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A REGIONAL VIEW OF NEGOTIATIONS ON BIODIVERSITY

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A. THE CONCEPT OF BIODIVERSITY

As currently defined, the term "biodiversity" is limited to the biological and ecological aspects of the diversity of the ecosystems, the species and the intraspecific genetic variability of the components of the biosphere (Office of Technology Assessment, 1987; Wilson and Peter, 1988; McNeely and others, 1989).

Researchers have been unable to agree on a single explanation for biological diversity. According to Lugo (1988), there is no one way of dealing with the existence of regions that are rich or poor in terms of biological diversity.

According to this author, factors such as climate, number of organisms, topography, physical substratum, time and heredity must be considered in conjunction with each other in order to form an overall view of the topic.

Lugo (1988, p. 2), basing himself on a review of the literature, lists 11 empirical pieces of evidence related to biodiversity on Earth:

1. The diversity of most animal and plant groups increases with proximity to the tropical latitudes and, within the intertropical belt, with proximity to the equator.
2. The total number of species by unit of surface area is generally greater in the wet tropical forests than in the other ecosystems located in latitudes to the north or south of these forests.
3. Tropical forests have greater diversity than other forests on all measurement scales: within habitat, between habitats and between biotopes.
4. Within the same altitude range, the number of species increases according to the rainfall index.
5. Between different altitudes, the number of arboreal and bird species increases with altitude.
6. In island environments, the number of animal species increases with the size of the island and the nearness

of these environments to the continent. In island environments with uneven topography, the number of species also increases.

7. Tropical mountain areas (especially high mountains) contain a greater number of animal and plant species than equivalent temperate mountain areas, owing to the variability of the environments, which range from tropical at the base to alpine conditions at the peak.

8. Ecosystems with severe limiting factors, such as high salinity, floods and low temperatures, have a low biological diversity.

9. As forests recover from serious environmental disturbances such as hurricanes and fires, the diversity of species in the disturbed zone increases, reaching a peak after a number of decades.

10. Highly productive systems, when under management, are poor in species; they increase in specific diversity in the direction of the values observed in less disturbed, more balanced systems as pressure diminishes.

11. The natural landscape is not uniform in terms of specific diversity. Frequently, isolated areas exist with a large number of species that may be disseminated to areas having a low specific diversity.

In view of the above, discussions on biodiversity should lead to an assessment not only of their current stock, i.e., taking a static view of biological diversity, but also of the maintenance of their evolutionary dynamics.

Lugo (1988, pp. 8-9) notes the following determining factors in the richness and diversity of species:

Factors or complexes of factors	Probable results
Genetic changes	Creation of genotypes
Interspecific relations	Selection and extinction
Geomorphological changes	Changes in species dynamics
Climate changes	Extinction and selection of species
Extreme weather phenomena	Changes in the structure of habitat and specific diversity
Fire and other environmental disturbances	Changes in specific diversity
Dispersants (wind, water, biological agents)	Distribution of species

Biological agents	Changes in the regulation of species and diversity
Human interference	Changes in habitats, extinction of species, changes in wealth of diversity and specific diversity

In considering aspects relating to human interference, the diversity of uses which various cultures make of the resources of biological diversity should be taken into account.

While on the one hand the dynamics of modern occupation and use of natural resources have led to an unprecedented modification of habitats, traditional cultures on the other hand, having historically lived with biological diversity, possess forms of knowledge that can suggest alternatives both for balanced management of these resources and for their incorporation into advanced technological processes, as in the case of biotechnology and fine chemicals.

The harmonious relationship that exists between communities that have developed in environments with high biological diversity and the evolutionary dynamics of these environments is actually based on agriculture and pharmacology, among other fields of human activity (Hoyt, 1988).

Examples abound in Latin America where culture and nature interact to such an extent that it is difficult to distinguish between distribution by means of anthropogenic stimuli and natural dispersion of the species.

Brücher (1990) points out the importance of Amerindians in the dissemination of the species in the pre-Columbian period. He notes that evolution, domestication and the migration of more than 100 plant species were associated with indigenous populations, and the regions where this phenomena occur differ from the centres of diversity identified by Vavilov for Mexico and the Andes; in addition, Brücher feels that the notion of centres of specific diversity is inappropriate in dealing with the question of "diffusion arcs", which are dispersed for thousands of kilometres following the route of indigenous migration in the neotropical zone.

According to Kerr (1986, p. 160), another noteworthy factor in the relationship between indigenous populations and nature is the way in which their agricultural practices evolved where there is concern to maintain the heterogeneity of the species, as occurs in nature itself.

The Kaiapó people, for example, choose the location of their villages according to the proximity of areas of maximum species diversity, thus gaining access to various natural products and a great variety of game, depending on the season of the year (Posey, 1983, cited in Posey, 1986, p. 17).

Sauer (1986, p. 59) notes that the stock of plants grown by the American peoples is one of the most important, most obscure and least well-known aspects of their culture.

Maize (Zea mais) is what might be called a classic example. A basic food of the indigenous American population, its distribution and known varieties are closely connected with its assimilation by indigenous cultures. According to Bauer (op. cit.), the sacred maize of the Incas, grown on protected terraces and warmed by the sun above Lake Titicaca, marks the highest limit of this grain: 3 900 metres.

Likewise, manioc or yucca (Manihot esculenta) provides evidence of how the indigenous populations, throughout thousands of years of experimentation, maintained and manipulated genetic diversity (Chernela, 1986, p. 151).

Another important aspect of the definition of the term biodiversity is its economic potential, in terms of both the level of sustainability of traditional exploitation processes and of how it can be incorporated into the analysis of the potentialities of new technologies, such as biotechnology and fine chemicals.

In this context, the delimitation of a concept of biological diversity --in addition to its scientific, ethical and cultural aspects-- takes on the connotation of a reevaluation and expansion of the concept of renewable natural resources.

The linchpin of the new technical base, stemming from the development of the new technologies --especially the biotechnological aspect of these technologies--, is information. In the technical system that emerges, quantity gives way to quality, and information plays a pivotal role in the valuation of natural capital.

