black-neck swan which is one of its most characteristic species.

The implementation of a national Brazilian Agenda 21.

In the "Review of Progress Made Since the United Nations Conference on Environment and Development, 1922", information's provide by the Government of Brazil to the United Nations Commission on Sustainable Development, Fifth Sessions, 7-25 April 1997, New York (internet address: http://www.un.org/esa/earthsummit/brzil-cp.htm) we found that:

The National priority: high.

Status Report: An on going Coastal Management Program, coordinated by the Ministry of Environment, involving other federal agencies, coastal states and municipalities, and addressing practically every aspect of land zoning and use, pollution control, natural resource assessment and inventory, capacity building, identification of critical spots and contingency plans, in a decentralized fashion, has allowed for the development of an integrated coastal strategy.

Land based sources of pollution; partly due to the deficient sanitation systems or the location of **at** least 8 important industrial districts along the coast are a cause of concern and require constant monitoring.

The critical conditions of fisheries along the coastline has given way to the establishment of an Interministerial Working Group at the level of the Presidential

Office. The process of drafting a federal bill on Fisheries has taken into consideration the essential items of the FAO Code of Conduct of Responsible Fishing. A number of projects aimed at protecting endangered species, such as sea tortoises, manatees, whales and dolphins and aquatic birdlife have been implemented and expanded, with a recent addition of a regional project on the preservation of marine biodiversity and coastal wetlands, co-sponsored by GEF and UNESCO. The survey of living resources in the Exclusive Economic Resources Zone advances slowly in part due to inadequate resources.

In Brazil, protection of the ocean is a federal responsibility, primarily attributed to the Ministries of Environment, Navy, Science and Technology, and Mines and Energy. These and other Ministries are part of the Interministerial commission for Marine Resources, chaired by Ministry of the Navy, which supervises the research programs related do Continental Platform (LEPLAC), Exclusive Economic Zone (REVIZEE), Coastal Management (GERCO) and the Antarctic (PRO-ANTAR). The Ministry of Science and Technology through the Marine Sciences Program supervises the scientific and technological activities.

The UN - supported Train-Sea-Coast Center was installed at the University of Rio Grande, in the city of Rio Grande, State of Rio Grande do Sul. That is an important program on Brazilian capacity building in the marine sciences.

An important synthesis is presented in the report on the level of implementation in Brazil, of the activities included in Chapter 17 (Oceans) of the Agenda 21 and considered very important to Brazilian coastal region. Below, we reproduce some of the tables of that report:

Check in the table below in the left of each item, the level of importance of the activity, and in the right, the level of implementation of each activity:

Table I. – The Following Activities have been considered by the appropriate Coordinating Mechanism for Integrated Management and Sustainable Development of Coastal and Marine Areas and their Resources.

For level of importance use:	For level of implementation use:
*** = very important	*** = fully covered
** = important	** = well covered- gaps being addressed
* = not important	* = poorly covered
N = not relevant	O = not covered;
	N = not relevant

***a. Preparation and implementation of land and water use and siting policies. *

***b. Implementation of integrated coastal and marine management and sustainable development plans and programs at appropriate levels. **

***c. Preparation of coastal profiles identifying critical areas including eroded zones, physical processes, development patterns, user conflicts and specific priorities for management. **

***d. Prior environmental impact assessment, systematic observation and follow-up of major projects, including systematic incorporation of results in decision-making. *

***e. Contingency plans for human induced and natural disasters. *

***f. Improvement of coastal human settlements, especially in housing, drinking water and treatment and disposal of sewage, solid wastes and industrial effluents. *

***g. Periodic assessment of the impacts of external factors and phenomena to ensure that the objectives of integrated management and sustainable development of coastal areas and marine environment are met. *

***h. Conservation and restoration of altered critical habitats. *

***I. Integration of sectorial programs on sustainable development for settlements, agriculture, tourism, fishing, ports and industries affecting the coastal areas. *

***J. Infrastructure adaptation and alternative employment. *

***K. Human resource development and training. *

***L. Public education, awareness and information programs. *

***M. Promoting environmentally sound technology and sustainable practices. *

***N. Development and simultaneous implementation of environmental quality criteria. *

Table II. Technology (Marine Environment)

***A. Apply preventive, precautionary and anticipatory approaches so as to avoid degradation of the marine environment, as well as to reduce the risk of long-term or irreversible adverse effects upon it.*

***B. Ensure prior assessment of activities that may have significant adverse impacts upon the marine environment. *

***C. Integrate protection of the marine environment into relevant general environmental, social and economic development policies. **

***D. Develop economic incentives, where appropriate, to apply clean technologies and other means consistent with the internalization of an environmental cost, such as the polluter pays principal, so as to avoid degradation of the marine environment. *

***E. Improve the living standards of coastal populations, particularly in developing countries, so as to contribute to reducing the degradation of the coastal and marine environment. *

**F. Effective monitoring and surveillance within the exclusive economic zone (EEZ) of fish harvesting and transportation of toxic and other hazardous materials. *

Table III. Sewage and Related Issues

A. Sewage related problems are considered when formulating or reviewing coastal development plans, including human development plans.

B. Sewage treatment facilities are built in accordance with national policies.

C. Coastal outfalls are located so as to maintain acceptable level of environmental quality and to avoid exposing shellfisheries, water intakes and bathing areas to pathogens.

D. The Government promotes primary treatment of municipal sewage discharged to rivers, estuaries and the sea, or other solutions appropriate to specific sites.

E. The Government supports the establishment and improvement of local, national, subregional and regional, as necessary, regulatory and monitoring programs to control effluent discharge. Minimum sewage effluent guidelines and water quality criteria are in use.

Table IV. Other Sources of Marine Pollution, the Government has:

A. Established or improved upon, as necessary, regulatory and monitoring programs to control emissions, including recycling technologies.

B. Promoted risk and environmental impact assessments to help ensure an acceptable level of environmental quality.

C. Promoted assessment and cooperation at the regional level, where appropriate, with respect to the input of point source pollutants from the marine environment.

D. Taken steps to eliminate emissions or discharges of organohalogen compounds from the marine environment.

E. Taken steps to eliminate/reduce emissions or discharges or other synthetic organic compounds from the marine environment.

F. Promoted controls over anthropogenic inputs of nitrogen and phosphorous that enter coastal waters where such problems as eutrophication threatens the marine environment or its resources.

G. Taken steps to develop and implement environmentally sound land-use techniques and practices to reduce run-off to water courses and estuaries which would cause pollution or degradation of the marine environment.

H. Promoted the use of environmentally less harmful pesticides and fertilizers and alternative methods for pest control, and considered the prohibition of those found to be environmentally unsound.

I. Adopted new initiatives at national, subregional and regional levels for controlling the input of non-point source pollutants which require broad changes in sewage and waste management, agricultural practices, mining, construction and transportation.

J. Taken steps to control and prevent coastal erosion and deposition of silt due to anthropogenic factors related to, inter alia, land-use and construction techniques and practices.

Table V. Addressing Critical Uncertainties for the Management of the Marine Environement and Climate change. In order to Implement this Programme Area the Government is Carrying out the Following Activities:

A. Coordinating national and regional observation programs for coastal and near-shore phenomena related to climate change and for research parameters essential for marine and coastal management in all regions.

B. Providing improved forecasts of marine conditions for the safety of inhabitants of coastal areas and for the efficiency of marine operations.

C. Adopting special measures to cope with and adapt to potential climate change and sea level rise.

D. Participating in coastal vulnerability assessment, modeling and response strategies particularly for priority areas, such as small islands and low-lying and critical coastal areas.

E. Identifying ongoing and planned programs of systematic observation of the marine environment, with a view to integrating activities and establishing priorities to address critical uncertainties for oceans and all seas.

F. Research to determine the marine biological effects of increased levels of ultraviolet rays due to the depletion of the stratospheric ozone layer.

G. Carrying out analysis, assessments and systematic observation of the role of oceans as a carbon sink.

The related items on the charts above from the Ministry of the Environment reflect rather more the objectives to be reached than the effective results. In this way, for example, in the case of the submarine outfalls of urban sewer, there is little, if any, monitoring activity in many of them, although the situation of the industrial outfalls is far better, with good programs being developed, like the ones from CETREL/ Millenium in Bahia (Camaçari), and from the Aracruz cellulose, in Espírito Santo coastal region. There isn't also monitoring of the quality of the coastal water, following the Resolution 20 from 1986 from CONAMA – National Council of the Environment, which classified the national hydric bodies, including the coastal ones. Only the monitoring of the beach balneabilities, established by that Resolution, is carried out in Brazil.

The coastal management has to include the identification and the control of the terrestrial sources of marine pollution, and also apply effective measures of management and protection of the permanent conservation areas, like mangroves and coral reefs.

The Report of the Brazilian Independent National Commission of the Oceans to the Independent World Commission of the Oceans (1998)

According to the report, the exploration of the potential and the resources of oceans and marine bottom, including the continental platforms ones – food production, raw materials and energy, as well as new uses that the under accelerated evolution technology would permit – offers horizons open to the human adventure on the planet and promises more fair returns, on the exact measure of knowledge with which humanity respects equal rights of the future generations. This is, actually, a concern of the Brazilian people, shown in a poll made by the Gallup Institute, following a request of the Commission. It shows that the Brazilians value the sea (80%), mainly as a source of food (32%), for leisure (17%) and for its natural resources (10%). But the main concern is located in the ecological field: pollution (56%), uncontrolled fishing (51%), nuclear tests (36%) and the rise of the sea level (30%).

It emphasizes that the international community has been showing its intention to make compatible, in the use of the oceans, the joint application of the articles of the United Nations Convention on the Law of the Seas and the Agenda 21. Both instruments and an ample legislation of the sea and the activities therein constitute a complex legal situation where several interests are present.

The advancement of knowledge of the oceans requires high levels of cooperation, both nationally and internationally. A global vision is required. It must be remembered that there are processes that act more regionally, but there are others, like the ocean-atmosphere ones, that act on the climate, and whose effects are global. Considering that the oceans occupy more than 70% of the Earth's surface, the magnitude of the task faced by the scientists to reach an acceptable level of knowledge can be evaluated.

However, the scientific knowledge by itself just won't generate a solution for any problem related to the oceans and its uses if there will not be a transfer of this knowledge to the society, allowing those power to deciders, the decision markers, providing them with adequate tools for the management of the environment and the marine resources. But the decision markers must have the discernment to realize that steps can't be skipped in a scientific research: is necessary a period of studies coherent with the periodicity of the environmental events; in synthesis, results can't be obtained quickly. Besides that, it's also essential to have the involvement of the population as co-responsible for the maintenance of the integrity of the marine environment.

In December 22nd, 1988, Brazil confirmed the CNUDM, which enter in force in December 16th, 1994. Since this date, Brazil, together with the other countries, started to comply with the obligations and to exercise the rights predicted by the new Sea Law. In this way, the exploitation of live marine resources, especially by fishing (because the mariculture in Brazil, besides having advanced recently in Santa Catarina University center, is still incipient) has deserved special attention. Brazil, because of its long coast and the articles of CNUDM that regulate the matter, has a ZEE (Exclusive Economic Zone), with about 4 millions of square kilometers. The REVIZEE program tries to recognize the biological resources in it and its sustainable limits of capture. It is known that the species diversity and the low biomass of each stock are elevated.

Besides the existence of estimates showing that we have a sustainable annual potential of capture of up to 1,7 millions of tons, the Brazilian marine production never went above 770 thousand tons. Even more, studies show that the stocks that answer for 30% to 40% of that production present reliable signals of overfishing, that today can really reach 80% of the stocks under exploitation.

Another major question is the degradation of the coastal ecosystems, especially of the estuarine systems, destruction of mangroves, disseminated fecal pollution, elevation of the turbidity of the coastal water, oil spill, predatory fishing, which destroys the environments where larva and young's of many species live later migrating to the continental platform, where they reach maturity.

The Brazilian Continental Platform Survey (LEPLAC) came to the conclusion that the national economic space should be increased by about 1 million square kilometers enabling the country to place these new limits to the Limits Commission created by the Convention.

Finally, the Independent National Commission of the Oceans recommended an increase in knowledge acquisition in our country in order to wait for a better connection with the national requirements:

1. The **inexistence** of a clear political mark, compromised with the premises of sustained development and to which, in what fits, all the specific policies adjust to, like the fishing, industrial and urban development, tourism, etc. The actual situation, of relative **indefinition**, ends up resulting in an aggravation of the risk that there might be taken less compromised decisions to the country and the future generations, moved by the idealism, opportunism and even by the lack of information. Such decisions **prescind** from the scientific and technological knowledge, and for this reason, frequently, put scientists and public administrators in opposite and unreachable fields.
2. The fixation of policies, plans and research programs with a low level of audience to the directly interested segments, being them productors or consumers of the generated knowledge's.
3. The lack of an adequate and permanent national coordination to take care of the research and development activities and use a political power to promote the incorporation of the results obtained from the power of decision processes and/ or appropriate productive.
4. While in Brazil the exploration of offshore oil has been very successful, both technologically and in production, fisheries have had several serious problems that have yet to be solved with success.

The Plan of Federal Action for the Coastal Zone of Brazil

The Plan of Federal Action for the Coastal Zone of Brazil (PNZC): it was in 1998 elaborated by the Interministerial Commission for the Resources of the Sea (CIRM) and by the Group of Integration of the Coastal Administration (GI-GERCO) of the Ministry of the Environment, of the Water Resources and of the Amazonian Legal (MMA).

The Federal Law 7661/1998 instituted the National Plan of Coastal Administration (PNGC I). A first version of that Law was presented in November of 1990 and approved through the Resolution CONAMA 001/90. A new version, updated, was approved by the Resolution 005 of CIRM in 1997 (PNGC II). In this last version, necessary level of the federal performance was accentuated in GERCO.

PNZC shows that the first legal document to be considered in the discussions on the coast Brazilian zone is the Federal Constitution of 1988, that in its Art. 225, # 4 define the coastal zone as national patrimony, beside the Amazon Forest, the Pantanal, the Atlantic forest and the Coastal Brazilian Zone. The Federal Law 7661/1988 that established PNGC foresees in its article 5. that it will be elaborated meditating, among other the following aspects: urbanization, occupation of the soil, use of the soil, of the underground and the waters, parceling of the soil, transport systems and production systems, transmission and distribution of energy, house and basic sanitation, tourism, recreation and leisure, patrimony natural, historical, ethnic, cultural and landscape. In spite of the width of those areas, the Law 7661 doesn't detail instant-applicable mechanisms of performance, sending such regulations for CONAMA and for Coastal Management National Plan that should be elaborated by SECIRM–Secretariat Executive of CIRM.

The National Politics for the Resources of the Sea it was instituted in Brazil in 1980 for a Presidential Measure, tends as executive organ the SECIRM - Interministerial Commission for the Resources of the SEA Secretariat (CIRM), whose Minister Coordinator is the Minister of the Navy.

PNGC II is explicit in the search of partnerships and of articulate activities among government organs. That purpose is clear in its items:

5.4–the incorporation of the environmental dimension in the sectorial politics gone back to the integrated administration of the coastal and sea atmospheres, compatiblenised with PNGC.

6.1. –compatibility of the actions of PNGC with the public politics that they happen on the Coastal zone, among other, the industrial, of transports, those related to the territorial ordaining, resources hydrics, occupation of "navy lands", units of conservation, tourism and fisheries, in way to establish partnerships, seeking the integration of actions and the optimization of results.

