# The Role of Biological Nitrogen Fixation in Land Reclamation, Agroecology and Sustainability of Tropical Agriculture

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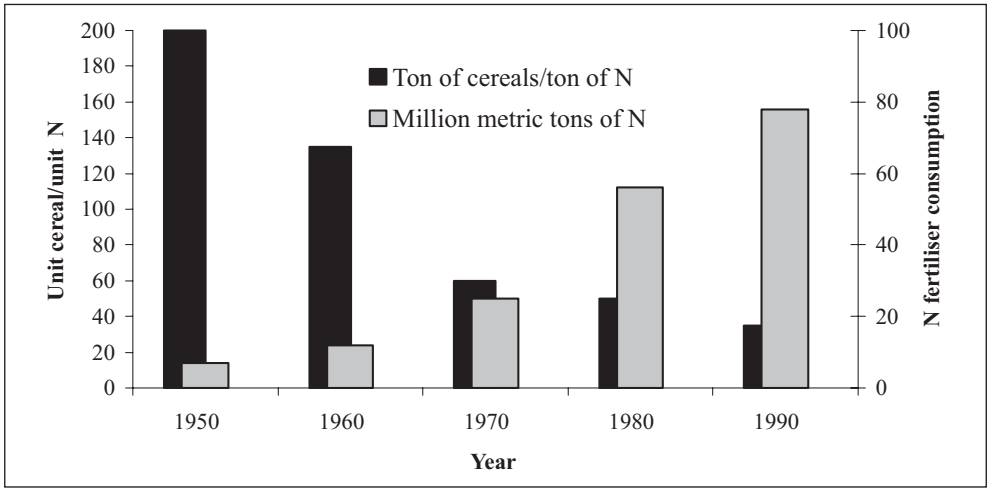
# Introduction

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.

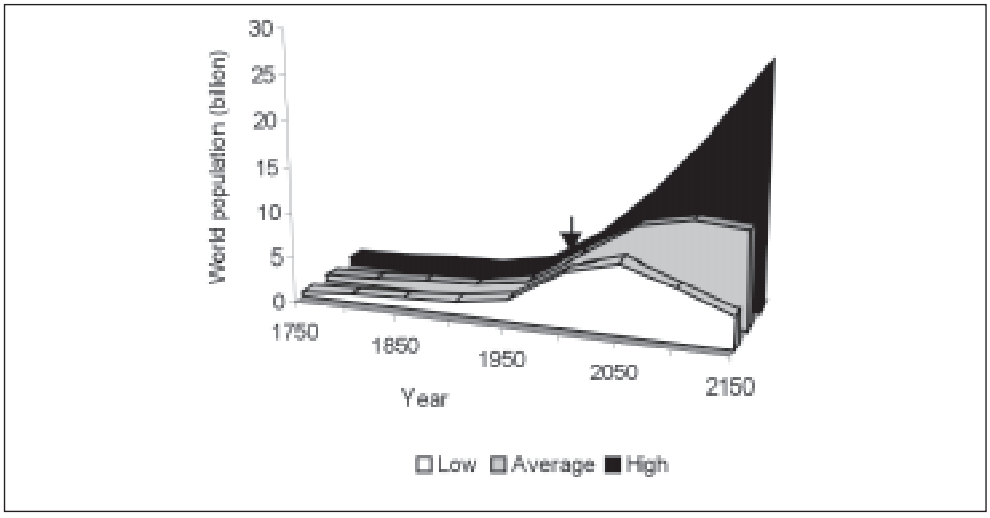
Table 1 – Population and world cereal supply of the world.

| 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).