Sasson (1985, p. 11) observes that modern biotechnology actually consists of using bacteria, yeasts and animal and plant cells in the form of cultures, where metabolism and the capacity for biosynthesis are oriented towards the fabrication of specific substances.

According to the definition of the European Federation of Biotechnology, as quoted by Sasson (1984, p. 11), biotechnologies, through the integrated application of knowledge and techniques from biochemistry, microbiology, genetics and chemical engineering, make it possible to take advantage, from the technical standpoint of the capabilities of micro-organisms and cell cultures.

The concept of biotechnology provided by the United States Office of Technology Assessment (OTA) (United States, 1984, p. 3) has a broader coverage that is more directly related with biological diversity. It states that biotechnology, generally speaking, includes any technique that uses living organisms (or parts of living organisms) to make or modify products, to improve plants or animals, or to develop micro-organisms for specific use. This definition actually recognizes that this group of technologies, now known as biotechnology, represents the most recent phase in the historical evolution of techniques related to the use of natural resources, especially germ plasm.

Thus it can be said that there is an "expansion" of the concept of natural resources and that their valuation is now based not only on their availability in terms of quantity but also --and especially-- on their diversity as an element capable of introducing new data into advanced technological processes.

Technical progress in the field of biotechnology, as in fine chemicals, will be intrinsically linked to the capacity for valuation of the genetic code. In this sphere, access to biological diversity and the subsequent analysis of biological functions stemming from the various adaptative mechanisms to be found in organisms will be of great importance to technical and scientific progress.

Biodiversity, then, represents a wealth of active principles and information that is decisive in the development of intensive information technologies, especially options offered by the chemistry of natural products and by genetic engineering.

Data generated from studies on zones of high biological diversity could be used as inputs for research and development and for the obtainment of new products and processes in such fundamental areas as medicine and agriculture, opening up new, sizeable markets to the technologically advanced countries.

Consequently, if the concept of biodiversity is seen only in terms of zones, animals and plants that need to be protected, it will not be broad enough to characterize the problem being addressed here.

To achieve greater clarity in the conduct of negotiations, it will be necessary to include aspects relating to the development of options that allow for progress in the countries having zones of high biological diversity at levels that are compatible with regional socio-cultural patterns and the opportunities offered by modernization.

B. THE PRESENCE OF BIOLOGICAL DIVERSITY IN THE WORLD AND IN LATIN AMERICA

According to Wilson and Peter (1988, p. 3), world publications note that nearly 1.4 million species of organisms have been described. Of these organisms, 750 000 are insects, 41 000 are vertebrates and 250 000 are plants; the rest correspond to a complex of invertebrates, fungi and micro-organisms.

Taxonomists believe that barely 20% of the species present on Earth have been described as yet; this estimate may be even lower in view of the difficulties encountered in gaining access to biotopes such as the treetops of tropical forests.

These organisms are unevenly distributed and are concentrated in the intertropical belt. In this region may be found the zones studied by Mittermeier (1988, cited in McNeely and others, 1989, p. 88) as areas of megadiversity.

The concept of megadiversity involves taking an overall view of the presence of species, critically important ecosystems and biogeographical regions, freshwater systems, marine systems and the presence of wilderness areas.

According to McNeely and others (1989, p. 88), the use of the concept of megadiversity makes it possible to establish a list of 13 countries where conservation of biological diversity should be regarded as critical: Australia, Brazil, Colombia, China, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Peru, Venezuela and Zaire.

These zones, according to the World Wide Fund for Nature (WWF, 1989, cited in McNeely and others, 1989, p. 88), represent 70% of the Earth's biological diversity.

Within the biogeographical zones into which the biosphere can be divided, the neotropical zone, in which Latin America and the Caribbean are located, is one of the richest areas of the world in terms of biological diversity.

Land biomasses are responsible for the pre-eminence of the neotropical zone, since marine biomasses are largely represented by the wealth of the systems of the West Indian and Pacific oceans. According to Goldman and Talbot (1976, cited in Reid and Miller, 1989, p. 16), there are more than 2 000 species of fish living in or near the coral reef systems of the Philippines, while only 507 species live in the Bahamas.

However, it is important to remember that biological diversity in marine environments is just as important, and coral reef habitats may be compared with the environments of the dense tropical forests (Connell, 1978, cited in McNeely and others, 1989, p. 35).

Ray (1988, cited in McNeely and others, 1989, p. 36) observes that trophic chains in marine environments are more complex than land chains, and that marine organisms are more complex from a genetic standpoint.

All these factors mean that coastal and marine environments, although they may be much less well known than land biomasses, have a special place in the study of biological diversity which will certainly require specific studies and individual decisions concerning the management of coastal systems.

As for land systems, despite the importance of such areas as the "closed" formations of Brazil, the flooded zones of the Chaco River and wetlands and the complex systems of the Andes, attention is being centred on dense tropical forests.

The biological wealth of the dense tropical forests is very considerable from the point of view of land systems. Approximately 40 to 100 species of trees per hectare may occur in the dense tropical forests of Latin America, while only 10 to 30 species per hectare occur in the northern hemisphere forests (Reid and Miller, 1989, p. 16).

Within the neotropical zone, Reid and Miller (1989, p. 17) point out that there is a greater diversity of mammals in Central America, while the northern part of South America has more plant species. In the data presented by the authors, El Salvador holds a prominent world position with regard to the density of mammals per 10 000 square kilometres despite the greater absolute number of species in countries such as Mexico, Brazil, Peru and Colombia. According to McNeely and others (1989), these countries (together with Venezuela in terms of birds and Ecuador in terms of birds and insects) are among the biggest world possessors of biodiversity. According to the same authors, Mexico has the greatest numbers of reptiles and amphibians on Earth.

Bearing in mind the importance of the dense tropical forests for biological diversity (Wilson and Peter, 1989; McNeely and others, 1989; Reid and Miller, 1989), some data are presented below from the Food and Agriculture Organization of the United Nations (FAO) on the distribution of these plant formations in the world for 1981 (tables 1a, 1b and 1c).

Taken as a whole, dense tropical forests cover an area of 1 200 889 000 hectares. This total, however, represents only 7% of the Earth's surface and may contain, according to estimates by McNeely and others (1989, p. 10), 90% of its biological diversity.