To render those purposes, a permanent forum of interministerial dialogue was created in the sphere of the Union: the Group of Integration of the Coastal Administration (GI-GERCO), inserted in the structure of CIRM, seeking to promote the articulation of the incident federal actions in the Coastal Zone.

UNCED ratified by Brazil in 1988 little discuss in reality, in the specific problems of the Coastal Zone, and practically it ignores the problem of the coastal spaces, but in its Art. 194 establish that... States should take, individually or jointly, as appropriate, the compatible measures with to present Convention, that are necessary to prevent, to reduce and to control the pollution of the sea... and they should make an effort for harmonizing its politics to that respect...

The Agenda 21 proposes clearly to States, the creation of programs of coastal administration, led by a national coordination, that it would impel several mechanisms, among them: implementation of politics gone back to the use of the earth and of the water and the implantation of activities; implementation of plans and integrated programs of coastal administration and of maintainable development of the coastal zones; preparation of coastal profiles that identify critical areas; integration of the relative sectorial programs to the maintainable development... that use or link to the coastal area. Those determinations force the preparation of national guidelines for the coastal administration and the integrated development of the coastal zones and they are the larger objective of the Plan of Federal Action of 1998 for the Coastal Zone of Brazil.

It is important to mark, whatever the federal presence in the Brazilian coastal zone, that the federal Constitution of 1988 discriminates in its art. 20, some goods of the Union, or be:

iv - the marine beaches; the oceanic islands and the coasts, excluded of these those belonging to States and Municipalities;

v–the natural resources of the continental platform and of the exclusive economical zone

vi - the territorial sea

vii–the "navy lands" and its added

Like this, so much the seafront, as the sea front of the Coastal Zone is under federal domain in Brazil, and under the guard of the Union.

In 1988 there were 29 areas protected located in the Coastal Zone of Brazil, or be: 6 National Parks, 5 Biological Reservations, 7 Ecological Stations, 1 Ecological Reservation, 9 Areas of Environmental Protection and 1 Reserve Extrativist.

One of the most important aspects of the Federal Plan for the Brazilian Coastal Zone, is the identification of the origins of the existent use problems in her, or is:

1. Inexistence of effective politics of use and occupation of the soil and of use of the natural resources in the Coastal Zone. Deficiencies in the harmonization and implementation of the proposals of ecological-economical zoning of GERCO and of SAE/PR. Inexistence of integrated plans of regional development.
2. Validity of activities of sectorial planning disarticulated to each other. Lack of articulation of the public politics, especially in definition of the state investments. Public financing of irregular works and irregular performance of public entities.
3. Lack of regulation of juridical instruments and validity of norms and inefficiency and legal conflicts. Inefficient accomplishment of the laws and in the punishment to the transgressions. Existence of legal conflicts of attributions.
4. Low mobilization and involvement of the society and deficiency of participative mechanisms (especially in the budget subjects). Little involvement and sensibility of the private section for the environmental subjects.
5. Conflicts of competence of performance in the licensing actions and fiscalization and absence of systems of appropriate environmental monitoring.
6. Inexistence of municipal managing plans in most of the coastal municipal districts and desarticulated conflict between this government level and the state and federal administrations.
7. Lack of qualified technical personal, for accomplishment of the necessary tasks to the administration of the environment, in the several government levels. Technical ignorance concerning the geographical areas of performance.
8. Validity of economical activities that don't incorporate the local populations, and non-valorization of the traditional activities. Inadequate utilization of Coastal Zone potentialities, with sub and on-use of the resources.

9. Infrastructure inadequacy, mainly of basic sanitation.

Seeking to heal that whole problem, the Plan of Federal Action will try to guide the Federal Government's actions in the Coastal Zone, by the participative planning and a cast's of prioritized actions integrated implementation; it will identify the opportunities of optimization of the installed capacity and it will promote the cooperation interinstitucional; and it will promote the development of strategic actions for harmonization and articulation of incidents public politics in the Coastal Zone, looking for participatives responsibilities of performance.

The Plan try also to regulate the Federal Laws 7.661/88 (it instituted the National Plan of the Coastal administration) and the Federal Law 9.636/98 administration of areas of patrimony of the Union), particularly in the referring aspects to the definition of general norms of use and occupation of the coast, starting from the classification topologic of the beaches, and establishment of criteria for the release of a line of coastal protection. It tries to regulate and to regularize the aquatic facilities. It will try to conclude the ecological-economical zoning, articulate to the administration plans and monitoramento programs. It will diagnose the environmental assets of the Coastal Zone, proposing guidelines for your uses. It will try to do administrations for the approval of the Federal Law Project 37/96 that updates the legislation about sea pollution in Brazil. It will set up and it will implement a Program of Fiscalization Integrated for the Coastal Zone, optimizing the existent systems and of articulation of institutional mechanisms, especially in what he/she refers to the of federal organs. Realization of campaigns of control of the environmental quality in critical areas, in an integrated way and articulate among the several organs.

Specially, it will try to incorporate the principles of PNGC to the Plurianual National Plan (PP 2000-2003) considering the Coastal Zone a unit of federal planning.

V – Sectorial Plan for the Resources of the Sea (V PSRM)

The Federal Decree 2956/1999, approved V Sectorial Plan for the Resources of the Sea (V PSRM). We will do to present, an abbreviation summary of the same.

As that Decree, the National Politics for the Resources of the Sea has for purpose to fasten the essential measures so much to the promotion the integration, of the Territorial Sea, the Continental Platform and of the Exclusive Economical Zone (ZEE), to the Brazilian space and the maintainable use of the resources of the sea, understood the resources alive and not alive of the column of water, soil and underground, that present interest for the economical and social development of the country. The Sectorial Plan for the Resources of the Sea (PSRM), of that treats that Decree, it constitute an unfolding of PNRM.

V PSRM is conditioned and this in consonance with the National Politics for the Resources of the Sea, as well as, with the basic instruments of the International Right of the which Brazil is signatory, as for instance, UNCED, the Agenda 21, MARPOL, RAMSAR, etc. It is conditioned by the Brazilian national legislation as, for instance, the Federal Constitution of 1988, the Federal Law 7661/88, the Federal Law 9433/97 (National Politics of Hydric Resources), the Federal Law 9605 (it disposes about penal and administrative penalties derived of conducts and harmful activities to the environment – it is named federal Law of the Environmental Crimes), etc.

V PSRM'S primordial objective is the knowledge and the evaluation of the potentiality of the resources alive and not alive of the sea areas under national and adjacent jurisdiction, seeking to the administration and the maintainable use of those resources.

It considers as resources of the sea all those resources alive and not alive that they are in the column of water, in the soil and underground, as well as in the adjacent coastal areas, whose exploitation is important under the point of view economical, social and ecological. It considers fundamental condition for the correct use of the resources of the sea, the existence of global knowledge and integrated on the elements that compose the several ecosystems, as well as on the anthropic actions that modify them.

The need of a restructuring of the national fishing segment, whose revitalization should be made in maintainable bases highlights, and for so much, it is indispensable an integrated planning, participative and co-responsible in consonance with the main world tendencies. In that sense, it was created at level of the Presidency of the Republic, GESPE–I Group Executive of the Fishing Section. This elaborated a proposal of National Politics of Fishing and Aquiculture, and of your execution instrument, the master plan, that you/they already meet at the Civil House of the Presidency.

V PSRM present a discussion and prioritization of actions, for all areas of interest of the Brazilian Sea.

Final considerations

Despite many laws, is yet very difficult in Brazil, control littoral urban, portuary, or industrial expansion, and many kinds of environmental destruction, especially of mangroves, estuaries and of our fish stocks.

There is the need to solve social, economic and technological questions connected with the fishing sector. It must be remembered that the fishing sector affects a contingent of 3 million people whose subsistence depends, directly or indirectly, on this activity. It's necessary to strengthen and reorientate the institutional structure which coordinates priorities and execution of research and activities that form the basis for new decisions on the regularization of exploration, arrangement measures, specific legislation, incentives to the productive activities and all web of requirements involved in the administration of fishing resources. We need institutionalize ecologically based sustainable management of our marine fisheries, using optimum yields in preference to maximum sustainable yields, and specially, applying the precautionary principle.

There is also the need to clean up definitely the national coast, protecting public health, guaranteeing a safe use of sea food for human nourishment, and with this, contributing to tourism and social development and the protection of the ecosystems. We need try to establish zero discharge levels of toxic substances, especially that bioaccumulate or biomagnify.

The development of mariculture, in a sustainable way, with no impact is also desired. On our long and diversified coast, there is, undoubtedly, several opportunities for mariculture, yet to be used.

We need to replace the current, fragmented approach to Brazilian Ocean studies and management with a collaborative, integrated approach. We need to expand working partnerships among ocean stakeholders and increase their responsibilities and accountabilities; we need optimize the economic potential of our ocean while ensuring their conservation and sustainability.

We need to continue to expand our scientific knowledge of our coastal regions and its resources, including the dynamic of fished stocks and the effects of pollution on its ecosystems.

We need a national framework to provide environmental and economically sustainable development of our ocean resources, with an effective National Ocean Strategy (understanding our ocean; conserving ocean biodiversity; marine environment quality; shipping and maritime safety; integrated planning and management; ocean industries and related opportunities; maritime security and enforcement; international considerations; public and community awareness, understanding and participation), addressing the concerns of all Brazilians who enjoy the economic, sociocultural and recreational opportunities offered by our ocean and coastal regions.

The Brazilian National Ocean Strategy should really take into consideration: marine biodiversity conservation and the introduction of exotic species; marine and coastal habitat loss and degradation; the role of marine protected areas and their relationship to limited and multiple use practices. We need increased understanding of the impacts of marine industries and recreational activities; increased understanding of the causes and rates of degradation and recovery of the ocean environment; and of the impacts of climate variability and change on marine ecosystems.

We need funding and carrying out oceanographic research within national boundaries where baseline studies are lacking. We need support marine biotechnological researches. We need support centers of oceanographical research, natural history museums, and repositories of specimens and of oceanographical data. We need promote genetic research of marine organisms, and promote studies of marine ecoservices and calculations of the area of coastal and marine natural areas need to maintain those services. We need develop and apply cumulative assessment guidelines of environmental impacts.

If we want to see a cleaner coastal environment in this country, we must all actively participate in cleaning it. And especially we need remember, all the times that the Eco-services provide by our sea are vital to our country biodiversity and specially, to our populations. And that the sea is one of the most important part of life-sustaining Earth support processes.

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Perspectives for Sustainable Management of the Renewable Natural Resources of the Amazon Forest

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I - Introduction

In the last years of the 20th century a major world concern unites different research groups, social segments and governments - conservation of the tropical forests, meeting the requirements of the human population and the necessary economic growth. The initial outcome of this concern today is the notion that only by adopting a sustainable development project integrating technique and social improvement will it be possible to conserve natural resources, tropical forests all over the world and improve the quality of life for the human race.

Historically, the countries where the nature-society bionomial has high levels of degradation lie exactly in the inter-tropical areas, between latitudes 23° North and 23° South. Their histories demonstrate a sad relationship between colonization, exploitation of their natural resources, population growth, demographic implosion of autochthonous groups, method of production, technology and social exclusion.

The consequences of this relationship, considered today to be unsustainable, are the increase in geometric progression of the processes linked to incorporating land into the prevailing productive methods, always beginning at the deforestation stage; deteriorating living conditions in the rural and urban environment; and loss of autochthonous cultural roots.

In this sphere, the Amazon domain has been recognized as a matter of worldwide concern regarding its progressive natural and social deterioration and its potential and importance in maintaining the biosphere-atmosphere balance.

The Amazon, stretching across nine countries, Brazil, Colombia, Peru, Venezuela, Ecuador, Bolivia, French Guinea, Surinam and Guyana, comprises a total area of around 7.8 million km^2, 70% of which is in Brazilian territory, representing more than 60% (around 5.5 million km^2) of this country.

It is defined in Brazil, for political-administrative purposes, as the Legal Amazon, consisting of the states of Acre, Amazonas, Roraima, Pará, Mato Grosso, Amapá, Tocantins and most of western Maranhão (Fig.1)

II - General Ecology

In terms of river drainage, the Amazon region covers the Solimões-Amazon, Tocantins river basins and part of the Orinoco river basin. The 6,577 km long Amazon river is considered today the longest river with the largest volume of water in the world. It is the area with prevailing plant formations of tropical rain forests and savanna vegetation.

Alongside this apparent unity in terms of river drainage, a range of complex ecosystems have developed with different characteristics of relief, soil, flora, fauna and morpho-dynamic processes. In order to understand these different landscapes, it is necessary to go back to the history of the Amazon basin's physical geography and its beginning when the Andes mountain range emerged around 68 million years ago (Cenozoic Era).

This new mountain range inverted the previous drainage pattern, creating today's vast depression between the arch at the foot of the Andes mountains, the Guyana and Brazilian plateaus, and is considered one of the largest inland lowland amphitheaters on Earth. Fluvial-lacustrine deposits prevailed for some time in this depression. Another slight uplift sloping generally eastwards determined the Amazon river and its western tributaries. In this sense, then, the Amazon is a geologically young river.

Today the relief system consists of a broad amphitheater opening eastwards and limited in the West by the Andes, by the Guyana plateau in the North and Brazilian plateau in the South. This physiography and its latitudinal position, cut by the Equator - influenced the prevailing warm rain-carrying winds blowing from the East to eventually give rise to a hot wet climate which permitted the development of the current climatic conditions.

Moreover, numerous recent studies show that the continuing prevailing climatic conditions and ecological dynamic balance itself are determined partly by the existing forest. This fact confirms the hypothesis that over time, under the prevailing hydrological conditions, plant-animal interactions gradually changed the conditions of climatic behavior until the present.

From the paleoclimatic viewpoint, the many studies performed on the Cenozoic in Brazil have shown that the evolution and development of the relief systems existing today resulted from the recurrence of the alternating dry and wet climates.

An increase in and better distribution of the rainfall, predominance of chemical alteration of the rocks, soil formation, spread of forest vegetation and development of the river basins were associated with the rainy eras. In the river basins erosion was under control, and only occurred in a linear fashion. These were the times when biological life developed and diversified.

On the other hand, a decrease in and concentration of rainfall were associated with the dry eras, which reflected immediately on the forest vegetative cover that tended to diminish in favor of the expansion of open vegetation (grassland, steppe, savanna, scrub land). The outcome is the removal of soil by the action of rainwater and filling up of valley bottoms, obstructing the flow of the rivers, since the increase in debris was much higher than the capacity of the rivers to carry it. During these dry seasons, slope erosion processes prevailed, ranging from surface run-off to mass movement, increased rates in the mechanical alteration of rocks, a drop in the river water volume and widening of the river beds. These are the times when biological life diminished and the general degradation of the landscape increased.

The many studies already performed to define the role of the alternating climates have revealed the occurrence of considerable paleo-hydrological fluctuations on a regional basis, between 21,000 and 12,500 years ago, and around 7,520 years ago, when dry or semi-arid climatic conditions prevailed.