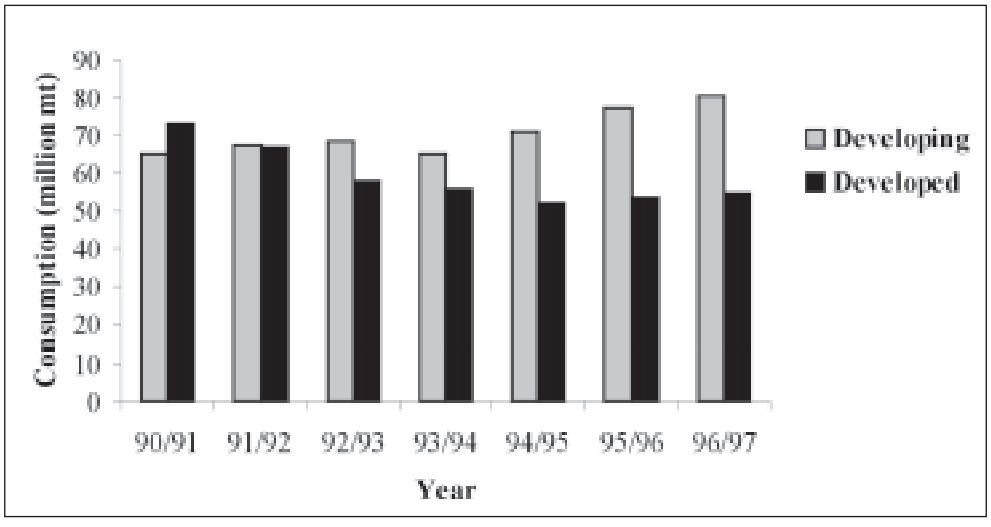
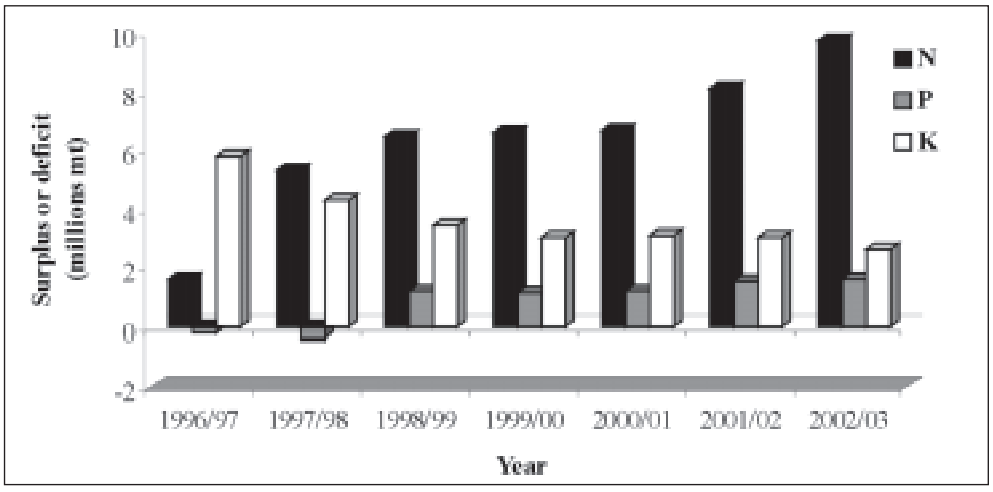


FIGURE 4- WORLD N, $P_2O_5$ AND $K_2O$ SUPPLY AND DEMAND BALANCE (EXTRACTED FROM FAO, 1998).




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.

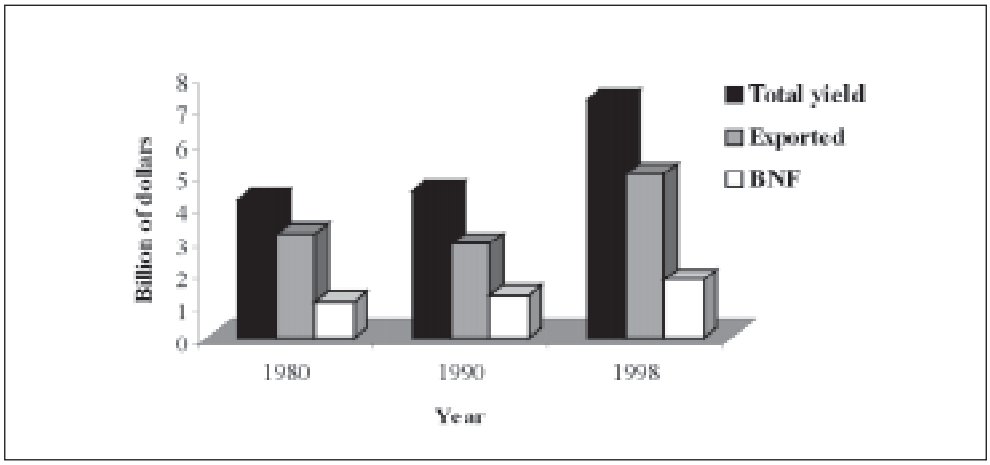



TABLE 3 – PLANTED AREA, TOTAL PRODUCTION, PRODUCTIVITY AND TOTAL NITROGEN EXPORTED IN THE GRAINS FROM 1970 TO 1998 IN BRAZIL.

| 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).

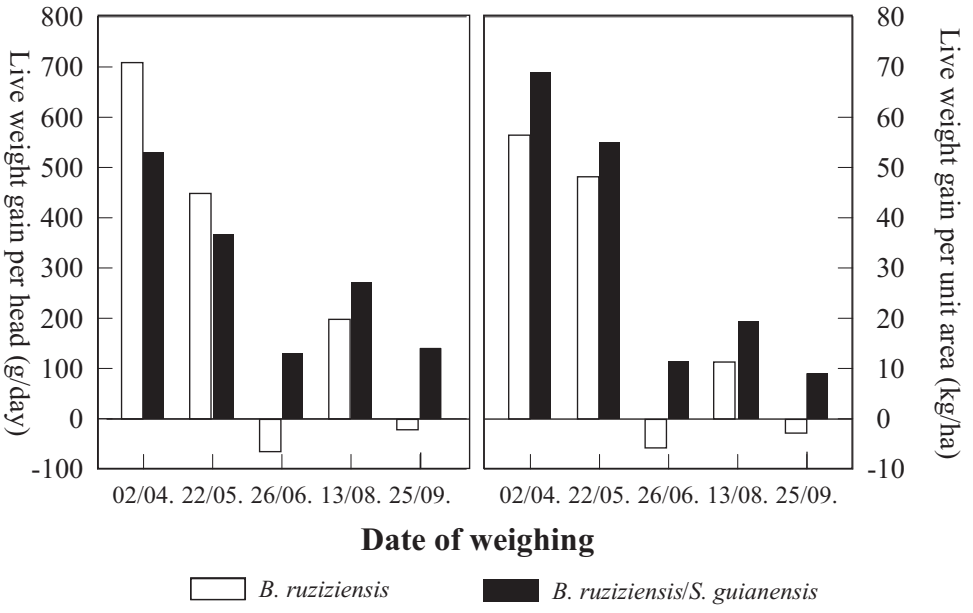
Table 5. Live weight gains of Nelore cattle grazing on a mixed pasture of *Brachiaria dictyoneura* and *Arachis repens* in the Atlantic forest region, Southern Bahia, Brazil. Data from *Santana and Pereira (1995).