As for spatial distribution, the dense tropical forest covers 18.04% of the surface of Africa, 25.45% of that of Asia and 56.51% of that of Latin America.

Of this total surface area, a group made up of 18 countries possesses nearly 88% of the dense tropical forests (see table 2); of these countries, nine are Latin American; their surface areas, when added together, represent 53.55% of the world's dense tropical forest.

Within the neotropical zone, a group of 10 countries, taken together, represents 96% of the Earth's surface covered by dense tropical forests: Brazil (52.7%), Peru (10.3%), Mexico (6.8%), Bolivia (6.5%), Venezuela (4.7%), Guyana (2.7%), Suriname (2.2%), Ecuador (2.1%) and the French Department of Guiana (1.3%).

Territorial extension, while relevant in considering biological diversity, should not be the only element in attributing importance to zones of diversity. It should be recalled that the treatment of biodiversity involves, as mentioned above, complex elements of ecological analysis (Lugo, 1986, and Mittermeier, 1988, cited in McNeely and others, 1989). Certain countries which do not have large areas of dense tropical forests (see table 2) are considered important for purposes of conserving their biological diversity.

Thus, island areas such as Madagascar, which have only 0.86% of the dense tropical forests, are considered to be among the regions having megadiversity, since they contain nearly 6 000 species, of which 4 900 (82%) are endemic.

In analysing the representativity role and management practices of zones that are rich in biological diversity, it is therefore essential to have access to technical and scientific data which can be used as a basis for determining which criteria should have priority in integrating the vectors of the dynamics of ecosystems, the social and cultural dynamics of regions, the representative indexes of species diversity and the dynamics and genetics of populations.

C. BIOLOGICAL DIVERSITY AND CULTURAL DIVERSITY

The literature on the subject provides various examples of the capacity of indigenous communities to use and maintain biological diversity. To these communities could be added, at least in part, the mestizo populations. Having originated in the mixture not only of races but also of the cultures of the colonists, Africans and indigenous peoples, they developed forms of interaction that were very rich in the use of biological diversity (CONCYTEC, 1983; Prance and Lovejoy, 1984; Ribeiro, 1986; Posey and Overal, 1990).

Table 1a

DENSE FORESTS IN TROPICAL AFRICA
(Thousands of hectares)

World surface area covered by dense tropical forests: 1 200 889 000 hectares

Country	Total surface area	Dense forest	% of country	% of bioregion	% of world total
Zaire	226 760	105 750	46.6	48.8	8.81
Congo	34 200	21 340	62.4	9.9	1.78
Gabon	26 767	20 500	76.6	9.5	1.71
Cameroon	47 544	17 920	37.7	8.3	1.49
Madagascar	59 099	10 300	17.4	4.8	0.86
Nigeria	92 377	5 950	6.4	2.7	0.50
Côte d'Ivoire	32 246	4 458	13.8	2.1	0.37
Ethiopia	122 190	4 350	3.6	2.0	0.36
Central African Republic	62 298	3 590	5.8	1.7	0.30
Zambia	75 261	3 010	4.0	1.4	0.25
Angola	124 670	2 900	2.3	1.3	0.24
Guinea	24 586	2 050	8.3	0.9	0.17
Liberia	9 632	2 000	20.8	0.9	0.17
Ghana	23 854	1 718	7.2	0.8	0.14
Somalia	63 754	1 540	2.4	0.7	0.13
Unted Republic of Tanzania	93 970	1 440	1.5	0.7	0.12
Equatorial Guinea	2 806	1 295	46.2	0.6	0.11
Kenya	58 037	1 105	1.9	0.5	0.09
Mozambique	78 303	935	1.2	0.4	0.08
Uganda	19 684	765	3.9	0.4	0.06
Sierra Leone	7 333	740	10.1	0.3	0.06
Guinea-Bissau	3 613	660	18.3	0.3	0.05
Sudan	250 581	650	0.3	0.3	0.05
Chad	128 400	500	0.4	0.2	0.04
Togo	5 680	304	5.4	0.1	0.03
Senegal	19 672	220	1.1	0.1	0.02
Zimbabwe	38 936	200	0.5	0.1	0.02
Malawi	11 858	186	1.6	0.1	0.02
Rwanda	2 634	120	4.6	0.1	0.01
Gambia	1 040	65	6.3	0.0	0.01
Benin	11 262	47	0.4	0.0	0.00
Burundi	2 783	26	0.9	0.0	0.00
Mali	120 383	x	x	x	x
Niger	126 700	x	x	x	x
Namibia	82 429	x	x	x	x
Botswana	57 500	x	x	x	x
Burkina Faso	27 420	x	x	x	x
Totals	2 176 262	216 634	10.0	100	18.04

Source: FAO, World Forest Inventory, 1981.

x = insignificant values in relation to scale used.

Table 1b

DENSE FORESTS IN TROPICAL AMERICA

(Thousands of hectares)

Country	Total surface area	Dense forest	% of country	% of bioregion	% of world total
Brazil	851 196	357 480	42.0	52.7	29.77
Peru	128 522	69 680	54.2	10.3	5.80
Colombia	113 889	46 400	40.7	6.8	3.86
Mexico	196 718	46 250	23.5	6.8	3.85
Bolivia	109 858	44 010	40.1	6.5	3.66
Venezuela	91 205	31 870	34.9	4.7	2.65
Guyana	21 497	18 475	85.9	2.7	1.54
Suriname	16 382	14 830	90.5	2.2	1.23
Ecuador	27 067	14 250	52.6	2.1	1.19
French Department of Guayana	9 100	8 900	97.8	1.3	0.74
Nicaragua	13 000	4 496	34.6	0.7	0.37
Guatemala	10 889	4 442	40.8	0.7	0.37
Panama	7 708	4 165	54.0	0.6	0.35
Paraguay	40 675	4 070	10.0	0.6	0.34
Honduras	11 209	3 797	33.9	0.6	0.32
Costa Rica	5 090	1 638	32.2	0.2	0.14
Cuba	11 450	1 455	12.7	0.2	0.12
Belize	2 297	1 354	58.9	0.2	0.11
Dominican Republic	4 840	629	13.0	0.1	0.05
Trinidad and Tobago	513	208	40.5	0.0	0.02
El Salvador	2 099	141	6.7	0.0	0.01
Jamaica	1 142	67	5.9	0.0	0.01
Haiti	2 775	48	1.7	0.0	0.00
Totals:	1 679 121	678 655	40.4	100	56.51

Source: FAO, World Forest Inventory, 1981.