In the studies on the Legal Amazon carried out by Brazilian Geography and Statistics Institute (IBGE and FBDS,1994) the mapping of natural landscape systems on a scale of 1:2,500,000 revealed this complexity, and 104 systems and 224 subsystems of natural landscapes were identified. These studies showed the importance of the presence of dichotomic natural landscapes (that is, in imbalance) between the hydrological and flora and fauna behavior, considered overall as tropical, and the abiotic landscape (relief, soils) with characteristics that differ from those of today. Such a fact confirms the hypothesis that the wet tropical conditions for the Amazon were recent and calls attention to the recentness and fragility of its biodiversity and, thereby, its ecosystems.

III - Population Growth

On the other hand, the same Brazilian Amazon today has a population of over 20 million inhabitants, representing around 15% of the whole Brazilian population, of which around 55% live in urban centers. The remaining indigenous societies total approximately 100,000 inhabitants.

The regional society is formed by Indians, mestizos, small farmers, homeless groups, urban workers, large and small landowners, traditional and modern entrepreneurs. Most of these social players comprise the groups of immigrants who at different times moved there, adding to the diversity which is so characteristic of this area. This no longer includes merely its physical-natural and biological diversity but also the diversity of the social, economic and cultural colonization.

In short, the change in the ecological and cultural mosaic of the Brazilian Amazon may be considered the result of four landmarks: the Portuguese spread in the 17th century; the Marquis of Pombal's policy in the 18th century; the rubber boom in the 19th/20th centuries; and the developmentalist policy of the second half of the 20th century.

The 1990s, however, seem to bring with them a new referential regarding the role of this region, caused by global economic and political changes. A new phase appears now with reference to the scientific-technological revolution, environmental crisis and social movements.

Meanwhile, countless projects for organizing and integrating this geographical area have been proposed and implemented. The sixties, however, may be considered the major landmark that was the basis for the changes which caused the most dramatic ecological and cultural transformations. In the early years of that decade the population was 2.6 million and by the end of the eighties had reached around 17 million (figure 2).

As a result of these changes, for the period between 1960 and 1991, in demographic terms, there was an increase in the population of 14 million inhabitants, which means a total growth rate of 550%. In terms of vegetative cover, taking into consideration the forest and non-forest vegetation, in 1991 a total of 14.07% of Brazilian Amazon territory was impacted and/or deforested (Ferreira, 1996).

To discuss this incorporation and "humanization" of the Amazon area entails discussing the different stages of devastation undergone by this region during its occupation. This expropriation of man and nature, mostly a result of the idea of "the great frontier of resources", when it acquired gigantic proportions, caused the idea that there were inexhaustible resources and almost an obligation to exploit them.

On the other hand, the "demographic void" slogan transmitted the idea of the need to occupy an area of continental dimensions. And so this region began to be compulsively colonized, on a three-pronged basis of the need for progress, search for national and international integration, and economic growth.

IV - Land Transformation.

These are transforming agents generated most frequently in areas outside the Amazon and the continent. The extent of these forces creates demands that can exert so much pressure on the social groups living there that they become local agents of the devastation

In fact, this progressive devastation, educational and cruel at the same time, is responsible for different external and internal demands for raw materials and inputs necessary for the prevailing form of production, as well as the need to solve social issues in different regions beyond the Amazon (Northeast, Mid-West and South). The answer lies in the penetration and consolidation of the control of the territory, gradual privatization of land, mines and forests and the economic and political organization of the region.

The First Changes.

Since the arrival of the indigenous nations in the Amazon, at an unknown date, until the decline in the rubber boom at the end of the 1940s, anthropic changes had little effect on the landscape. The demand for food (pirarucu, manatee), oil for lighting (manatee oil for candles and turtle oil), leather, skins and feathers for the fashion industry (alligators, monkeys, wild cats, egrets and other colored birds) and aromatic woods for perfumery (rosewood and cinnamon), was responsible for the extermination of large contingents of regional fauna and flora. Even today the pirarucu, manatee and turtles are still being destroyed and their populations have diminished greatly.

The loss of biodiversity in the region can be followed throughout its history. The first devastation was that of the gallery forest along the navigable river routes. The intent was to find "drugs from the *sertão* (inland)" (cinnamon, clove, indigo, cacao, aromatic roots, oleaginous seeds, timber, sarsaparilla, etc.) used in food, seasoning, shipbuilding and the pharmacopoeia of western Europe of the 17th and 18th centuries, as well as to expand Portuguese territory. Settlements were based on the military and colonial centers and religious missions (São Gabriel da Cachoeira, Barcelos, Tefé, Santarém, etc.). Market pressures and potential led to the metropolis tentatively starting a move from collecting to cultivating these drugs.

The need for manpower forced the settlers, mainly from Maranhão, to capture Indians as a labor source. The clash between the Jesuits who defended the Indians and the Maranhão settlers who produced sugar, tobacco and other products caused a further move inland by the settlers who discovered new potential products, that is, spices. This period is called the "inland drug boom".

In the 17th century an enormous quantity of smoked or salted manatee meat or *mixira* (preserve of young manatee in its own oil) was sent to Europe. Every year more than 20 vessels laden with manatee meat sailed from the port of Gurupá. By the 18th century it was hard enough to fill even one vessel with this cargo. Veríssimo, who was an encyclopedia of knowledge on Amazon matters, in 1895 spoke of the disappearance of the turtle and manatee populations from Marajó bay and the lower Tocantins. Between 1885 and 1893 the average pirarucu fish production was 1,283 tons, corresponding to 2,500 tons of fresh fish. Between 1933 and 1936, at the same port, the average annual production of dried pirarucu was 563 tons, that is, around 1,130 tons of fresh fish. These depleted resources in the 19th century were caused by the food requirements of the contingent of rubber soldiers who were the work force on the rubber plantations.

The second major devastation occurred between the last decades of last century and the first two of this century as a result of two major demands: Europe and the United States demanded a massive volume of rubber to manufacture domestic appliances, tires, war material and for shipbuilding; and the other was the need to solve problems in the Northeast due to the prolonged drought between 1877 and 1880. This was the time when Southwest Amazon was invaded and integrated, and from this period dates the incorporation of what is today the state of Acre. This was the “rubber boom”.

The association of these national and international external demands caused a substantial increase in the number of the local population. The human contingent increased from 127,000 in 1823 to approximately 1.4 million inhabitants around 1920. They were additions to the lines of workers who spread out over those areas of thick rain forest, which has the largest occurrence of *Hevea brasiliense* (rubber tree). Of these areas, Acre had the largest influx of immigrants.

The 1920s and 1930s saw the start of the invasion of the cattle raising and mining forerunners who penetrated through the wide gaps left by the rubber and nut extractivist organizations. The latter activities satisfied predominantly local and regional demands, resulting from the need to attend a local consumer market then and to complement the resources of those who lived on subsistence and/or plant extractivist farming.

During the rubber boom, biodiversity was endangered by hunting for the rubber tappers’ food. As most of the work force was busy with latex extractivism, there were few extensively cleared areas in the western Amazon for farming. Most farm products were imported from other regions.

Although the cropland frontiers had existed for a long time in the Amazon, they had the boundary of the forest against farther penetration. The whole rural spread ascertained until then occurred in areas of savanna and cropland. This farming activity put little pressure on the Amazon forest area until the 1960s because of its characteristics of expansion on natural pastureland and its secondary role, which demanded little in terms of the number of workers.

Decades of Devastation – 1970-980s.

But the arrival of the 1970s inverted this situation. From that moment, the “discovery” of mineral wealth and poverty of the soils made these two “frontiers” responsible for a new “boom” in changing this ecological mosaic.

The opening up of the Belém-Brasilia highway in the 1960s formed a North-South axis joined by the pre-existing secondary roads or those to be built. This redefined the whole system of access to the region, the circulation of the expanding frontiers and merchandise in the East-West direction.

The construction of this highway led to a faster advance of cropland fronts following the highway, moving towards Araguaia and the Xingu, the first signs of considerable changes in East Amazon. These changes, however, were only to be deeply felt ten years later when the Transamazonica and Cuiabá-Santarém highways were built. At the same time, during this period, there was a sharp rise in the number of small farmers expelled from the Northeast, who had been “advised” and “encouraged” to move onto the fore-Amazon and Amazon lands where, according to the propaganda, there was plenty of “free land”.

The rate and intensity of this occupation meant, as a rule, a dramatic break from the activities that were being reproduced in the "demographic void", within a social and economic diversity that basically sheltered a population formed of Indians, riverside dwellers and some Northeastern immigrants, many of whom were mestizos, attracted by the successive booms in the extractivist economy.

From 1960 to 1980, the Amazon population grew from 2.6 to 11 million. The population boom is again the result of migration.

In an attempt to improve the organization of this occupation process, INCRA (National Institute of Settlement and Land Reform) was created in 1970 in order to organize and undertake land reform and to organize, coordinate, control and carry out colonization. According to IBASE (1985), INCRA would have moved around 400,000 settlers to the Amazon region between 1970 and 1974.

Directed settlement appeared as one of the most significant forms during this intense occupation process over the last twenty years. In general, settlement projects do not have a uniform pattern, differing from each other in terms of area occupied and the nature of the enterprise.

Although they have the same government policy, they have different aspects of access to the land through settlement.

The official settlement projects undertaken by the government were scattered over East Amazon (Altamira, Itaituba, Marabá, Carajás II and III, in the state of Pará; Barra do Corda in Maranhão), while in West Amazon they tend to concentrate in Rondonia. They may be of three types: integrated colonization projects, directed settlement and joint settlement. They covered 73.4% (7,104,285.3 hectares) of the land appropriated for this purpose.

Private colonization projects, however, by private enterprise occur predominantly in Mato Grosso, such as, for instance, those in Sinop, Alta Floresta and Juína. These projects cover 26.6% of the whole area (2,573,485.6 hectares).

If, on one hand, in terms of land penetration, land, mines and forest ownership, and economic and political organization of the region, it can be considered as the last devastation, it may, on the other hand, mean a new beginning.

The Pressures Continue – 1980-1990s.

A new phase appeared in the early 1980s as a reflection of the new world economic order, dictated by a structured raw material market on a worldwide scale. The commitment of this economy caused the retrieval of resources which have now become scarce (timber, hydroelectricity), use of other resources in a growing demand for modern technology (aluminum), in addition to the lower costs of abundant traditional raw materials in the area (iron ore).

From a Brazilian viewpoint, the 1980s represented the implementation of a modernization policy of this territory, with a view to industrialization of the Amazon and exploitation of its mineral resources on updated bases. It was in the eighties that the Grand Carajás Project (PGC) was installed, considered in terms of both physical area (900,000 km^2) and projected investments as one of the largest integrated development projects ever begun by a developing country (Hall, 1990).

Basically this new project led by the State brings demands for timber, hydroelectric power, organizes the opening of areas for mineral exploitation and provides new mobility for the population in the Amazon area.

In the wake of these demands comes the new mobility of the population inside the Amazon region itself, especially from immigrants from Maranhão. They are encouraged to move to areas where they are needed as manpower in the building of the infrastructure (Carajás railroad, mining area, steel mills, etc.) and for future industry.

Interaction between demands, exploitation of resources and need for labor caused a spatial "disorganization" of the deprived social segments who eventually consider the exploitation of this asset as an alternative for survival. Groups of migration were seen within and outside the Amazon (Mid-West and South). This was seen in the gold rush (prospectors and small companies), of which the best known example is Serra Pelada. This boom reached its peak in 1985 when more than 500,000 people converged on this area, crammed together in towns, such as, Marabá, Eldorado do Carajás, Curionópolis, Parauapebas and Rio Verde. This is the second major ecological and human change in eastern Amazon.

As an outcome of these induced geographic organization projects in the Amazon (Ferreira et al, 1995, 1996), it was found that between 1976 and 1991 around 35.61% of the area where the vegetation is seasonal and rain forests and 20.41% of the contact areas were rain/seasonal forest, was impacted and/or deforested. If we take into account the other non-forest vegetation, in 1991 we have a total of 14.07% of the Brazilian Amazon territory impacted and/or deforested (Fig. 3).

These figures correspond to the total percentage of the Brazilian Amazon area converted into pastureland, farming areas, lumbering, mining, prospecting, plant extractivism and urban areas.

New Economic Pressures and Deforestation – 1990s.

The nineties seems to bring in its wake a new reference point regarding the role of this region, caused by further changes of a world economic and political order. This is a new phase now in relation to the scientific-technological revolution, environmental crisis and social movements.

The transforming forces, previously exclusively external, now blend with the national and local internal demands. The Amazon is becoming the product of local, regional, national, international and planetary demands. Its future is the world's future.

In this new context where the technical-ecological vector characterizes the production methods, the Amazon has become the center of a worldwide debate. According to Becker (1996), "all elements in this vector are present in Brazil and much more clearly in the Amazon, which has become the contradictory synthesis of the prevailing industrialist and eco-developmentalist models at the end of the millennium. For this new production method, nature is valued as capital with future returns for native populations and environmentalist movements. Nature is valued as a source and means of life, while it is still the essential basis of resources for productive segments and Brazilian society in general".

However, although the technical-ecological vector emerges as a debate that seems to permit the preservation of this geographical area, it is found, on the other hand, that there are accentuated external economic demands for staple raw materials (principally timber) and primary products (cereals) that again put heavy pressure on this region because of the exhaustion of other areas.

The rise in deforestation rates disclosed by INPE (figure 4), principally in 1990 and 1991, and IBGE's mapping of human development seem to indicate that these new demands are already in the pipeline.

If we look at the deforestation rate per state (figure 5), we will see that the states of Rondonia and Mato Grosso showed a progressively higher rise in deforestation rates for the 1990-1994 period. The progressive increase in rates in the state of Mato Grosso can be explained by the advance of the soybean agribusiness that is already moving into the southern areas of Pará and Maranhão.

On the other hand, when we look at the graphs on urban and rural population growth (figures 6 and 7), we see that since the 1980s both West and East Amazon have undergone an increasing urbanization process of their populations, headed by the states of Amazonas and Mato Grosso, followed on a lesser scale by Rondonia and Acre.

If we compare the graphs on urban and rural population growth and the deforestation rates in the Amazon we will see that a population growth in rural areas does not correspond to this substantial increase in deforestation rates.

This offers us the hypothesis that progressive deforestation is not a product of direct demographic pressure but rather of transforming economic forces entailing technological packages which exclude large quantities of manpower. Such transforming agents represent pressure groups at local, regional and international levels.

This hypothesis is confirmed by the types of international and national demands (Figures 8 and 9) that exert more pressure on this region. The products in most demand are represented by timber, cattle raising and cereals, activities which absorb little manpower but with a high spatial capacity for destroying the ecological mosaic. Grain farming, although representing a recent demand, has been encroaching on the remaining savanna areas in northern Mato Grosso and southern Pará since 1988 as the IBGE mapping reveals (1995). Today this cereal production is already encroaching on the forest-savanna transition areas.

This new order of devastation is currently reflected in the disordered growth of the towns that, in some places in the Amazon, have even had a relative growth of 7,000% between 1980 and 1991 (IBGE, 1995). These towns have become the locus of a cultural and ethnic disruption, with the consequent loss of identity by native segments who have for centuries adapted to the regional ecosystems.

Questions of health arise in this complex urban scenario and this last decade has seen a substantial increase in the incidence of endemic diseases, principally malaria, cutaneous leishmaniasis, typhoid, leptospirrose and leprosy (IBGE, 1995).

The figures undeniably demonstrate the importance of the different social segments in the progressive transformation of the Amazon domain and the external transforming agents that are able to engender processes hard to control at a regional and national level.