| 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 | | | Tolerance to: | |
|---|---|---|---|---|---|
| | P | K | S | 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].

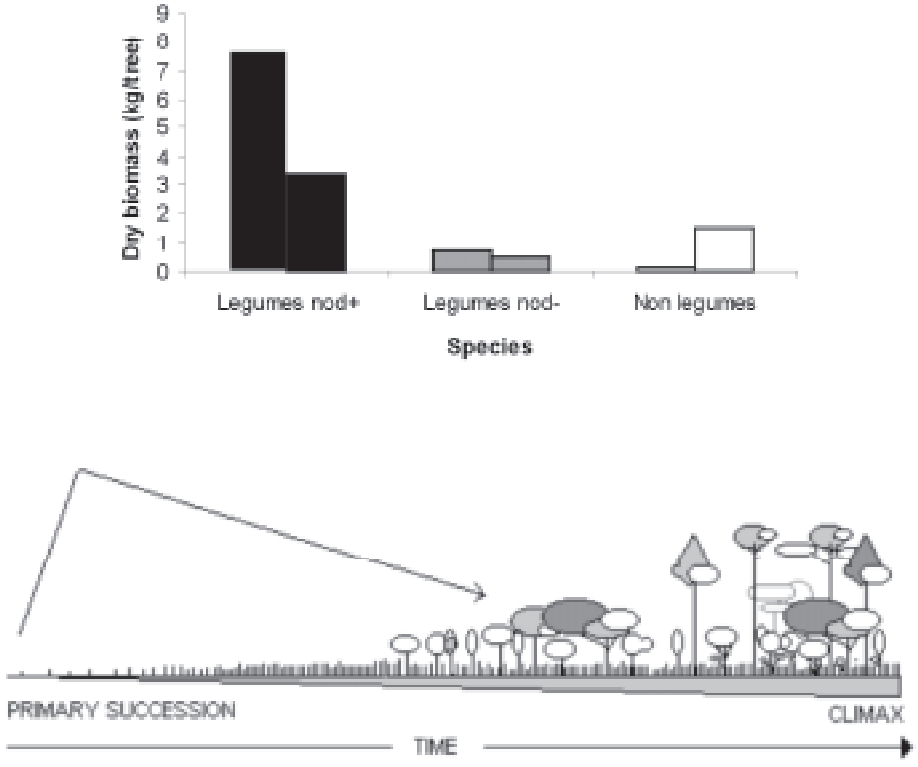
| Inoculation treatments | Nodule dry weiht | Root infection AMF | Plant dry weight | Accumulated in the shoot | |
|---|---|---|---|---|---|
| | | | | N | P |
| | (g/pot) | (%) | (g/pot) | | (mg/pot) |
| None | 0 | 0 | 4.3 d | 116 d | 5 c |
| Rhizobia (R) | 81.7 | 0 | 5.7 c | 200 c | 8 c |
| Arb. Mic. 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)*

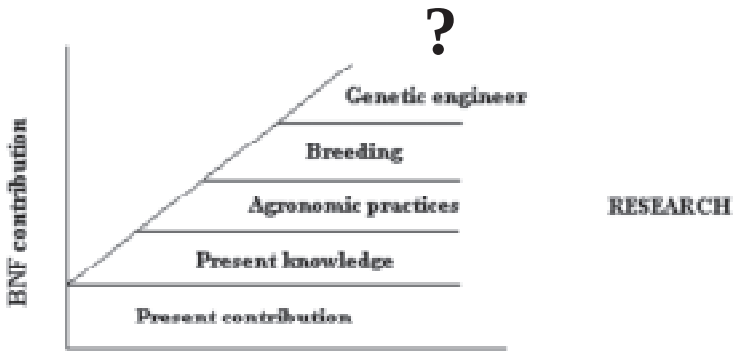
This approach of land reclamation by using BNF and using minimum quantities of fertilisers has been showing good results in the field. Franco et al., (1994) are recommending the application of 100g rock phosphate per plant with success in several soils of Brazil while Dart (1995) is recommending 200g 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.

## BNF AND FOOD PRODUCTION IN THE NEXT CENTURY

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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