Table 1c

DENSE FORESTS IN TROPICAL ASIA

(Thousands of hectares)

Country	Total surface area	Dense forest	% of country	% of bioregion	% of world total
Indonesia	191 930	113 895	59.3	37.3	9.48
India	328 700	51 841	15.8	17.0	4.32
Papua New Guinea	46 170	34 320	74.3	11.2	2.86
Myanmar	67 658	31 941	47.2	10.5	2.66
Malaysia	33 008	20 995	63.6	6.9	1.75
Philippines	29 940	9 510	31.8	3.1	0.79
Thailand	51 352	9 235	18.0	3.0	0.77
Viet Nam	33 433	8 770	26.2	2.9	0.73
Laos	23 680	8 410	35.5	2.8	0.70
Cambodia	18 104	7 548	41.7	2.5	0.63
Pakistan	80 519	2 185	2.7	0.7	0.18
Bhutan	4 660	2 100	45.1	0.7	0.17
Nepal	14 080	1 941	13.8	0.6	0.16
Sri Lanka	6 558	1 659	25.3	0.5	0.14
Bangladesh	14 400	927	6.4	0.3	0.08
Brunei Darussalam	577	323	56.0	0.1	0.03
Totals	944 769	305 600	32.3	100	25.45

Source: FAO, World Forest Inventory, 1981.

Table 2

COUNTRIES HAVING THE BIGGEST AREAS OF DENSE TROPICAL FORESTS

Country	Total surface area	Dense forest	% of country	% of world total
Brazil	851 196	357 480	42.0	29.77
Indonesia	191 930	113 895	59.3	9.48
Zaire	226 760	105 750	46.6	8.81
Peru	128 522	69 680	54.2	5.80
India	328 700	51 841	15.8	4.32
Colombia	113 889	46 400	40.7	3.86
Mexico	196 718	46 250	23.5	3.85
Bolivia	109 858	44 010	40.1	3.66
Papua New Guinea	46 170	34 320	74.3	2.86
Myanmar	67 658	31 941	47.2	2.66
Venezuela	91 205	31 870	34.9	2.65
Congo	34 200	21 340	62.4	1.78
Malaysia	33 008	20 995	63.6	1.75
Gabon	26 767	20 500	76.6	1.71
Guyana	21 497	18 475	85.9	1.54
Cameroon	47 544	17 920	37.7	1.49
Suriname	16 382	14 830	90.5	1.23
Ecuador	27 067	14 250	52.6	1.19
Totals	2 559 071	1 061 747	41.49	88.41

From the standpoint of culture, biodiversity brings to mind two major issues:

- The question of the systematizing and use of the knowledge of local populations about biological diversity and sustainable management;
- The modern assimilation of biological diversity through new technologies and their relationship with ethnobiology.

These questions, although apparently situated at different levels of study and technological development, are closely linked and should not be dissociated from the negotiation process; otherwise, a worsening of the impact of technological modernization on indigenous populations will result.

According to Posey (1990, p. 3), traditional knowledge about the potential of biological diversity has already been recognized, in fact, by the pharmaceutical industry and other sectors of the chemicals industry which use this knowledge to obtain new products.

Posey (1990, p. 3) observes, for example, that in the earlier forms of colonialism, drugs from the remote interior (sertão) of Brazil constituted the basis for the health system in the colonial period; more recently, the pharmaceutical industry has become the principal researcher on knowledge of traditional medicine in order to obtain more products and greater profits.

The author, basing himself on data from the Brazilian Foundation for Medicinal Plants (FBPM), reports that the world market for drugs derived from medicinal plants used by indigenous peoples amounts to an annual total of US$43 billion.

In 1989, estimated sales of the three main natural products in the United States were as follows:

Substance	Sales (millions of dollars)
Digitalis	85
Reserpine	42
Pilocarpine	28

Posey (1990, p. 4) observes that, although no similar analyses exist for natural insecticides, insect repellents and genetic plant material culturally assimilated by indigenous populations, their potential would be easily adaptable for use by the drug industry;

in addition, the international seed industry records an annual figure of more than US$15 billion.

The assessment of the role played by cultural diversity in the discussion of biological diversity should have more weight in this discussion, bearing in mind the basically intertropical origin of germ plasm which presently feeds and provides chemicals and drugs to the world population, and the still unexplored possibilities for genetic diversity that have been opened up by biotechnology.

The economic benefit of using the knowledge of indigenous populations will obviously be a relevant point in the future debate on the management of natural resources.

The level of interconnection between cultural and biological diversity in indigenous populations (Meggers, 1984; Posey, 1986, 1990; Brücher, 1990; Elisabetsky, 1990) will necessarily entail a careful analysis of the possible impact of a biological diversity convention on these populations.

The purpose of the present negotiations should be to gather and evaluate traditional knowledge, while providing an economic benefit to the local populations, whether indigenous or mestizo. Thus the importance of cultural information in the use of biological diversity will be given due recognition.

The acquisition of indigenous knowledge and its use in advanced technologies without any form of protection of, or respect for, the property rights of these populations constitutes an unprecedented cultural expropriation and is profoundly unethical and antisocial.

D. BIODIVERSITY AND BIOTECHNOLOGIES: NATURAL RESOURCES FOR THE NEW TECHNOLOGIES

As noted above, biotechnologies (in the plural as some researchers prefer) or biotechnology (in the singular to connote a precise technological procedure, as others prefer, especially in the United States and the United Kingdom) are an element that can help to bring out the potential of the natural resources of biological diversity.

Actually, biology-based technologies are very old --nearly as old as history itself. In ancient Egypt, the fermentation process was used to make beer, a process which is, in principle, merely the application of a biotechnology; the selection and hybridization of plants to obtain varieties are also, strictly speaking, biotechnological processes.