It is, however, necessary for us to identify as early as possible the new pointers of the human dimension that now emerge and those that may potentially arise with a view to being able to supply not only past but future models of scenarios of changes in the biosphere-atmosphere.

Lastly, it is important to remember that at the end of this millenium, the Amazon domain is at the same time one of the last vast and wealthy sparsely populated areas on the planet and one of the world's most complex and vulnerable ecosystems which "makes its development an incognito and a challenge to world and national sciences" (Becker, 1996).

V - The Evolution of the Scientific Knowledge of Amazonia.

The First Descriptions

The stories of the first conquerors who traveled as far as the Brazilian Amazon attest to their wonder at the sight of such natural abundance. The presence of adventurers from many European countries was a sign that this territory was coveted by n means few European powers, and that, on beholding such tropical lushness and biodiversity, they believed that they had found in the Amazon a fortune that would make each common conqueror a wealthier man than the Portuguese king himself. They believed that this land was part of the earthly paradise or the mythical Renaissance cities (El Dorado, Land of the Amazons).

We owe the first accounts of this region to the Dominican friar, Caspar de Carvajal, who wrote in detail of the expedition of Francisco Orellana, Spanish conquistador, who founded Guayaquil and brother of the cruel Gonzalo Pizarro, who annihilated the Inca empire. The first journey along the Amazon river was made following the waters eastwards from the West. Friar Carvajal's writings are the first descriptions of the general characteristics of the river with the largest volume of freshwater on Earth. This navigation took around eight months and ended in August 1542.

One of the interesting facts mentioned by Carvajal is the existence of the Amazons, described by him as women who courageously fought with bows and arrows, were naked and wore their hair very long, in plaits entwined around their heads, and that they were organized socially in groups of villages. Even today we are not sure if this people had light skin, if they really existed, if Carvajal had mistaken them for long-haired men, or if he unwittingly adopted the Greek myth of the Amazons. The fact is that this is why the great river along which they sailed became known as the river of the Amazons. The accounts of all these journeys tell us that there were people living in organized communities along the Amazon, under the command of a chief, with large tracts of land and remarkable buildings, but we are not sure how many there were. (Oliveira, 1983)

These indigenous peoples had sophisticated in-depth knowledge of the ecosystem and farming and several species were domesticated for food or otherwise by the Amazon nations, and which are still used by us today. These Indians, living in the floodplains or forests (mainland), were knowledgeable about and used a large variety of plants such as: tubers, bulbs, seeds, fruit, nuts and other plant products. The vegetation also supplied poisons for hunting and war, in addition to medicinal products and drugs used to cure some diseases and in religious rituals. The forest was also the source of timber for firewood, to build utensils, weapons and cabins, as well as a source of material for basketry, clothes, resins, oils and pigments. The fauna supplied food, especially meat, eggs, insects and honey, as well as ornamental and building material for instruments and weapons.

Between 1637 and 1639, the Portuguese captain Pedro de Teixeira led an expedition from Belém to Quito and back to Belém. On the return journey, from Quito to Belém, Pedro Teixeira is assisted by Father Acuña, who in 1641 publishes the *Nuevo Descubrimiento del Gran Rio de las Amazonas* in Madrid, the most detailed treaty until then on the nature of the tropical region and the uses and customs of the Indians.

In 1743, Charles Marie de La Condamine, entrusted by the Science Academy of Paris to set the exact coordinates of the land Equator, sails up the Amazon river and, after enduring a series of hardships on his expedition, returns to Paris and leaves a vivid account of the aspects of nature in the tropics.

However, the best account of the Amazon is found in the report of two emissaries from the Portuguese court. The report by Francisco Xavier Ribeiro de Sampaio, in 1774-75, as justice of the peace and General Overseer of the River Negro administrative division, covers vast regions, as he visited indigenous villages to find slaves. The most detailed and only report written by a naturalist is still consulted today by scientists and students of the Amazon, and we owe it to a Brazilian, born in Salvador, who studied Natural History at Coimbra University. Alexandre Rodrigues Ferreira (1756-1815), when 27 years old, was commissioned by the Portuguese court to write a scientific report on the river Negro. Between 1785 and 1791, Rodrigues Ferreira collected animals and plants, visited Indian villages, where he gather ethnological material, drew numerous drawings on several aspects of nature and indigenous customs. On his return to Portugal, he wrote "*Viagem Filosófica pela Capitania do Rio Negro*" (Ferreira, A. R., 1792). He was a renowned scientist and became administrator of the Royal Botanical Garden in Lisbon. After the earthquake in that city and the Napoleonic wars, his collections and publications were scattered and few have survived.

The Classic Era

There is no doubt, however, that the 19th century is the era of the great naturalists. We have from this time the best collections and studies of Amazon plants and animals. The systematic and taxonomic studies, on which scientific knowledge of this forest's biodiversity is based, was undertaken by Humbold and Bonpland who spent the years from 1799 to 1800 sailing along the Cassiquiare channel between the Orinoco and Negro rivers. Then, between 1817 and 1820, two other great German scientists, Spix and Martius sailed down the Amazon, exploring the Juruá and Madeira rivers.

There were several other accounts by military men and priests during these years, with the main focus on indigenous problems, with nature on a secondary plane. Some examples are that of Major João Henrique de Mattos, in 1825, who mentions the decadence of the Indians in the upper Negro river. By Navy Lieutenant Henry Lister Maw, in 1828, who arrived in Brazil at Tabatinga, and traveled as far as Belém, leaving us accounts of civilized Indians. Sir Robert H. Schomburgk, from Prussia, who visited between 1838 and 1842, employed by the Royal Geographical Society of London, explores and maps the region between Brazil and Guyana. His numerous collections are kept at the British Museum and his cartographic studies were used, at the International Court of The Hague, to arbitrate in favor of Brazil, the dispute on the boundary lines between Brazil and former British Guiana.

In the mid-19th century, four outstanding naturalists broadened and founded the tropical taxonomic science. Alfred R. Wallace, entomologist, gathered his Amazon collections in the 1849-1852 period. He visited and collected mainly fauna from Belém in Pará to the upper river Negro. His notes, drawings, articles and most of his collections were lost in a fire on the ship that carried Wallace back to England. His friend and also entomologist, Henry W. Bates, also visited the Amazon and explored the Amazon river tributaries. He stayed for eleven years (1849-59) in the region and his vast collection reached England safe and sound.

Turtle Oil

The Spanish and Portuguese conquistadors told how the Indians, during the ebb tide, would capture a large number of turtles. They were left imprisoned in small lakes to fatten and were then used as food when they reached adulthood. This primitive management system can still be found in remote communities. The oil taken from turtle eggs started with the Europeans, as there is no record of the Amerindian peoples using this oil since they were only interested in the fresh meat and eggs as food. The oil is obtained by breaking thousands of eggs under the hull of a canoe, crushed and mixed with the oar until a mixture is obtained from which the fat is removed and placed in large mortars for purification and reduction. Henry Bates calculates that to fill a pot (unrecorded volume) 6,000 eggs would be needed and that, in the region of the upper Solimões and Madeira rivers, 48 million eggs were destroyed every year. This corresponds to 400,000 turtle nests.

From his entomological collections, it has been possible to describe 3,000 new species of insect. Richard Spruce, an American naturalist, who between 1849 and 1855 followed in the steps of those two above, formed an important collection on the regional flora. There is no shadow of doubt that these three men were the forerunners of taxonomic knowledge of the biodiversity of the tropical rain forest. The American ichthyologist couple Agassiz traveled the Amazon rivers and gathered the largest collection of fish ever. By the end of the century their publications were the bible of taxonomic studies on Amazon fish.

In the late 19th century (October 6, 1866), Brazil founded a Research Institution that is now called the Emilio Goeldi Museum in Pará. For the first time, scientific research was now based in a local institution. In addition to studies on birds by Goeldi himself, mention should be given to the work on fish and fishing by Verissímo, which is still being quoted. From the studies carried out by the Goeldi Museum, scientific research was consolidated as an ongoing activity of the Amazon intelligentsia.

The prosperity from the rubber monopoly since 1880, reaching its peak in Brazilian production between 1910 and 1912, brought significant improvements to the region but this did not reflect in scientific research. However, since 1914 with the decline in the Brazilian monopoly, the Brazilian government took a series of measures to save the rubber and look for alternatives for farming development. Some of the programs amplified the basic knowledge on the regional nature as they focused on research. This phase includes the Rubber Defense Plan, 1912, in the government of Hermes da Fonseca; the Rondon Commission, 1907-1917, started by president Afonso Pena, extended studies on the indigenous communities; land concessions to the Japanese for exploiting jute and then black pepper coincides with the formation of farming cooperatives and the creation of the Northern Agronomy Institute in 1941, to undertake research on plant production, species acclimatization and soil and forest identification. The Emílio Goeldi Museum of Pará and Northern Agronomy Institute together have performed the best scientific research every done in the Amazon to date. The specialists and researchers working there have formed the basis for undertaking future investigations that today are spread throughout the universities and public institutions in all Amazon states.

Organized Research

With the end of the Second World War and continuing signs of internationalizing the Amazon, especially with the American proposal to create the International Institute of Amazon Hylea in a town in the Amazon region as the headquarters for international scientific research in the region, the nationalist government of Getúlio Vargas reacted and in 1952 created the National Institute of Amazon Research (INPA), based in the city of Manaus.

In contrast to the Emilio Goeldi Museum of Pará, who focused for decades on systematic and anthropological research, from its early years INPA concentrated on studies of the relations between the environment and biological systems that would later lead to important research on how ecosystems are structured and operate.

This new point of view originated the primordial work of Professor Sioli on the river system in the region. The division between white, black and clear waters proposed by these researchers from the studies of their physical, chemical and biological characteristics were the pillars of the limnological studies on the whole Amazon region. Since the 1960s, a significant research effort has been made to establish scientific bases of the dynamic processes to maintain the ecological balance of the Amazon.

By the end of the sixties two major lines of work had emerged. The first endeavored to discover the importance of the forest in the water cycle, especially investigating if large-scale deforestation could be an influence on climatic changes in the region. This line of work was first adopted by Eneas Salati and eventually established the Amazon water cycle (Salati & Vosse, 1984).

The second line of work sought to discover the importance of nutrient recycling in maintaining the primary productivity of the forests, that is, the continuation of the forest biodiversity. This kind of work was undertaken in the laboratory by Herbert Schubart and his results were summarized in two important publications (Schubart,1983; and, Schubart,1998).

The Forest and the Water Cycle

The work performed since the end of the sixties to date shows that the forest vegetation plays a relevant role in the influence of the water and solar energy balance (Salati & Marques, 1984; Salati et al, 1978; Salati et al 1979; Salati and Volsen, 1984; Salati et al, 1990; Salati and Nobre, 1991).

Many papers have been published stressing the importance of the Amazon rain forest and the maintenance of the climate within this region, as well as the areas around the Amazon and even global climate changes.

The main functions of the rain forest affecting the climate balance in the Amazon region are listed below:

- due to its structure, the forest intercepts the rain causing direct evaporation and returning water vapor to the atmosphere. The amount of water vapor generated thus depends on the structure of the forest, and this figure varys from 17%-25% of precipitation for dense forest areas;
- trees within the forest structure act as "pumps" carrying water from the soil to the atmosphere. During this transpiration process, the energy needed to transfer the water from the liquid to the gaseous state comes merely from sunlight. In dense forests, this process represents approximately 50% of rainfall;
- the forests avoid surface run-off as the soil is covered by a thick layer of organic matter with a large water infiltration capacity. This means that the forest increases the length of time during which the water remains in the ecosystems, allowing the plants to act as systems transporting water from the soil to the atmosphere through transpiration;
- the forest controls the energy balance of the ecosystem. Studies show that some 75% of solar energy is used in a dense forest to evaporate water through direct evaporation of water retained in the canopy and plant transpiration. Deforestation alters this energy balance, as well as the water balance.

Based on this information and mathematical modeling, the forest system has been shown as an important factor for maintaining both regional and global climates. Deforestation could well result in climate changes at the local, regional (Gash et al, 1996) and global levels.

The appearance of global climate changes deriving from deforestation in the Amazon is particularly related to:

- quantitative alterations in the transportation of energy and water vapor from the Equatorial regions to higher latitudes;
- the emission of greenhouse gases produced by deforestation and burn-offs with CO_2 taken into consideration. Another aspect that should be recalled is the emission of nitrogen oxides produced during burn-offs.

Due to deforestation, direct CO_2 emissions in the Brazilian Amazon are estimated at some 0.3 GtC. These figures have prompted countless discussions due to relative uncertainty over deforestation rates and the quantity of biomass associated with cleared ecosystems.

The Forest and the Nutrients Cycle.

Schubart, in 1998, made an excellent summary of the role of the forest in recycling nutrients. The problems of establishing sustainable agriculture in the Amazon region are mostly the result of the break in this dynamic process with the forest ecosystem. Shubart summarizes as follows:

In the Brazilian part of the Amazon, the vegetation types of the vast Hylaea of about 3.7 million square kilometers are divided into 89% of non-flooded dense tropic rain forests, 2% of flooded forests, 6% of open vegetation types like savannas and *campinaranas*, and 3% of aquatic vegetation, rivers and lakes (Braga, 1979). The non-flooded dense rain forests are, therefore, by far the most representative forest cover of the region and will be thus specially considered here.

The two most conspicuous aspects of the structure of these forests are certainly the high biomass and the extremely high biological diversity. A complete sampling of a 2,000 square meters plot (0.2 hectare) of dense rain forest, growing on an oxisol near Manaus, found an amount of about 500 metric tons per hectare of plant biomass (dry weight), 14% of which was root biomass. This sampling also established the presence of 502 different tree species between one and 40 meters in height, distributed among at least 60 plants families (Klinge, 1973; 1976; 1983). None of these species showed any particular dominance over the others.

The thick forest around Manaus is clearly stratified in four stories: trees taller than 15 meters; trees between 12 and 15 meters; small trees and shrubs between 7 and 12 meters; and seedlings, saplings and shrubs less than 7 meters tall. The highest story has less individuals and species. There are not many emergent trees higher than 30 meters (about 4 to 10 trees per hectare). Twelve species in this area exceed 35 meters height, among which *Dinizia excelsa*, a legume tree, which is reported as the tallest tree in Amazonia, with a record of a 55 meters tall specimen. The diameters of the tree trunks of most species are not very large, at below 85 centimeters. Only 10 species were found with trunk diameters of more than 85 centimeters, including one tree of *Dinizia excelsa* with two meters. Other structural elements of the vegetation include palms, lianas, ferns, mosses and epiphytes. Their biomass is not quantitatively important, but they do represent an expressive share of the forest biodiversity and are functionally very important.

A study of the distribution of fine roots (diameters < 10 millimeters) and soil fauna (mainly arthropods), in two soil profiles to the depth of 1.6 meters, showed that about 85% of the dry weight of less than 2 millimeter roots and 66% of the roots between 2 and 10 millimeters are found in the top 10 centimeters of the soil. The same trend is true for the distribution of soil fauna: 84% of the total catch (expressed in number of individuals) in the mentioned profiles also occurred in the top 10 centimeters (Chauvel, Guillaumet and Schubart, 1987).

There are no really large animals in the Amazon rain forest. Of course, some of the world's largest insects and spiders do live a hidden existence in its shade. Among the large vertebrate predators are the jaguars and pumas, bush dogs and other dog-like species, the harpy eagle and several hawks, falcons and owls, besides a variety of snakes, toads and frogs. The largest herbivore mammal is the tapir, followed by several other groups of herbivorous or omnivorous animals, like deer, peccaries, agoutis and smaller rodents, opossums and other marsupials, the edentate armadillos and the tree climbing sloth, monkeys and marmosets, many insect or fruit eating bats, and a multitude of birds.

A long term research project being carried out North of Manaus to assess the impact of forest fragmentation on plant and animal diversity (Lovejoy *et al.,* 1983) has inventoried the vertebrates occurring in the area as follows: 44 species of amphibians, 89 species of reptiles, 300 species of forest birds and 51 non-flying mammals. It is interesting to note that the bats - flying mammals - are more species-rich than all other mammals together in the same area, amounting to between 60 to 65 species.

Then, there is a host of insects. The high diversity of plants seems to be at the origin of the high diversity in insects, due to the generally tight species-specific relationships between plant-eating insects and their feed plants. As a matter of fact, the number of species of these insects, and of their predators and parasites, can be very high indeed, as studies of the forest canopy insect fauna have shown. According to these estimates, the number of species of insects in all tropical forest could be as high as 30 to 50 million (Erwin, 1988).

However; the total animal biomass in the dense rain forest ecosystem is not so high when compared with plant biomass. A rough estimate of these biomass figures, expressed as fresh weight per hectare, reads as follows: 1,000 tons of living plants, of which 20 tons are leaves; 30 kilograms of herbivorous animals; 15 kilograms of carnivorous animals; 165 kilograms of soil fauna; an unknown amount of soil fungi biomass; and 100 tons of dead organic matter, mostly of plant origin. Most of this animal biomass consists of invertebrates, especially insects. The importance of the soil fauna, especially ants and termites, is particularly remarkable.

In terms of food chains, the rain forest ecosystem may be separated into two subsystems. The first is based on the direct consumption of leaves, fruits, nectar and parts of other living plants by insects, birds, bats, monkeys and other herbivorous animals, which in their turn fall prey to predators or carnivorous animals. The energy flowing through this so-called autotrophic food chain is only about 10% of the total solar energy fixed by the green forest plants.The remaining 90% of solar energy stored in plant tissues – leaves, flowers, fruits, bark, wood, etc. – as the leaves or the whole plant die, is transferred to the dead organic matter of the soil as leaf litter, dead tree trunks, rotten fruits, and the like. This raw organic matter store is the starting point of a very important food chain, in which the soil fungi and bacteria play an essential role as organic matter decays. This basic function is enhanced by the activity of a myriad of mites, springtails, millipedes, termites, wood lice, earthworms, ants, pseudo-scorpions, spiders, nematodes, protozoans, and so on, which constitute a complex food web of detritivorous and fungivorous organisms and their predators. All the biological activity in this so called heterotrophic food chain results in the breakdown and humification of the raw organic matter, the release of mineral nutrients to the plants, and the building up of porosity along the soil profile by the activity of soil animals, especially termites, ants and earthworms.

The mean yearly production of dead leaves and other fine debris by the forest trees varies between 6 to 8 tons per hectare around Manaus, and 10 tons per hectare around Belém. This litter fall is greatest during the drier months of the year; when leaf litter builds up on the soil. The breakdown of this leaf litter; on the contrary, is more intense and very fast during the rainy season, when the dead leaves may completely decay in about one month.

These lush dense rain forests thrive on the very mineral-poor soils described in the previous section, a situation that at first seems a paradox. The explanation is, nevertheless, simple: these rain forests store in their biomass, and recycle, all the mineral nutrients. The concentrations in the water of the forest streams and rivers that drain these systems, are minor and comparable to the small mineral inputs from the rainfall and from the weathering of the already impoverished soil parent material.

The conclusion is that the Amazon rain forest ecosystem is very efficient in retaining and recycling its essential mineral supplies under a regime of very high rainfall. Actually, these forests have been described as biological mineral filters, in which the complementary and finely tuned functions of a multitude of trees and their fine roots, epiphytes, animals and microorganisms, together, help to find and consume any remaining small piece of nutritious food, or any leaking droplet or mineral concentrate. In this model, therefore, the reportedly high biodiversity of the rain forest plays a very central role, which is schematically shown in Figure 3. Without attempting to explain every relationship depicted in this diagram, it is worthwhile pointing out a few of them. First, the tropical climate conditions are very favorable to plant production. However, these same conditions also favor the year-round development of insects, fungi and bacteria as plant pests and disease agents, and also cause the intensive weathering of clay mineral and leaching of soil nutrients. Both of these last mentioned consequences – pressure of plant predators and parasites, and impoverished soils – favor the increase in plant diversity by different means. The first, by decimating any clustering of a single species – "natural single crops" – which could occur in the forest as, for instance, all the seedlings germinating under the mother tree. Isolated individuals are statistically harder to find by their natural enemies and are, therefore, less vulnerable).

As a result of this pressure of phytophagous insects and disease agents on plant populations, the forest ecosystem develops a higher plant diversity in equilibrium. Here, the importance of seed dispersal by birds, bats, agoutis, monkeys, etc. to maintain the plant diversity of the rain forest becomes evident. The second consequence – impoverished soils and their role in plant diversity – can be explained by the growth rates of different plant species under different soil nutritional status. In fertile soils, some species grow very rapidly and occupy all the available space, to the exclusion of many other species. In more mineral-impoverished soils, no species can grow fast enough to exclude the others. Once again, the outcome will be a more species-rich plant community.

Recent International Cooperation

Since the eighties, a series of projects began in INPA in cooperation with international and Brazilian institutions outside the region, which introduced an integrated view of the importance of the Amazon for the planet and the effects of global anthropic changes on the region. Integrated projects are also underway to investigate the ecological relations established during the evolution process of the Amazon biota.

Two lines of research started in the late seventies consolidated the knowledge about the structure and functioning of the non-flooded and floodplain ecosystems. Since then, with growing international concern for the effects of deforestation on the biodiversity of the non-flooded forest, a research team was created in INPA to study the effects of fragmentation on the ecosystems through the Biological Dynamics of Forest Fragments Project (Projeto Dinâmica Biológica de Fragmentos Florestais - PDBFF). This program, now more than 20 years old, trained 39 new Masters and Ph.D. researchers, and every year holds a course on tropical ecology for students from the whole of Latin America, as well as producing vast literature on fragmentation issues. Based on 11 forest fragments close to Manaus, this project is the result of a bilateral cooperation agreement between INPA and the Smithsonian Institution. The results already obtained from basic research help towards drawing up social integration policies and developments more suitable to ecological relations.

With regard to the floodplains, the projects by INPA and the German Max Planck Institute on the influence of the ebb and flow pattern on the ecology and biology of the floodable areas, were also the basis of the ecological and anthropic relations of this Amazon ecosystem, which have historically been most impacted by man since the Indians set up home along the rivers (Junk, 1997). This line of work led to the application of basic research studies on a proposal of sustainable development for the Amazon floodplains, through German-Brazilian cooperation that produced the Program of Studies of Human Impacts on Tropical Forests and Plains - SHIFT.

Now at the end of the 1990s, awareness that the global climate changes are the result of anthropic actions and that the impacts of these changes can affect continuing economic development, creates the need to set up research programs that strive to model the anthropic effects on bio-geochemical cycles, especially with regard to the carbon cycle. From this latest point of view, Brazil and the international community have set up a research program called "Large Scale Experiment on the Biosphere-Atmosphere in the Amazon". This experiment attempts to answer two major questions: how does the Amazon currently operate as a regional entity and how will the changes in the land and climate affect the biological, chemical and physical functioning of the Amazon, including its sustainability and influence on global climate. These questions will be answered through studies on the carbon exchange and storage, bio-geochemistry of trace gases and nutrients; chemistry of the atmosphere; surface hydrology and chemistry of the water and changes in land use and vegetative cover. The results will help towards the development of public policies for the sustainable used of the natural resources in the region.

Obviously, the development of scientific research in the Amazon has always had international cooperation and, although still quite fragmented and with major gaps even in such basic subjects as taxonomy and systematics, it has reached a level of integration and global thinking that permits the establishment of major multidisciplinary projects in the latest international scientific investigations.

VI - Factors that limit sustainable development in the Amazon

Sustainable development projects in the Amazon are limited by a number of environmental pressures, which are as follows:

- low productivity originating from the actual bio-geochemical cycle, as in the example in the following item;
- variation in available resources, typical of the flooded areas where the water supply cycle varies widely between seasons;
- biological pressure, namely pests, disease and predators that attack plantations, the clearest example being the fungus that attacks rubber trees, against the cultivation of single *Hevea* crops in the Amazon.

In addition to these environmental pressures are the limiting factors relating to the expression of the political and economic culture, that are of a technological, institutional and market origin. In this chapter we have endeavored to show how the biological and cultural factors limit the success of economic ventures and that identifying the factors is a key to implementing sustainable development projects in the Amazon (Salati et al, 1998).

Factors that Limit Biological Productivity in Natural Ecosystems

Environmental limiting factors can be easily described through understanding the primary productive process. The basis for establishing a food chain in the Earth's major ecosystems depends essentially on the possibilities of organic matter production through photosynthesis. During this basic process of nature, carbon dioxide assimilated by the plants during the day produces simple organic compounds that, by biochemical processes, become more complex organic compounds. In order for this phenomenon to occur, that is, for "primary production", some conditions are necessary, such as water, light, inorganic chemical elements, suitable temperature conditions and the existence of organisms that can produce photosynthesis.

With the exception of the polar regions, there is always some plant species that can survive and produce organic matter, which accumulates for some time and then is fully or partly oxidized. This basic process, occurring on Earth for at least the last 3.2 billion years, permits the accumulation of a large quantity of carbon in the form of organic compounds.

The animal kingdom depends for its survival on basic organic matter that is the start of quite a complex food chain in the various ecosystems on the planet. This ability to produce organic matter, that is, biochemical fixation of carbon, depends on numerous factors that define and determine the "exuberance" of the ecosystem under study.

The lack of conditions for plant growth can be described by limiting factors that hinder or prevent efficient photosynthesis of a certain species or plant community.

When addressing a farming ecosystem, that is, the production system in which man utilizes the photosynthetic conversion to supply his food requirements, the appearance of limiting factors should be avoided. This is possible by using farming techniques where, for instance, only selected crops adapted to the local ecological conditions are planted. The development of the root system should be maximized, in order for a more efficient absorption of mineral nutrients and water required to increase production. Selected crops have the advantage of resisting local diseases.

In some natural ecosystems, the limiting factors in the cultivation of farming species are so obvious that no attempt is made to do so. Thus, for example, in the desert regions like the Sahara, for instance, the obvious limiting factor is water. Thereby, before any farming activity or plan of action is adopted, it is necessary to find out if there are water sources in order to cancel out the most important limiting factor.

In other regions, the limiting factor for farming cultivation is the temperature. In large regions, such as, Siberia and some very high plateaus (Tibet, Chile), the average temperatures during the year discourage the growth of exotic crops in the open air. In this limiting situation, some kind of farming activity can be performed by using artificial systems, including greenhouses, which permit the cultivation of some plants of economic interest.

Another limiting factor in tropical, temperate or semi-arid climates is soil fertility. The reason for low fertility can sometimes be related to the origin and evolution of the soil; at other times, the degradation of the ecosystem by anthropic action accelerates erosion and the leaching process, resulting in barren soil, unproductive in farming terms. In this case, the problem is solved by using specific techniques, such as, proper soil management, cultivating pioneer species, using nitrogen-fixing plants and artificial fertilizers, including macro and micro-nutrients.

The productivity of various natural ecosystems in the Amazon is closely linked to the characteristics of the soils. Evidence of this fact is the existence in the Manaus region of very different ecosystems with a variable biomass from a few dozen to 400 t/ha. When studying these ecosystems, it is found that the wide variation is related to the soil characteristic, for example, too much aluminum or sand, since the climate and topographical conditions are practically identical.

The thick mainland forests grow on clay soils and the vegetation becomes more sparse as the clay content diminishes until reaching the "campinas" (savanna) conditions where the trees show evident signs of xerophytism. This scenario is repeated in parts of the river Negro, mainly in its upper course, where savanna land prevails. The particular features of this associated flora and fauna are the result of the soil's fertility and variables, such as the groundwater level and slopes.

Also in the flooded forests, the flora characteristics are associated with the availability of nutrients from the river waters flooding the area. Along the Amazon floodplains, flooded periodically by white water rivers, such as the Solimões and the Amazon itself, there is a large quantity of organic matter in the water and consequently a high total biomass for the gallery forests. In the areas flooded by black water rivers, poor in nutrients, there is little organic matter, and, therefore, less total biomass in the forests in these flooded areas, or *igapós*. Flooding time is longer in the flooded forests, and the trees are under water for a long period in some places, while the seeds are under water for up to 6 months. This water "stress" is a selection factor and only some species have adapted. This limiting factor also explains the smaller diversity of the *igapó* flora.

In general, in the case of the tropical rain forests, with special emphasis on the Amazon forest, the lushness of the vegetation depends fundamentally on the soil and climate conditions. The humidity, temperature and light levels are excellent for the plants. It is mistakenly believed that there are no limiting factors for intensive and/or extensive farming. This simplistic view has pushed visionaries or men with a developmentalist mentality to establish large settlement projects in the Amazon. However, the experience of some decades of settlement has shown that in the rain forests the limiting factors make intensive farming a thankless and unproductive task and it most often depends on the use of techniques, which is practically impossible given the socio-economic reality in the region.

Factors that limit the Implementation of Sustainable Productive Systems

In order for a project to be sustainable, it must adopt basic guidelines of economic sustainability, ecological adaptation and social justice. To date and for various reasons, these guidelines have not been achieved by the development projects in the region. A complete study of this topic would be of great value to learn about the limiting factors that exist and that have challenged the public or private authorities and the scientists or politicians that endeavor to equate and solve the problems of the Amazon.

Some specific examples have been analyzed, with special mention to those relating to the implementation of cattle raising projects. One of the examples was setting up farming villages along the Transamazonica highway.

It was expected that a region covered by thick forest could easily be transformed into an agriculturally productive area. In fact, it was exactly the opposite. The creation of estates for cereal crops and cattle raising came up against major obstacles. Another example was the installation of the Northwest Center Project when the Cuiabá-

Porto Velho highway was built. It was expected that the development model, based on building housing schemes and encouraging the building of farming villages, would in a relatively short time make the region economically independent. Today, 15 years after the start of intensive colonization in those areas, agricultural production and consolidated sustainable productivity are still a dream.

The projects implemented by small farmers and those with heavy capital investments, using all available technology, are examples of the failures to be expected when the Amazon territory is exploited using a technology foreign to its own ecosystem.

The Jari Project is a typical example of how planning and expected success were very far from the real achievement. Despite these examples and hardships, other programs and projects are being implemented in the region, such as, the production of pig iron in the region covered by the Carajás iron railroad. In this case, iron ore is transformed into pig iron, using charcoal as a source of energy and reducer. There are strong indications that this project is not sustainable from an ecological viewpoint, since the sparse natural forest resources and forest planting will probably make the project economically unfeasible. Despite this study and the experience already gained in the Minas Gerais region, several industries are still setting up their plants in the region. The analysis of this problem shows that, despite the willpower, enthusiasm, hope and efforts of government agencies and private institutions, there are environmental factors that, in themselves, or by interacting with other causes, are detrimental to the project's implementation.