Today, processes associated with molecular biology are called biotechnology or "new biotechnologies".

These new technologies began to appear in the early 1960s, when there was frequent talk of the emergence of "a new biology", which could lead, at the operational level, to a profound modification of the processes of manufacturing a great number of chemical and pharmaceutical substances (Sasson, 1984).

These developments, which are related to research findings in the past 30 years, especially in the United States and the United Kingdom (Dibner, 1986), made possible a multitude of discoveries in biochemistry, molecular biology and cellular biology in the 1970s, together with the appearance of techniques for planned intervention in micro-organisms and later in higher organisms.

According to Sasson (op. cit.), this progress stemmed, first of all, from the elucidation of the structure and functions of certain enzymes and their use, in immobilized form, in various manufacturing processes; microbiologists and enzymologists were responsible for these first stages. In the second place, specialists in molecular genetics discovered techniques for modifying desoxyribonucleic acid (DNA) and transferring it from one organism to another.

Sasson (op. cit.) observes that data on techniques such as genetic engineering were able to be gathered and organized only after significant progress had been made in the fields of virology (research on bacteriophages), bacteriology (advanced research on physiology, molecular genetics of coli bacilli and plasmids) and enzymology (restrictive enzymes).

At the same time, the possible economic implications of these techniques became evident, since, for example, the recombinant DNA technologies which developed out of the basic discoveries paved the way for cellular engineering, which made it possible to manufacture protein-based products with a high commercial value.

The conjunction of these conditions led to emergence of a new set of biology-based technologies, such as enzyme engineering, cell cultivation and genetic engineering, as well as hybridoma techniques, which are proving their capability of providing an impetus to economic and technical progress in at least five major markets: health, agriculture, food, energy and chemicals.

Moreover, modern biotechnologies, as mentioned above, allow for a new approach to be taken to the resources of the biosphere in order to obtain new industrial products or for agricultural development, mining (through bioleaching) and the discovery of products that can be used in the field of medicine; this will make it possible, in principle, to use natural resources in a less destructive way.

It is important to note that there is no conflict between the "old" and "new" biotechnologies: the old technologies --traditionally used in the health and agro-food sectors-- and the new technologies complement each other.

The "old" biotechnologies are being revitalized through the use of new techniques, since these allow for more precise control of the mechanisms which were already taken into account in traditional technologies. On the other hand, the traditional technologies provide the basis on which the new techniques can be grounded, since they are important points at which the new techniques can be incorporated into the production process.

The direct relationship between the potential of biological diversity and biotechnologies is somewhat distant and obscur, however, in view of the fact that there is a long way to go between conducting basic studies on diversity and achieving biotechnological development.

It is obvious that the process is very complex; nevertheless, more and more major studies are being done on the links between phytochemical and ethnobiological studies and biotechnological production (Elisabetsky, 1990).

Actually, the road ahead is not so long if we take into account the internal environment of the specialty areas that make it possible to obtain such products as pharmaceuticals. Ethnobiology, the study of fine chemicals and biotechnology are carefully co-ordinated within the strategy of the big corporations working in these sectors.

Crocomo (1989), in his presentation to a symposium between Brazil and China on chemicals and pharmacology based on natural products, states that the demand for natural, plant-based products is increasing for use in the pharmaceutical, cosmetics, food and textile industries, which makes the market very attractive. Indeed, market prices vary from a few dollars per kilo to thousands or millions of dollars per kilo. He notes the decline in prices of phytopharmaceutical products as a result of the introduction of production through synthesis. However, Crocomo goes on to say, certain products such as fragrances, flavours and elements used in the pharmaceutical industry are very difficult to synthesize and they cannot be produced by chemical means, since they are the result of the combination of several hundreds of compounds.

Crocomo also observes that the raw materials from which these products are extracted could be affected by climate changes or diseases. These conditions can be avoided through in vitro culture methodologies, which offer alternatives for a constant and homogeneous production of the material necessary.

Lastly, Crocomo states that by using these in vitro techniques new compounds could be produced or low-value substrata could be converted into high-value products through biotransformation, and he notes at least two ways of obtaining these advantages:

- microprogramming, through the use of selected specimens, thereby permitting the domestication of endemic plants;
- culture of cells and tissues in liquid suspension, a situation in which secondary metabolites can be produced and, in some cases, separated in the medium, from which they would be extracted, purified and marketed.

Elisabetsky (1990, p. 12) describes the links between pharmaceutical science and ethnobiology through ethnopharmacology. He observes that, owing to the cost of pharmacological and phytochemical studies, the selection of plants to be studied is a decisive factor in the cost/benefit ratio.

According to the same author (ibid., p. 113), there are three strategies currently being used to manufacture plant-based drugs: 1) random studies; 2) chemotaxonomy, and 3) ethnopharmacological sampling.

The first strategy largely depends on the availability of resources for basic surveys; the second, chemotaxonomy, selects species on the basis of families or genera with greater potential for the presence of compounds of a specific chemical category, thus restricting it in terms of the range to be analysed.

Ethnopharmacology, according to Elisabetsky (ibid.), makes it possible to select species on the basis of the therapeutic effects attributed to them by the user populations and thereby to discover new compounds.

Although there is a fair amount of complexity in the analysis of ethnopharmacological data (Foster, 1976, cited in Elisabetsky, 1990, p. 111), it is evident that ethnobiological techniques make possible the assimilation of new compounds for various fields of application. These, through the use of new technological methods such as those found in biotechnology and referred to by Crocomo (1989), may be obtained and permanently maintained.

Another dimension, which complements the relationship of biotechnologies to biological diversity, is the ex situ recovery and maintenance of genetic resources, in conjunction with in situ conservation, a strategy which is regarded as indispensable in preserving the availability of these resources.

Ex situ conservation means all the mechanisms used for maintaining germ plasm outside of its place of origin. This category includes the techniques used in repositories for the study of recovery of genetic material, such as active germ plasm banks, cryopreservation, associated with lyophilization techniques, and other options for keeping the genetic potential intact.

Because of the characteristic isolation of genetic material from its place of origin, ex situ conservation, although important because it represents the time of the appropriation of the germ plasm and the initial determination of its potential application, is not an alternative that can be used by itself.