Technological Limiting Factors against Primary Production

When an economic activity is based on farming or cattle raising this implies that there must be a capacity for primary production. In other words, plants grow and from this growth some product destined for human activity must result, such as: food, fibers, medicaments and other products used for agribusiness purposes. Some factors are essential for the growth of plants, as follows:

- existence of a soil with a certain level of fertility;
- available water at the stage required for plant growth;
- solar energy for photosynthesis and a suitable temperature to complete the biological cycle of the species.

When studying an Amazon forest ecosystem, especially in the case of the dense forests, the conditions of development exist and continue over the years. The tropical rain forest, by its very nature, has numerous species of animals and plants that, in an interacting process, maintain the soil's characteristics, recycle the nutrients of the dead plant tissues, regulate the moisture in the soil and establish conditions of dynamic balance favorable to energy and water processing. On a scale of small river basins or on larger regional scales, the forest maintains the bio-geochemical cycles in dynamic balance in benefit of its own survival. The forest also controls the other cycles necessary for stabilizing the conditions of water balance and sunlight.

When the forest is cleared and the soil is then used for farming, this causes a drastic change in the ecosystem, altering the balance existing until then. The replacement of forests by another plant formation with less species per hectare completely modifies the dynamics of the bio-geochemical cycle. The decay of organic matter and re-use of the nutrients by the plants is totally changed. In addition to these changes, others vary with the specific characteristics of the ecosystem, such as the nature of the soil, for instance.

The Amazon plateau has irregular relief, principally around Manaus, where the topography, like half an inverted orange, is typical. Experience has shown that soil management is quite difficult on rough terrain. After deforestation, these areas show a rapid process of erosion and reduced fertility. The soil becomes compacted, hindering water seepage and root growth.

On the microclimate scale, it is found that the temperature of the soil and air rises. These factors modify the behavior of the water process at a local level with influence at a regional level, as mentioned in Chapter 1.

The observations, taken from several scientific investigation projects, show that in order for the limiting factors to maintain a high productivity in farming and livestock farming are as follows:

a) chemical and structural nature of the Amazon soils;

b) distribution and intensity of rainfall;

c) relative humidity in the air;

d) existence of pathogens in the soil, principally fungi and nematodes;

e) increase in attack by insects, fungi, bacteria, virus and others harmful to intensively cultivated crops.

There are others, besides the natural factors, relating to human activities at the various stages of anthropization of the ecosystems under study. Some of the limiting factors arising from human activities are as follows:

a) type of soil management;

b) the farming techniques used, and

c) the species and varieties of crops cultivated.

In this group of limiting factors, it is important to mention that there has never been, at any time whatsoever, a technological cattle raising package that can be used without risk in the tropics.

Current recommendations have been tree farming in which the annual crops are developed jointly with the formation of forest groups, including fruit trees, forest species of timber economic interest or otherwise, plus fruit or oil producing species.

When implementing intensive farming systems, for instance, at the start of colonization in Rondônia, the harvested produce could not be sold due to the absence of an efficient transportation system. Farm produce transportation and storage is also a determining factor in successful trade.

Due to the distances between producer and market, the sale of a certain product did not have continuity, the supply was interrupted and the economic sustainability of the producer became more difficult.

Technological limitation is a determining factor in the success of tree farming in the tropics. However, in order to have a technological leap in this activity it is not necessary to start from zero.

Research of the tree farming systems has been based very much on the farming experience of the local populations. The different ethnic groups living in the tropical forest band around the world have, through their cultural evolution, developed farming practices that have permitted survival of their descendants in a sustainable manner.

All those groups have a fact in common that is to imitate the structure and functioning of the natural forest in their fields or plantations, consisting of:

- A wide diversity of species planted with few individuals per species.
- Planting of species that bear fruit alternately, providing different harvest dates throughout the year.
- Selective choice of the adult height of each crop, to take best advantage of the photosynthetic capacity, imitating the vertical pseudo-disorganization of the native forest.
- Short crop rotation cycle, with fruiting species in a long cycle; in some cases, planting species with delayed fruiting to be used soon after abandoning the place.

These characteristics are common to most of the different ethnic groups, whether they live in Tropical America, Africa or Asia. Cultivating plants is necessary to supplement the products extracted directly form the forest. Crop selection varies greatly between the different ethnic groups, at both the species and variety levels. After the post-Columbus period, some exotic species were introduced but the indigenous fields continued to be farmed with Amazon species. The major diversity of crops are the energetics, rich in starch or saccharoid: manioc, corn, sweet potato, different varieties of banana, *pupunha* (a type of palm), *açaí,* yams, arrowroot, etc. But indigenous farming does not stick to food production alone but is combined with an enormous variety of medicinal plants, spices, such as different species of pepper, drugs for religious ceremonies and social events, plants for pigment, poisons, etc.

Manioc and indigenous technology

The different South American ethnic groups domesticated some of the plants that are most used by mankind, such as: potato, corn, cacao, tomato, peanut and some beans, e.g. which are part of our daily meals. Cultivating manioc and the technology to remove the highly toxic prussic acid is an example of the technological processes developed by the South American Indians. There are two varieties of manioc, *Manihot esculenta*, one toxic and "harsh" and the other "sweet" that may be eaten after cooking. Every indigenous nation in the Amazon maintains, classifies and selects manioc crops in their fields and changes them for others from farther afield. Ethnobotanists have devoted their time to the selection processes of these crops that until a few years ago were ignored. A piece of harsh manioc has toxins that could kill several people. This toxic variety is used in daily meals. The change to flour ensures the extraction of prussic acid. The roots are first scraped and put into running water over night, then are grated and this pulp is placed in a press (*tipiti*) where the water mixed with the acid is removed. The remaining solid part is still not suitable for eating, is heated in a pan under a controlled temperature so that it does not burn, to remove the rest of the toxins. This is when the manioc in flour form is ready for consumption. An extra advantage is that it can be stored for years without attracting fungi, bacteria or insects, which seems impossible in this hot wet climate.

Twenty-seven different cultivated species were used by the Way-Way of Guyana. Fifty-four species were found in the fields of the cultured Sion-secoya in Ecuador. The Amerindian ethnic groups cultivate native forests and secondary areas. Ethnobotanist Possey has widely published the management techniques of the Kayapo Indians. In an inventory in Gorotire village, the flora used by the Kayapos, in their secondary areas, records 185 planted trees representing 15 different species; 1,500 cultivated medicinal plants and 5,500 individual plants for food, some still unknown by science. Other eminent scientists have shown that there are already ecologically balanced systems of forest occupation, but all at a subsistence level.

For some anthropologists there is, in the indigenous concept, no difference between a cultivated and natural forest. In handling the tropical ecosystem, the indigenous populations presume a continuum between the domestic species on their farms, the semi-domestic, which are manipulated and what we call the wild species. Each of these species plays its role in the group's subsistence or in the social calendar. In some areas that were and continue to be itinerant zones of the indigenous communities, what to us seems a natural forest is the result over thousands of years of cultivation and co-evolution between the ethnic groups, plant and animal species that form the ecosystem. The basic know-how has already been acquired from years of adaptation to the tropics by these men and women who, like the forest, are also threatened with extinction.

It is possible to set up small farms based on tree farming developed from the Amerindian technologies, although further scientific investigation and experiments are necessary, so that these farming practices can become a tool for sustainable development, on a market and subsistence scale. More control over the environmental limiting factors is necessary by using techniques that permit an increase in productivity.

Population growth and resulting environmental exhaustion is also a limiting factor in fragile ecosystems. What we see today and in the near future in the Amazon is a trend towards concentration of populations in large urban centers. Manaus, Belém, Santarém, Porto Velho, for example, already have more inhabitants that they can support. This trend towards megacities is a third world trend, where the rural zones are still poor and the dream of wealth and quality of life is associated with opportunities found in an urban center. How can these megacities live in a world based on the concept of sustainable development? or how can a society based on sustainable development meet the consumer demand of megacity populations? So far, there are no answers to these questions.

What is apparently clear is that there is a level for sustainability of development when based on Amerindian models, that are effective on a small scale but need a technological leap to be able to supply the demand of the growing Amazon population.

THE MAYAS AND ENVIRONMENTAL EXHAUSTION

The Maya civilization flourished over 22,715 Km^2 between the Yucatan peninsula in the Campeche-Quintana Roo zones (Mexico) as far as the Petén region (Guatemala) and mountains of Belize, and was the only one to fully occupy a tropical rain forest, with standards comparable to that of the ancient Egyptians. The monuments, writings and archeological discoveries attest that the Mayas were the only neotropical nation to leave history engraved in stone.

What are the reasons that led to the extinction of this tropical sedentary civilization? The main factor was the increase in population. In 1,000 BC the population was estimated at 161,000 inhabitants, that is 7.09 persons/Km^2, in 300 BC the population was already 242,000 (10.65 persons/Km^2). By 300 AD there were 1,020 million inhabitants (44.90 persons/Km^2), the peak was in 800 AD with a maximum of 3,435 million persons (151.22 persons/ Km^2). At the time of the conquest of the Mayas they were already in decline with 104.00 person/ Km^2. It is presumed that by 300 AD, 75% of the land had already changed. The central lands of the Mayas were drastically altered, forests cleared and floodplains destroyed for farming purposes. Ecological models used by the Mayas explain that the sharp increase in population growth reduced the stability and increased the resilience of the ecosystem. This agrees with Holling's principle, according to which complex systems fluctuate more than simple systems. With the drop in population the forest returned, with its altered flora composition. Today the forest is more lush than at the time of the conquest, but the Mayas were already culturally dispersed.

Institutional Factors

Another group of limiting factors is linked to the lack of policies in favor of sustainable development, which is reflected in the lack of facilities of the local institutions. An improvement in institutional performance is important since they are institutions, public or otherwise, that should make the binomial efficient: competent human resources and proper financial resources in implementing development projects. This point is of some importance when we consider that the institutions are not a neutral factor in the development process but represent values that, in their turn, are related to interests of some political or social group, and therefore greatly hinder the process of implementing sustainable development in the Amazon. In order to exclude the institutional limiting factor it is first necessary to ensure that the values are in the correct position and that institutional guidelines are in tune with the goal to be achieved. Only after this point should more technical matters, such as the use of resources, transfer of scientific, technological or managerial know-how to a certain institution, be discussed. Even then, this capacity building must be correctly measured so that the organization can effectively handle its new institutional level.

One way of visualizing an efficient institutional scheme when implementing sustainable development is to create an institutional flowchart with the participation of organizations that work at a micro, medium and macro level.

The micro level is that at the level of the community. Here organizations represent ideas and needs of the people living in the community who have entrusted them to represent their interests and be able to communicate with the higher organization levels of the authorities. For this level of action to exist, they presume that the community has access to information on regional and national development policies. This also requires that the country assume a certain decentralization and accept the right of community leaders to participate in the decision-making process. This is the preferable scenario for the work of grassroots non-government organizations. The various sections of the National Rubber Tappers Council that are present in the extractivist reserves, Land Pastorals linked to the Church, fishing villages, scattered through the Amazon hinterland, indigenous organizations, to mention the better known, are institutions of this kind. According to a study by the United Nations Development Program (UNDP) on the third world, the largest number of grassroots organizations are in India, focusing on mostly social questions, then environment and class. The World Bank, UNDP, Global Environment Facilities (GEF), United Nations Program for the Environment (UNPE) and several large international NGO programs have created financing to support projects of these grassroots institutions.

The middle level is intermediary, between the goals of grassroots organizations and the central authorities, and is the prevailing area of the NGOs. They are more sophisticated organizations with a blend of technical, managerial capacity and political pressure, and their principal strength is the ability to work with information. An example of institutions between the micro and macro levels are: cooperatives, unions, research and training institutes, organizations which represent the medium-sized company, religious groups, non-profit foundations. In order for these NGOs to be effectively able to achieve their goal, they must create the skill of coordination between the opinion makers and grassroots organizations. The process of implementing sustainability requires the transfer of responsibilities from the central government to the communities, the working scenario of the NGOs, that can assume such a task, principally in those poor regions where many municipalities and towns do not have the public institutional equipment for such a purpose.

On all continents, over the past two decades, NGOs have become the principal political and executive act at this medium level. They have shown to have more capacity, speed, efficiency and responsibility in dealing with the issues that concern society than the public institutions themselves. NGOs have already demonstrated to be outstanding substitutes for the role of the state.

The capacity for international mobilization of these institutions, especially those in the northern hemisphere, have prevented continued crimes against the environment, very often against the interest of the national governments and major corporations. This feat caused a movement of counter-information against these organizations, accused of defending exotic interests, with the intent to discredit the politically correct work of the NGOs. Many forget that the institutions working at the medium level are identified with the environmental issue and not with the government policies of their home countries. In the Amazon, the work of non-government organizations at a regional level is still in the early stages. The NGO role is more political and preferably outside the Amazon. Organizations that do field work in the region are extremely rare. It is expected to see an increase in the number of South American NGOs on the international scene in the near future.

The macro level is that of the governments, which, in the past 20 years, have been forced to redefine the role of the state, very often traumatically. The southern hemisphere, under pressure of its foreign debt, has been obliged to climb down from its dominant role in national development, very apparent in the spate of privatization that the governors have announced throughout the third world countries.

Society's further participation in running public matters and the renewed democracy of the South American countries in the 1980s provided political foundations to create public institutions that cooperate with non-government organizations in implementing sustainable development.

At a macro level the public institutions created developmentalist policies for the Amazon that hastened the deforestation process and aggravated the environmental limiting factors. The two examples below show how government institution decisions can drastically alter the Amazon ecosystem:

- **Tax incentive policies —** independent of size, a company could register a cattle raising project with SUDAM, in order to receive tax incentives by deducting income tax or having subsidized credit. The sole requirement was that the project would provide improvements to the purchased land. The law recognized any land clearance as an improvement. Therefore, a variety of projects for deforestation, blocking river islands, opening up pasture land, intensive plantations and rubber, cacao, eucalyptus and other crops were awarded tax incentives. This policy was aiming at destroying the forest and any project that proposed to create a reserve or prospect biodiversity for the pharmaceutical industry would never receive a tax incentive.

- **Increase in the farming frontier —** credit facilities led several farmers in the South and Southeast to exchange their crops of rice, beans, corn and food products for export crops like soybean, wheat, cacao, coffee, etc. It became harder for the small producers to get loans and they sold their land, attracted by the colonizing companies that were starting to cultivate the Amazon. The largest group of migrants since the 1970s came from South and Southeast Brazil. People from Paraná, Rio Grande do Sul, São Paulo and Minas Gerais sold their small and medium-sized properties to the planters of soybean, wheat and other mechanized crops. The increase in the Amazon population was the result of migration and not from the increase in the local birth rate. As long as real consequent land reform is not carried out in South and Southeast Brazil, this outside pressure will continue to increase the exhaustion of the Amazon ecosystem.

Throughout Amazon history, the role of the state has been dominant in encouraging development. At the macro level, therefore, it is essential to identify the limiting factors present in the public institutions.

The lack of environmental policies, dissemination of technical know-how and financing for sustainable development, is reflected in the executive agencies of environmental overseeing, in the agencies in charge of financing projects and in those for rural advance, especially with regard to the small farmer. We could identify the following limiting factors in the public institutions:

- reinforcement in applying environmental laws, increase in supervision and punishment for crimes against the environment. Brazilian environmental law is one of the most modern in the world but is constantly being broken due to the absence and/or disregard in supervision. The overseeing and legal agencies are unprepared to enforce the law;

- lack of appropriate adequate farming transfer of know-how relating to the specific problems of the Amazon area, which range from fishing activities, plant extractivism, selective lumbering and small scale farming. We are talking about farming transfer policy in its most traditional concept, which is the transfer of technical-scientific know-how generated by the research institutes to the rural zone;

- lack of a proper structure for the environmental and planning agencies to be able to interact on an ongoing basis with the communities, NGOs and official agencies, in order to implement ecologically suitable and economically sustainable projects;

- lack of a farming loan structure focusing on sustainable projects with regard to the quantity of resources required and the overseeing of approved projects;
- lack of regional planning based on ecological-economic zoning for the Amazon, with the intent to implement sustainable development projects;

It is the task of the central government to encourage its own institutions to draw up policies that reflect the interest of the local communities through:

- more equality at the negotiation tables of the international cooperation, credit and trade agencies;
- enhanced Brazilian ability to formulate policies for sustainable development, as a way to minimize the dependence on international experts who very often area unaware of the demands of local communities, cultural traits of the nation and Brazilian peculiarities;
- improving the public institutions so that claims from medium and micro levels can reach the central government, facilitating partnerships with non-government organizations in promoting sustainable development.

We believe that sustainable development projects can be established in the Amazon, as long as scientists, environmentalists, decision makers, those who draw up regional policies and the local communities are aware that limiting factors exist at different levels, making it necessary to have a change in people's awareness about the occupation of this territory.

The first step in this awareness is to understand that nature imposes limits on farming and cattle raising in this ecosystem. We must also bear in mind that the available technologies for use in other ecosystems are not suitable for the Amazon and that the empirical technological knowledge, already developed by the local ethnic populations, is appropriate for occupation of areas that can be farmed on a small scale. On this particular point, it is important to strive for efficiency through technological enhancement. In environmental terms, efficiency means the decrease in environmental exhaustion caused by the incompetent use of raw materials and energy.

The various institutional players must work together so that the research and public development institutions and non-government organizations also work as a team. An important role is also expected form the international community, specifically by creating new business opportunities for the countries that invest in conserving biodiversity and carbon dioxide sequestration, services that have clear global effects.

VII - How does the conservation of the Amazon combine with the sustainable use of its natural resources?

Throughout history, settlement attempts in the Amazon have been an ongoing and constant challenge. The experiences of livestock farming settlements, either through government or private programs, have shown the inability of its sustainability over the years. So the major tree farming projects, both those undertaken in the past and those in recent decades have led to the increase in environmental exhaustion, in addition to investors' losing money due to the deforestation encroaching into new primary forest areas. Today the areas where these projects were installed are degraded.

Despite the disastrous results of such attempts to develop the region through projects which had not considered the existence of limiting environmental, social and institutional factors, the problem continues. The current land distribution policy for family allotments repeats the same mistakes of the past settlement attempts. In the latest government land distribution policy, there is no sign of implementing demonstration projects of sustainable use of natural resources.

The increase in scientific know-how in the Amazon region and wet tropical regions today permits a different focus on accepting this challenge, that is: implementing projects for sustainable use of the resources in the Brazilian Amazon, which guide and demonstrate to the settlers that it is possible to ensure long term farming production in the same area without needing to open up new areas of primary forest. (ALMEIDA-VAL, et al, (eds) 1991; BARTHEM, R. B. 1992; NEPSTAD, D. and SCHWARTZMAN, S. (eds). Non-timber products from tropical forests. *Advances in Economic Botany,* Volume 9. p. 79-86)

The literature on the Amazon, outcome of scientific meetings on regional development and experience of students concerned with the Amazon **STRONGLY SHOW THAT:**

- Previous settlement experiments confirm, without a shadow of a doubt, that if nothing is done to include scientific know-how in the planning of land use in the region, serious social problems will arise.
- It will be impossible to maintain sustainability of the settlements, both in degraded and virgin lands.
- Land exhaustion and the consequent environmental degradation will lead the settlers to occupy new natural landscapes still untouched by man.
- These new occupied lands, in their turn, will be degraded in a few years, thereby perpetuating the cycle of destroying the wet tropical rain forest, as the history of Amazon settlement has been demonstrating.
- There is already enough criticism and scientific know-how to draw up sustainable development projects.
- Among other options, using the state-of-the-art know-how on the tree farming systems, the deforested areas of the Amazon will permit the survival and continuity of human settlements, as long as they are based on social, economic and ecological sustainability.
- It is possible to set up experiments to act as demonstration and multiplier projects of the correct use of the potential of the already deforested Amazon ecosystems, ensuring the permanence of settlements and preservation of this huge tropical rain forest for future generations.

VIII - Future Research

Based on this background, a future agenda to continue the research in the region should include in-depth studies on:

Sustainable Use of Natural Resources with emphasis on:

Sustainable Forest Management - MFS including in the exploration process the economic value of forest-intrinsic biodiversity and showing if MFS proposals should be considered as an economic activity for the region or should be abandoned;

Fishing Management and Fish Farms, enhance the studies on fishing biology and ecology, as well as develop suitable techniques for fish farms;

Forest Farming Systems, develop and set up forest farming demonstration projects as models for regional development ;

Bioprospecting, develop prospecting rules and procedures in accordance with the recommendations from the Biodiversity Convention and the Brazilian law on the matter, in order to create model procedures in Brazil that will be used as an example for future prospecting activities of biodiversity.

Creation of Models:

Climate models that integrate the biosphere to the atmosphere showing the relationship between the global climate changes and the Amazon. Provide the decision makers with planning tools.

Socio-economic models that integrate changes in land use with the forces of social and economic transformation that put pressure on the occupation of the Amazon.

Planning and Control

Economic-ecological zoning, on a 1:250.000scale, of all Amazon territory, as a decisive tool in planning territorial management.

Amazon watch system, continuing with the physical installation of SIVAM and setting up databases and their interpretative tools for the end user.

Climate Control and Biodiversity Conservation:

Carbon sequestration through demonstration projects that integrate biodiversity conservation with reforestation by forest farming systems, using the clean development mechanism.

IX - Implementation of Demonstration Projects on Sustainable Development in Degraded Areas in the Amazon: a FBDS Framework

The definition of a series of projects on sustainable use of natural resources based, among other technologies, on the advanced know-how of tree farming and clean energy. Such projects shall be implemented in settlements located in critical areas, where there are basic data at a suitable level and with settlers ready to go ahead with this experiment.

I. BASIC PREMISES

- the project shall, from the beginning, involve the local community since it is ultimately responsible for actually adopting the proposed measures;
- the work shall be carried out in both the urban and rural areas and permit an exercise to implement sustainable development through the joint action of the

local communities and their interactions with the "outside world" at home and abroad;

- the municipalities shall be studied regarding the urban outline, material used in the buildings, basic sanitation, water supply, energy sources, health and education and the economic activities, such as transformation industries, mining exploration and commercial activities;
- in the rural areas, special emphasis will be given to sustainable forest management, rehabilitation of degraded areas, tree farming and field activities of the farmers, health and education, rural electricity supply, enhanced communication and transportation systems and establishing loans to implement and enhance these activities;
- in all work to be carried out, priority will be given to programs which use "clean sources" to produce energy, provided that they are feasible. Techniques shall also be examined in the treatment of drinking water, urban sewage and solid waste, which are compatible with the social-economic reality of each place, seeking those most ecologically and economically self-sufficient.

II. STAGES

- Identify settlement areas close to medium-sized or small towns.
- Examine the environmental and socio-economic problems of the urban and rural areas.
- Identify the limiting factors in order to set up a sustainable development program based on the criteria of economic, social and ecological sustainability.
- Identify the players in the process and establish the relationship between the public and private authorities in order to implement specific projects.
- Establish an analytical and follow-up system which permits changes and adaptations as a result of the gained experience.

III GOALS TO BE ACHIEVED

- Reduce the anthropic pressure on primary forests.
- Renew and expand biodiversity which is endangered during the deforestation process and installation of farming activities.
- Increase the residence time of peasants in the same place, giving small communities time to settle and establish feasible production and commercial lines for the local conditions.
- Increase the stock of carbon in the biosphere by growing secondary forests.
- Set up tree farming and cattle raising processes which are feasible in these extremely fragile systems.
- Re-establish the water and bio-geochemical cycles of the ecosystems, since they are radically modified during the deforestation process.
- Re-establish the inter-relationships between offshore and onshore ecosystems which maintain the productivity of the offshore fauna and very often survival of the onshore fauna. This point is of the utmost importance along the floodplains and banks of the *igarapés* (river islands).

IV. METHODOLOGY

- The formation of a small group of specialists from such institutions as EMBRAPA, INPA, IMAZON, Goeldi Museum and FUNTAC, to urgently define a pilot-model for sustainable use of natural resources, on a real scale.
- The basic function of this pilot-model would be to guarantee the settlement and permanence of settlers in the chosen regions. These settlements would be the predominant factor and responsible for preserving and maintaining the tropical rain forest. This would be the basic tool for future generations to inherit this priceless heritage of our land.
- Identify, by comparing data from the economic-ecological macro-zoning of the Amazon, priority areas for future settlement in regions already deforested and suitable for implementing feasible programs of sustainable use of natural resources.
- Identify sources of international resources and aid programs (preferably non-performable loans) which guarantee the implementation of such demonstration projects.

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Science and the ethics to sustainability

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A New World

With the advent of the industrial revolution that followed the Age of Reason, the world population that was nearly stable till then started its exponential growth, the rate increasing three-fold from 1750 to 1850. At the end of the eighteenth century, Thomas Malthus in his *Essay on the Principle of Population* warned us that this rate was faster than the subsistence opportunities and that Mankind could head towards disaster. Developments like crop mechanisation, fertilisers, railway systems, steam engines etc that marked the peak of the *First Industrial Revolution* have shown that this pessimistic outlook, however, was not corroborated by facts. Rather, the outlook was that new developments in science and technology could always avoid disaster, fulfilling the increasing demand for food, energy and for more technological progress. As it left out the old supernatural and mythic cosmovision that prevailed in the Middle Age, Society was developing in the nineteenth century an optimistic view towards the future, building up a technical modernity marked by the faith on science as the solution to all problems. It was a renewed thrust on the *Scientific Revolution* initiated with Descartes *Discours de la Méthode* with the belief that Nature and Life could be reduced and understood through their mathematical expression and that "*the scientific knowledge could be used to render ourselves masters and possessors of nature*". It was, above all, a laic, pragmatic and utilitarian vision of the world, translated into a utopia focused on material prosperity and on the possibility of distributing and socialising the products of the technological progress.

Thus, we witnessed, at the beginning of the twentieth century, the acceleration of a productivity rush that was fed by another rush: the competition to advance science and to develop new technologies. Following this trend we also witnessed a progressive specialisation in every branch of science and the multiplication of techniques demanding more and more specialised scientists and high-skilled technicians and engineers. The broad, classic and universal education that prevailed until World War II moved, then, towards providing the professional competence demanded by the competitive job market, in the qualified fields of knowledge that fed the technological advances. The advent of the specialists that these changes brought about, brought also the fragmentation of knowledge (e.g. Morin, 1986; Capra,1982; Wilson, 1998). While there was a tremendous efficiency gain in the education and in the science/technology systems as measured by a variety of established indicators, there was a huge loss in the perception of our true objectives and what should be our overall efforts. The more we specialise in a branch of knowledge, the more we analyse a specific part of a problem without an equivalent effort to integrate it, the more we loose the perception of the whole. What is worse, we lost our critical sense, the conscience of the necessity and the usefulness of things. Specially, we became blind to the consequences of the use of a specific knowledge as we lost our broader knowledge and wisdom.

In recent times, this tendency for specialised science, for specialised education and for the parcelation of science into disciplines has increased dramatically. To some extent, we lost our broader references and the ability to distinguish means from goals. We do not know anymore what we want to achieve. We can only record that the current science-technology system is leading us to a whole new world and bringing some new deep worries. The perplexity and indignation registered in Bronowski's publications (e.g.1972,1978) is a clear example of this. A leading member of the *Manhattan Project,* this physicist who helped to make the atomic bomb, then confessed his unawareness of the destructive implications of his studies. Man had taken the role of God, he warned us, *a posteriori*.

But, even when widespread warnings were shouted before the tragedy, as in the case of Rachel Carlson 's *Silent Spring* (Carlson, 1962), the large-scale devastation promoted by the *Green Revolution* was not avoided. The power of the self-sustained and interlinked science-technology-economic system of this new world seems hardly affected, even when warning comes from the United Nations (1987), the National Academy of Sciences (1990) or from Al Gore (in Carlson, 1994,), the Vice-president of the powerful United States. We need some new way to develop.

The search for a new kind of development.

In feudal times changes were slow and unwelcome. Any advance or development was more the result of external and unpredicted events than of the wishes of people or of their rulers. The word *development*, teaches us *The Petit Robert Dictionary*, was only used with a meaning associated with the economy of a country or a region in the second half of the eighteenth century. It was only with the advent of industry that emerged a co-ordinated effort and a true Government concern to promote conditions for expansion and reproduction of the economic activities. In the process of pursuing progress and guaranteeing a continuous economic growth, nations started building up, at the turn of the century, more and more complex and specialised administrative structures to manage economic systems, to promote internal social peace and to secure foreign economic affairs for a sustained (economic) development.

In the twentieth century, we witness the economic dominance of nations who had massively invested in science and technology in connection with war efforts and the installation of defence systems. But after World War II, it became apparent that a country's economic success would not necessarily bring social justice nor prevent the relative impoverishment of other nations and regions. It became also clear that the present patterns of economic growth were promoting unprecedent ecological devastation and worrisome social changes. They are installing, according to Gunnar Myrdal, 1974 Nobel prize laureate on economics, a "vicious cycle of poverty". For Gore (in Carlson, 1994), 'the present system is a Faustian bargain. We get short-term gains at the expense of a long-term tragedy. And there is reason to believe that the short-term can be very short indeed'.

Regardless of our degree of hope and the gravity with which any of us see the present crisis, there has been a growing consciousness that our present system is breaking apart the sane relationships between man with his own self, his family, his society and the environment to which he belongs (e.g. Roszak, 1992; Boff, 1996; Mungall & McLaren, 1990; Gardner & Stern, 1996). It became clear that development cannot be achieved in economic terms alone and should not just reach a small part of Mankind. It is also clear that the present crisis is a crisis of the patterns of our development. Focussed on consumerism utopia, our so-called development has yielded appalling waste, social inequality and widespread irreversible damages to the environment. Many were the traumatic experiences and technological disasters denounced either by scientists, themselves, such as Bronowski and Carlson, or by the social movements, such us the Women's rights, Peace and Green movements. Man is becoming aware that through the indiscriminate use of science and technology he is excluding ¾ of mankind, extinguishing fellow species and modifying his own habitat regardless of its resilience. As he recognises that science can be an important tool to help him understand the world, he also perceives that the science-technology-education system has been used as an instrument of political and economic domination of a few at the expense of both the environment and the people it has excluded. He presses for changes.