In situ conservation strategies, i.e., the creation of preservation and conservation areas where the genetic evolution of the species may continue, are the most effective means of conserving biological diversity.

E. BIOLOGICAL DIVERSITY AND THE PRESENT TECHNICAL BASE

Despite the potential for exploiting biological diversity through new technologies, it is obvious that this technological path is not the only way of valuating the economic potential of biodiversity.

The United States Office of Technology Assessment (OTA) made a study in 1987 entitled Technologies to Maintain Biological Diversity, which complements the proposed approach, in the case of continental environments, in the OTA document published in 1984 entitled Technologies to Sustain Tropical Forest Resources.

These documents systematize the available information on the subject. However, the question of biodiversity needs to be tackled from a much broader perspective.

The mere application of isolated technologies cannot preserve biological diversity; organized, joint techniques need to be identified.

Indeed, the maintenance of biological diversity will depend more heavily on the harmonious and equitable development of the societies living in regions with such diversity, involving the formulation of a political plan from both the technological and social point of view, than on the transfer of maintenance technologies or the decision to undertake a conservation programme in areas rich in diversity.

The pressure being exerted on natural environments in the developing countries by population growth, the organization of space and the export of raw materials has resulted in a high rate of environmental degradation which will be arrested only when alternative ways are found to produce goods and services and to increase the income of populations which are compatible with the preservation of diversity.

The natural environments of the neotropical region or any other natural zone on Earth are incorporated into the economic process according to the technical and economic paradigms which govern the current technical system.

It is understood, as Gilles (1978, p. 19) pointed out, that in general techniques are interdependent to a certain extent and that there must necessarily be some kind of linkage among them: the whole set of linkages at various levels of all structures, all sets and all ways of using technologies form what could be called the technical system.

The current worldwide technical system is highly raw material and energy intensive, a fact which has significant externalities from the environmental point of view that in the long run compromise the sustainability of the economic process itself.

As has been demonstrated in recent years (SEDES, 1981; Barre and Godet, 1982), it is obvious that incremental innovations in traditional ways of using technologies have served to meet the need of adapting production technologies to social and environmental factors, with a view to maintaining their capacity to promote longer-term accumulation.

On the other hand, market conditions in part determine the process of innovation itself and therefore have an impact on the dynamics of incorporating scientific knowledge into the technical base and its later dissemination within the technical system.

As Jantch notes (1978), there are various different "time periods" for the various stages of the journey from basic scientific knowledge to its application: i) the period up to its discovery; ii) the period between the discovery and the technological application or invention; iii) the period between the invention and the beginning of large-scale development; and iv) the period of development.

As a result, any analysis of the technological and scientific factors in the process of developing tropical ecosystems must take into account other opportunities which are outside the prevailing technical system, but not necessarily completely divorced from it.

These are techniques developed on the basis of other cultural patterns, i.e., those of the indigenous populations which, although obviously not within the dominant technical system, constitute an alternative technical system which is capable, according to recent studies (Posey, 1986 and 1990) of being integrated into the existing biodiversity and obtaining from it the most varied inputs to meet these populations' immediate needs.

The distance between the economic and social assumptions of the dominant technical system and those underlying the system of the indigenous populations makes it impossible, however, to have an unmediated linkage between the ways that technologies are being used by each group. The differences between the two technical systems, left to their own dynamics, are irreconcilable.

At present, however, the hegemony of the technical base is being ruptured as a result of the appearance of new technologies that have a considerable capacity for linkage with technological patterns previously regarded as being alternatives.

This is due to the fact that the whole set of new technologies is connected together to form a new technical system. This system, unlike the prevailing system, is predominantly focused on the diversity of information and the capacity for obtaining diversified products with high added value.

There is a point in common, then, between two apparently opposite technical systems: the systematic use of the diversity of inputs, as follows:

- In indigenous cultures, through the maintenance of processes for obtaining products based on direct co-existence with the diversity found in ecological zones (Posey, 1986) to obtain a great variety of products that are essential to the sustenance of the local communities;

- In the technical system formed by the new technologies, through the systematic use of diversified data bases, including genetic bases, and their incorporation into new products, with a potential to serve the market, and capable of absorbing high-technology products and significant value added.

Thus, in areas having a wealth of biodiversity like Latin America and the Caribbean, various technical systems therefore co-exist. These may be grouped as follows:

a) Culture-based techniques, traditionally developed in these regions, which are largely able to meet the assumptions for sustainable, long-term use of renewable natural resources.

These techniques, however, are incapable of sustaining a process of accumulation and regional economic integration in accordance with the prevailing paradigms.

b) Raw material-intensive and energy-intensive techniques, which sustain the present technical system and are based on the current accumulation process.

These techniques, because of the economic assumptions governing them, are and will continue to be incapable, without being a burden on the economic system that depends on them, of maintaining the environmental sustainability of economic processes in the long run.

These technical systems have been made more compatible with environmental requirements (and ultimately with the expansion of their useful life), in the sense that the adverse environmental externalities have been offset by the appearance of technical alternatives known as "soft" or "clean" technologies on the one hand, and "decontamination" technologies on the other; the present market for such technologies is now expanding and being strengthened in the developed countries, in the industrial sectors and services specializing in the development and production of these technologies.

c) Information-intensive techniques, which are the so-called "new" technologies. These techniques, now in the appraisal stage of their development, appear to offer a greater potential for co-existence with biological diversity and to sustain the process of accumulation at levels compatible with the present notion of modernness.

This third technical system, although apparently very promising, could have a major impact on the indigenous communities, in the sense that the use of their knowledge, as in the case of the ethnobiological collection of information, for example, does not afford an economic benefit to these communities, as mentioned above.

As a result, the appraisal of technological factors should take into account the real or virtual co-existence of these three groups of technical systems in the region and examine them at the same time as results of the various socioeconomic realities which are now in competition for the use of the region's natural resources.

Thus, the challenge of the neotropical zone consists of consolidating a technical system that is able to co-exist and interact with the three systems of paradigms, enabling the region to make the transition from its present phase of technical dependence to a modern scenario which will not necessarily correspond to the hegemony of one of the above-mentioned alternatives but rather to the harmonization of the options offered by each of them.