Gathering a record number of 179 nations, the United Nations Conference on Environment and Development (Rio 92) prepared a 500 page-long consensus document called **Agenda 21**. It was the first global answer to the aforementioned pressure. Its 40 chapters offer the broad guidelines towards the achievement of ***Sustainable Development.*** This concept was based on the concept of Eco-development established in the *UN Conference on Environment* in Stockholm, 1972 (See also Sachs, 1980, 1993) and developed through many years of discussions by the Brundtland Commission. In its *1987 Final Report* the principle of the sustainability of future generations is internalised within the concept of development, opening a new horizon for mankind. Sustainable development is the development that supplies the basic neeeds of the present without risking the potential of future generations to supply theirs. The above reflections tell us that the logics of development must not obey the command of a *technical modernity* but should be subordinated to the principles of an *ethical modernity*. It is this ethics that should answer the new challenges confronted by Mankind. And this ethics should go beyond a mere 'social contract' settled with reciprocity and symmetry. It is a matter of setting, ethically, the asymmetry of power relations, even at its limits, with unilateral and non-reciprocal terms. This is certainly the case when we are faced with the vulnerability of the future life conditions due to the social and environment interventions carried out in the present reality by whoever has the power of action. We also need to consider the ethical frame of irreversible processes, as it is not always possible to amend in the future the undesired consequences of today's actions.

The sustainability principle

As the aim of ethics is the regulation of the power of acting, the threats posed by harmful technological interventions are, thus, growing in an "ethic vacuum". Recognising this, Jonas (1979) proposed the adoption of a new *principle of responsibility* where the highest rule be "let mankind exist!" The traditional concept of a "contract" *inter pares* as the ethical fundament fails at the present situation when we need to assure today, the quality of life of future generations. The *must exist* and the *not yet existing* are two essential points to impose on contemporary modernity the recognition of an objective *must be* (*at).* With that in mind, it is possible to deduce a commitment towards a responsibility for and the preservation of *the being* (Jonas,1979:102). This responsibility is, however, formal and its ethical and moral dimension only emerge with the existence of a *feeling* for doing goodness by its own inherent objective, as it shames on the selfishness of power (Jonas, 1979:175).

Hans Jonas proposal is to build an ethical modernity that is able to limit the human capacity as a destructive agent of the perpetuity or the sustainability of life. From that perspective, we can conceive sustainable development as a horizon within the framework of an ethical modernity, not only of a technical modernity. Therefore, the promotion of sustainable development requires not only wisdom and knowledge but also the ability to provide technical viable and ethically desirable solutions. Such know-how can also be defined as the knowledge and the skills that helps to promote the continuation of life. It should be expressed in terms of the different organised ways through which society acts or interacts (production processes, trade, profit standards, data processing, health prevention, water supply, garbage production, commodities consumption etc). As pointed out by Morin in several of his works (e.g.1977, 1986, 1990) and Wilson (1996) the approach to deal with complex and interacting systems, like life, society, the environment, economics and the World, must be transdisciplinary, so that the unity of knowledge is not lost. It must also not separate the observer from the observed or the object from the subject as they are intimately interconnected or one may belong or be part of the other.

Given technologies are sustainable and belong to an ethical modernity not because they resulted from the freedom of choice of economic alternatives but because they abide by the sustainability principle.

The philosophical meaning of modernity

The word *modern* is already present in medieval French in the XIVth century and *modernity* in the XIXth century. But according to the inspiring contribution of Brazilian philosopher Henrique Vaz (1992:85) "the concept is linked with the concept of philosophy itself, as we can state that there is a conceptual equivalence between modernity and philosophy: all modernity is philosophical or all philosophy is the expression of a modernity where it recognises itself".

This thesis, shown in such simple terms, needs some clarification. In the first place, we must bear in mind that the emergence of the meaning of modernity demands a clear-cut rupture with the representation of time. It needs to be emptied of the mythic-symbolic frame of the repetition and leave the logic of the identical to build a new home (*ethos*), in the dialectics between the identical and the different. The crucial matter being the emergence of the act of daring to philosophise, a move that attempts to disqualify the authority which is inherent to the ancient.

Through the exercise of the critical reason, the philosophical discourse bestows to the *times of the present* a new dignity, giving that moment a new quality. Modernity can be then installed as the readings of its time. As stated by Vaz (1992), the civilisations, which do not know philosophy, do not know a modern reading of its time, as they did not dare to judge their past during the present.

To Aristotle, *physis* and *ethos* are first forms of the presence of the *being.* The *ethos*, according to Vaz (1988:11), "...breaks with the succession of the *same*, which characterises *physis* as the domain of the necessity, through the advent of *the different* in the free space open by the *praxis*.

The term *ethos* is the transliteration of two different Greek words: the first is ethos beginning with the letter <u>eta</u> and, the second is the word *ethos,* beginning with the letter <u>epsilon</u>. *Ethos*(eta) means the home of man in the world as a biological and cultural being – a home that is supplied with shelter and material and immaterial conditions of survival and which is constantly built and rebuilt. *Ethos*(epsilon) means the human behaviour that is repeated many times as an acquisition of the culture and not as a necessity of the *physis*. Thus, *ethos* (epsilon) makes available the possibility of a permanent 'habit' for doing *goodness.* The mediation of these two moments of the *ethos* is given by the praxis. Vaz (1988:16) states that " the ethical action comes from the *ethos* as from its principles and returns to it as to his accomplished end in the form of a virtuous existence." This circular movement between both types of ethos completes itself in an individual and social educating process. Because the movement of the *ethos* from the universality of habit to the singularity of the ethically *good* action is free, it brings always the possibility of conflict.

The emergence of the democratic *polis* explicitly imposes the ethos as *nomos* (law) and the first constructive efforts of the new science of the *ethos* – **ethics,** focus on the reflection about the law. Justice (*dike*) turns to be the legitimate source of all *nomos*. Thus, concludes Vaz (1988:49): "...the action of being *just* is what qualifies the true citizen". In opposition to this are the intrinsic marks of the *unjust*: the lack of measure (*hybris*) of power ambition (*pleonexia*), the excess of possessing (*philargyria*) and the excess of displaying (*hyperephania*). The just brings within himself the *metron* (measure), fundament of *The Rational Ethics*. Plato built this science as the science of action according to virtue (*arete*) and as a radical criticism against the notion of destiny, uniting intelligence and freedom in a virtuous link with the act for doing good.

The modern scientific revolution links the theoretical *logos* (manifestation of the reason) with the technical *logos* in a way it was inconceivable to Classic Greek Antiquity, the modern human *logos* demanding for itself the *Demiurgic place* that Plato had reserved for God.

What is going on now is the human construction of a new Nature that takes the place of the ancient *physis* and the question regarding the ethical universality meets new challenges with the globalisation of the technical-scientific culture. While platonic science recognises itself as the ontology of the goodness, modern science makes a methodological difference between fact and value, behaving itself as ethically neutral and disconnected from the responsibility of its consequences to Mankind and the world.

Hans Jonas (1979) emphasises that modern science and its new praxis demand the foundation of a new ethics, as ethic nihilism grows along with the increase of the science-technology potential. Contemporary techno-science is building a new space. The dilemma is whether it will be an *ethos* opened to the dimensions of this space or whether ethical nihilism will open new possibilities for survival outside the home of the *ethos*, leading man towards a boundless space.

Ethics and responsibility

The praxis of the sustainability principle demands that a *purpose* for *reaching a certain end* be a key-concept, without which norms and objective values would be meaningless. This principle does not let us forget that our economy is grounded on the fact that we live at the expense of metabolic processes and are creatures with necessities and that the act of supplying our necessities is an act of self-affirmation of life. But so is the reconnaissance of the responsibility towards our descendants and hence the linkage between self-interest and responsibility for the other in the economic activity.

Our main concern is not the construction of an ethics to be reached at a given time in the future but to be able to build **now** an ethics that is concerned with the consequences of our acts for future generations. As a dangerous threshold in our capacity to built destructive technology is being reached, our awareness of a sense of urgency and the call for immediate action becomes clearer and clearer. To perform the acts demanded by this new responsibility, however, we need knowledge that is related to physical events but also to the ends of human purpose. This new responsibility demands, therefore, knowledge of a futuristic perspective, such as supported by futurology - a scientific–technological projection that is informed by scenarios to which present actions may lead. In this context Jonas (1992) faces us with the following warning: the futurology of the desired scenarios is known to us as utopia but we still have to learn the futurology of warning to alert us not to cross the threshold, beyond which life is bound to be jeopardised.

According to Jonas (1992:130), "man is the only being that can have responsibility. As he can have it, he has it. The capacity of the responsibility states its imperative: the power itself also carries its duties". The capacity of responsibility is an ethical ability that lays on the ontological aptitude of man to choose among different alternatives with knowledge and will. Responsibility is, therefore, complimentary to freedom (Jonas,1992: 131). Man can be held responsible for the consequences of his acts only as long as they affect another being, which becomes an object of his responsibility, but this has only an ethical value if the simple existence of this being is a value by itself. And this presupposes vulnerability of the other being and the possibility that he can be affected by the power of man. Thus, it is necessary (a) that we maximise the knowledge of the consequences of our acts in order to find how they can determine and threaten the future of man and b) that we elaborate a knowledge of the goodness that must not be sacrificed by technological development, i.e., what must and must not be, what is allowed and what is forbidden, what man may have and what man must be (Jonas, 1992: 134-135).

These philosophical anthropology arguments gain also support as we attempt to unite the knowledge of man moving through the disciplines of science. From history we can learn what are we at our best (e.g. Inca agriculture, Alexandria library, pasteurisation, art, altruism, philosophy) and, also at our worst (e.g. Hiroshima, ethnical cleansing, forest burning, pollution). Metaphysics provide us a veto towards our self-destruction and teach us the fundaments of what must we be. From psychology and psychoanalysis links we can learn about man's dreams and nightmares and the collapse of his relationships with his own conscience, his society and his whole environment. We can also learn how should we behave to keep acceptable sane relations within our surroundings and ourselves (e.g. Jung, 1964; Roszhak, 1979; Gardner & Stern, 1996).

Economics, sociology and biology show us that our evolution involves not only competition for the survival of the fittest but a high degree of collaboration (symbiosis) for the survival of the whole living system (see Barlow, 1991). Geology and palaeontology, on the other hand, remind us that all Earth processes are intimately interlinked with one another and that species evolve or become extinct in each major tectonic and climatological change. As man becomes a global geological actor, producing large-scale changes (Mungall & McLaren, 1991; Ephron, 1988; Salati, this volume) beyond the buffering capacity of the geosphere, he may be triggering natural feedback processes that he is powerless to stop (e.g. changes in the circulation patterns of sea and air currents and ice polar cap melting that may quickly lead to rising sea level). Rather than catastrophes, geologist and theologian Teilhard de Chardin (1955) recognises these phenomena as opportunities for an evolutionary step towards the expansion in the consciousness of the system man-biosphere-Earth, approaching man to Divinity. The earlier, man chooses to be conscious of the bio-geosphere he belongs and cares for the system with responsibility, the less will be the suffering of the next generations and the further will we depart from the anti-utopia scenarios like the one pictured in Aldous Huxley's *Brave New World*.

The science and technology paradox of being simultaneously the cause of the evil and the way of avoiding it, evoke Hölderlin's verses:

there, where danger hides is where salvation rises.

It is not Nature that scare us but our power to interfere with Her. Since the eighteenth century, the technological power is becoming more and more connected with the power structure of the state and with the so-called *free* market forces, to the point that, nowadays, the market chooses (Ferreira, this volume) from available alternatives, the most profitable technology. In this process, Nature is but a 'storehouse of matters' (Francis Bacon) and what really matters are values related to efficiency and productivity. Within such technical modernity, ethical concerns about Her preservation are but romantic wishful-thinking. Before *The Enligthenment*, ethics was part of religious education and since then man's position in relation to life became a personal task. We owe to the great German naturalist, Von Humboldt, the fundaments of an ethical modernity and the project of an universal education through the teaching of a science that knows itself as philosophy and where ethic autonomy is achieved with acquisition of scientific and artistic culture (Schelsky, 1963). As Max Weber (1987) has pointed out, no science is free of pre-conditions. Is its product worth to be known? To whose service is the scientific practice developed? There is no scientific answer whether contemporary science is following a good or a bad command. To many scientists, we need science for the Earth (Wakeford & Walters, 1995). To counterbalance the evils of a scientific-technological *laissez-faire* we need that science itself be responsible. In the core of the ethical modernity that has brought the sustainability principle are vulnerability limits. After surpassing tolerated limits of Nature and Society, development is suffering anti-productive degeneration as Homo industrialis is being reduced, according to Heisenberg, (1979:22) to "the situation of a captain whose ship is so well built with iron and steel that its compass no longer points to the North".

Technologies for Sustainability

Building population consciousness about the strategic importance of sustainability is a major concern of the **Agenda 21.** According to it, it is necessary to redirect the educational system towards sustainable development by training citizens in sustainability technologies. Education in sustainability must incorporate an ethical dimension linked to knowledge, techniques and behaviour. The technologies for sustainability deals with processes and products and, therefore, cannot be viewed as isolated units, but local systems that include scientific-technologic knowledge, know-how, goods, service, equipment and organisation procedures which must be compatible with socio-economical, cultural and environmental national priorities. Access and transfer of such technologies among nations must be more collaborative so that they will not increase the economic and technological dominance of a given nation at the expense of another. This, demands from developing nations considerable national training and innovative research efforts. The development of new such technologies must respect local and national social, cultural and environmental constraints. Its adoption cannot be imposed by market conditions alone and can only take place after there is no risk of irreversible damages. The establishment of international, national and regional co-operative education and research networks has, thus, strategic importance.

Sustainable development technologies demand assessments with long-term perspectives where uncertainties are the rule. This requires not only heavy prospective research on the behaviour of natural systems but a prudent interaction between the scientific endeavour and the decision-making process. Assessments, within the sustainability principles, are ethical decisions with the goal to promote the continuity of life and they must also incorporate local knowledge and wisdom. To become effective in the decision-making process, these principles, ethical codes and guidelines must not only be endorsed by the scientific-technologic community but also recognised by the whole community.

We live a critical transition which is associated to paradigm changes and to radical transformations in the technology base of our modern globalised civilisation (Hobsbawm, 1994). While there are many serious *cul-de sac* predictions like the *End of History* (Fukuyama, 1992), *of Work* (Rifkin, 1995), *of Science* (Horgan, 1996) and *The End* (Ephron, 1988) there are an enormous variety of global synthesis, scenarios, evaluations and agendas that may become building stones for the construction of a new utopia. *The* ***Agenda 21*** (UNCED, 1992) and the *Humane Agenda* (Galbraith, 1998) are already landmarks that can guide science and technology towards a sustainable development.

It is time to act, having in mind that a) technological projects have a long maturing time, b) that new changes must come gradually as to maintain institutional credibility and cultural sustainability, c) that the "sustainability principle" as the keystone of **ethical modernity** must support the *logic of being* to overcome the *logic of having*, d) that plurality and diversity are important qualities in Nature and in Society and e) that an universal education merging science and ethics is the starting point.

To summarise, science is a very important tool to drive Mankind towards the sustainable development utopia. The ethic imperative is that it should neither be self-commanded nor oriented by market forces alone. Rather, it should be at the service of the whole society with the purpose of serving Life!

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