It is worth noting, however, that the forging of a technical system requires the growing support of the technical and scientific community for projects whose purpose is to promote the historical and social integration of the production of knowledge.

Nevertheless it should be clear to planners that the internal links that give life to technical systems are increasingly numerous as time goes on and techniques become more and more complex. These links can be established and made operational only if the set of techniques has some level in common, even if the level of some techniques (more independent than others) remains marginally either above or below the general level. Once a balance is obtained, the technical system is viable (Gilles, 1978).

In negotiating the question of biological diversity, the real capacity of response of the alternative techniques chosen must be kept in mind. The management of biological diversity must present a development option for the region, for the purpose of analysing the integration of technical and scientific production into the process.

We agree with Gallopin's stated view (1988, p. 77) that there is no critical absence of technologies for the development of the region, but that it is necessary to decide on a political option in order to implement this development.

Assuming the feasibility of a regionally determined scenario, the next step would be an appraisal based on the technical systems present in the region and the possible future technologies (indigenous and mestizo techniques, production techniques stemming from the incorporation of the region into the international production system, and new technologies).

Consequently, in determining the scientific and technical factors associated with the chosen model, attention should be paid to the following:

a) Scientific resources;
b) Technological resources;
c) Basic technologies;
d) Functional technological systems;
e) Applications;
f) Environmental factors;
g) Social factors.

Criteria for the selection of guidelines for incorporating technology into the process of reorganizing the regional structure should be based on the following:

1) Recognition of the present way in which the regional technical base is used and how it fits in with the international economic system;

2) Recognition of the technologies developed on the basis of the cultural paradigms existing in the region, analysis and fusion of isolated technologies into a form of technology that can be used at the regional level, to

enable it to be incorporated into the accumulation process on a sound social and cultural basis;

3) Determination of demand for auxiliary or support systems to allow for technology diffusion and the development of basic technological research;

4) Evaluation of the ethical constraints on development objectives;

5) Technology transfer on socially acceptable grounds.

F. THE COST OF PROTECTING BIOLOGICAL DIVERSITY

Determining the cost of protecting biological diversity is obviously the core of the present debate on the question.

The United Nations Environment Programme (UNEP), as a contribution to the debate of the Ad hoc Working Group of Experts on Biological Diversity at its third session, held in July 1990, produced the document entitled "Biodiversity: Global conservation needs and costs" (UNEP/Bio.Div.3/3).

This document notes the need to take action in the form of regional plans aimed at containing the loss of biological diversity, stressing such aspects as inventories and confirmation of species present, technical assistance and co-operation for biological research, establishment of centres for the registration of biological diversity, socioeconomic research, education and training, administrative plans and strategies, technologies for conservation and sustainable use, monitoring and co-ordination of activities and giving priority to pilot projects, especially in tropical and marine environments.

The document stresses the need to review and describe biological diversity and assessment of demand for technology replacement.

Although these aspects are important, they should not be the only aspects to be taken into account. As has been stated succinctly in the present document, the question of biological diversity fits in with a broad economic, social and cultural regional context, meaning that ecological and technological matters cannot be treated in isolation from the present social base.

Inventories and the assessment of biological diversity should not be undertaken in isolation from their use for the benefit of regional communities, nor should technology replacement be selected as an option without evaluating its social and cultural effects.

Thus, in appraising the components of the costs of biological diversity, account should be taken of the special features of the region in order to form a correct idea of the dimensions involved.

The proposal by the Economic Commission for Latin America and the Caribbean (ECLAC, 1990) on changing production patterns with social equity could form the basis for determining the costs of biological diversity, since the proposed rationale for conserving it will necessarily entail achieving better balance in the distribution of income and (provided that it is established on new technical foundations) less pressure on the region's natural resources.

Without doubt, as is recognized in the ECLAC document (1990, p. 134), Latin America and the Caribbean have a per capita endowment of renewable natural resources that is far larger than that of other developing regions.

However, these resources have not brought the region higher growth rates. In fact, the region's position in the international scenario has led, in a number of respects, to highly negative environmental effects, especially on the frontiers of the natural resources themselves.

An analysis of the history of the incorporation of natural resources in the export model of the countries of the region and the international prices of these products indicates an increasing trend towards impoverishment of the populations which directly depend on these resources to survive and towards growing regional dependence on international fluctuations in the prices of raw materials and consequently heightened pressure on natural areas.

As suggested by ECLAC (1990, p. 134), "it thus becomes necessary to rethink the contribution made by natural resources to the development of the region and to consider the concept of sustainable development, that is, development comprising a blend of the objectives of economic growth, social equity and environmental conservation".

The ECLAC document goes on to say that "natural resources cannot be made subject to a scheme of maximum exploitation in the short term but must instead be given careful management in which the rate of exploitation of non-renewable resources is evaluated on the basis of their availability (supply) and their prospects on the markets (demand) and attention is paid to the maintenance of the reproductive capacity of renewable resources in the long term. Nor can the natural resources sector be perceived as a provider of income which can be transferred to other sectors. Instead, consideration must be given to the structuring of production networks spatially linked to industry and services in particular, in such a way that greater value is attached to resources and there is a process of technological land organizational change which strengthens their competitiveness".

This view, which is consistent with the question of biological diversity conservation, could serve as a guide in determining what the factors used in calculating the cost of conservation should be. These should include, among others, the following:

1) The regional economy of renewable and non-renewable natural resources, the conflicts between expectations concerning the use of areas and the mechanisms for technology replacement on which the region's production is based, so as to bring about an increase in income from, and valuation of, the products stemming from biological diversity;

2) The scientific and technological policy related with the regional capacity for taking inventories, and recognition and use of information stemming from biological diversity, in terms of both preservation and technology, especially the new, biology-based technologies;

3) Environmental policy, especially with regard to strengthening national integrated environmental management systems, provided that biological diversity conservation is not treated separately from the other aspects of environmental policy, and the need to have enough resources to regulate the management of natural areas under a system of conservation units;

4) Regional co-operation in the exchange of scientific and technological information, bearing in mind the special features of the neotropical region and the existent knowledge base in the region;

5) International mechanisms providing access to information generated about the region, especially access on the part of researchers to data bases outside the region.

G. CONCLUSIONS

The present paper has attempted to bring out the topics relating to biological diversity that must be considered in the process of negotiating an international instrument designed to promote the balanced management of these resources.

The list below, although not in order of priority, contains points of interest to the region, on the basis of the assumption that socially balanced development is fundamental for the conservation of biological diversity, which above all represents a stock of natural resources that must be primarily used for the benefit of the societies that own them:

1. A study of biological diversity and sustainable management should take into account:

   - the genetic diversity of individual organisms and ecosystems;

   - the diversity of regional cultures and their association with the use and maintenance of biological diversity;

   - the diversity of products, including some that may be obtained from varied ways of using technologies, from the traditional base to the new technologies.

2. Knowledge about the potential of biological diversity is centered in the populations which have traditionally co-existed with these environments. How this knowledge is integrated with traditional technologies and used in the development of new, environmentally compatible technologies must be determined.

3. Products and processes developed on the basis of the direct or indirect use of biological diversity should not constitute threats to the maintenance of biological diversity and should include long-term, ecologically sustainable practices.

4. Consideration of biological diversity should take into account not only the protection of regions, animals and plants but also measures dealing with the whole set of ecosystems that are rich in biological diversity, and the establishment of options that allow for the sustenance and progress of the local populations at levels which are compatible with the maintenance of the evolutionary dynamics of these systems, ranging from genetic variability to biotope diversity.

5. The outstanding role played by diversity-rich biomasses in the international supply of inputs for modern technology, and by traditional processes that result in products with high added value, should translate into economic benefits to the countries which contain biological diversity as a way of promoting their development in harmony with its preservation and valuation.

6. The protection of wilderness areas, conservation of secondary zones and rehabilitation of degraded zones in systems having high biological diversity all go beyond

the exclusively ecological framework and form part of a new medium- and long-term economic strategy aimed at sustainable development.

7. The circulation of germ plasm within and outside zones of high biological diversity should be the subject of systematic monitoring, in order to protect and maintain the integrity of biological systems; the establishment and co-ordination of these systems should receive preferential financing.

8. The amounts allocated to the conservation and management of protected areas should be incorporated into national accounting systems and counted as investments for maintaining and conserving the natural resources that are strategic to national development.

9. There is a need for international trade relations to offer greater opportunities to products originating in zones of high biological diversity, as opposed to what presently occurs, where only a small fraction of the possible products is negotiated at a low price.

10. The strengthening of maintenance infrastructure and mechanisms for the systematic collection of plants and animals, especially by museums and botanical gardens, in the biomasses with high biodiversity, is a basic element in the global strategy for the protection of these biomasses.

11. Easier access should be provided to herbaria and reference collections located in countries with a greater tradition and infrastructure for protecting this information, especially museums and botanical gardens, which traditionally store data from expeditions to biomasses that are rich in biological diversity; this could be achieved through financial support to researchers from the developing countries from which the samples are collected.

12. Access to advanced training in biotechnology and the study of fine chemicals and free access to data banks of genetic sequences decoded on the basis of systematic inventories in zones of high biodiversity, for research aimed at the ecologically sustainable maintenance and improvement of genetic resources.

13. The feasibility of sustainable development in areas of high biodiversity necessarily depends on the joint development, by technologically advanced and less developed countries, of technologies capable of generating products of high added value, especially

non-wood products, whose production supports the maintenance of biological diversity, increases the income of the local populations and valuates their cultural patterns.

14. In view of the challenge of biodiversity, there exists the possibility of co-operation between two kinds of knowledge: tradition (cultural) knowledge and technological know-how, which are interdependent and should be regarded as of equal importance both for the development of new technologies and for the maintenance and valuation of biodiversity.

15. Collection of local knowledge using ethnobiological methods should be carried out in such a way that it provides an economic and social benefit to the populations which possess such knowledge.

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GLOSSARY

Term	Source	Description
Recombinant DNA	3	Hybrid DNA resulting from *in vitro* fusion of portions of DNA from different organisms.
Gene banks	1	*Ex situ* facility for conservation of animal and plant samples (seeds), tissues or reproductive cells.
Biocatalyst	3	Enzyme which plays a fundamental role in living organisms by accelerating their metabolic processes.
Bioconversion	3	Chemical conversion by means of a biocatalyst.
Biogeography	1	Scientific study of the geographical distribution of organisms.
Biome	1	The major part of the living environment of a given region, which is characterized by its vegetation and maintained by local climate conditions.
Biota	1	All the living organisms, including animals, plants, fungi and micro-organisms, of a given area.
Centre of diversity	1	Geographical region with high levels of genetic or specific diversity.
Centre of endemism	1	Geographical region with numerous locally endemic species.
Ex situ conservation	1	Conservation method which involves the transfer of germ plasm resources (seeds, pollen, sperm, samples) from their original habitat or natural environment.

In situ conservation	1	Conservation method whose purpose is to protect the genetic integrity of genetic resources by conservation within the evolutionary dynamics of their natural environment.
Specific diversity	1	Function of distribution and abundance of a species.
Genetic diversity	1	Variation in the genetic make-up of individuals within the same species. Variation of genetic inheritance within and among populations.
Endemic	1	Restricted to a given area or region.
Genotype	1	Set of genes belonging to an organism.
Habitat	2	Place or type of environment where a plant or animal lives naturally.
Metabolite	3	Product resulting from metabolism.
Metabolism	3	Physical and chemical processes by which the components of food are used to synthesize complex elements; the complex substances are changed into simple substances and energy is provided for the use of the organism.
Rehabilitation	1	Recovery of the services of an ecosystem in a degraded habitat or ecosystem.

Source: 1. W.V. Reid and K.R. Miller, *Keeping Options Alive: The Scientific Basis for Conserving Biodiversity*, World Resources Institute, October 1989, p. 128.

2. McNeely and others, "Conserving the World's Biological Diversity", Gland, Switzerland, International Union for

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3. United States Congress, Office of Technology Assessment (OTA), *Commercial Biotechnology: An International Analysis*, Washington, D.C., January 1984, p. 612.