THE CONVENTION ON BIOLOGICAL DIVERSITY: A POLITICAL ECONOMY PERSPECTIVE

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RESUMEN

Este ensayo intenta evaluar algunas de las implicancias económicas de la Convención sobre Diversidad Biológica. Después de esbozar los principios más importantes y el enfoque de la Convención, se delinean los siguientes aspectos: la determinación del nivel "óptimo" de pérdida de biodiversidad, las consecuencias de la indeterminación del valor monetario de la biodiversidad y sus problemas con respecto del mecanismo de financiamiento, y se concluye con una discusión sobre el acceso a los recursos genéticos y a la biotecnología.

ABSTRACT

This paper attempts to assess some of the economic implications of the Convention of Biological Diversity. After outlining the main principles and the scope of the Convention, the following aspects are being addressed: the determination of the "optimal" level of biodiversity loss, the issue of the indeterminate monetary value of biodiversity and the problems it poses for the funding mechanism, and concludes with a discussion of the issues of access to genetic resources and to biotechnology.

1. The Protection of Biodiversity as International Issue

Biodiversity has become the new rallying cry for those members of the international community who are involved in ecological sustainable economic development and ecosystem conservation. The necessity for a comprehensive global system of managing the biodiversity resources are derived from two essential factors, namely, the multiplicity of biological resources provides fundamentally important life-supporting services to the welfare of the whole global community, and, furthermore, the owners-guardians of these vital resources remain generally uncompensated for the benefits provided. The combination of these factors essentially comprises the core of the problem of biodiversity protection.

In principle, the participants of the Earth Summit in Rio acknowledged the losses in biodiversity and passed the "Convention on Biological Diversity" (CBD) in December 1993 which has now already been signed by the majority of the world community (Grubb *et al.*, 1993, p. 75)[1]. The CBD provides basically a wider framework for the protection of all aspects of biodiversity, as well as the sustainable use of all components of biodiversity, and recognizes the interdependence between the industrialized countries (IC) and the developing countries (DC) in their obligation to maintain the biodiversity and to provide additional funds for this purpose.

This paper attempts to assess some of the economic implications of the CBD by discussing the following aspects: the main principles and the scope of the Convention, the determination of the "optimal" level of biodiversity loss, the issue of the indeterminate monetary value of biodiversity and the problem it poses for the funding mechanism, and finally the potential conflict between holders of biodiversity and the biotechnology industries.

2. The Main Principles of the Convention

The Convention's Preamble acknowledges the rapid loss of biodiversity and intends to arrest this development for anthropocentric and ecocentric reasons, whereby the economic reasons precede[2]. The explicit recognition that biodiversity has an "intrinsic value" implies that biological diversity has to be conserved for its own sake and, therefore, creates an additional problem for the decision makers, namely how much more of biodiversity has to be saved in excess to the "amount" of biodiversity necessary strictly for anthropocentric reasons. Furthermore, the Preamble asserts that biodiversity should also be protected for the continuation of evolution, for maintaining the life-supporting systems of the biosphere, and for humankind because of its various values, such as ecological, genetic, social, economic, scientific, educational, cultural, recreational, and aesthetic values for present and future generations. For all these reasons, which bestow biodiversity the features of a true global good, the Preamble stresses that the conservation of biodiversity has to be a common concern for the international community. Although, the individual countries maintain the sovereign rights over their biological resources, the CBD, nevertheless, explicitly reaffirms the DC' responsibility of sustainability for their uses which could be interpreted as a restriction of the nations' sovereignties in exploiting these biological resources (Preamble of CBD, Articles 1 and 3).

The objective of equitable and fair sharing of the benefits generated by the commercialization of genetic resources complements the other two objectives of conservation of biodiversity and sustainable use of its components. The ecological resources, especially the resources from the tropical rain forests, in DC offer a wide range of genetic materials which become scientific and economic inputs for numerous innovations and products in the pharmaceutical and seed-producing industries. Granted that these industries, generally located in IC, have invested substantial financial resources in research and development, but until recently they have exploited and utilized these genetic resources without taking into account the various forms of ecological and economic externalities. Consequently, the DC demand from the IC an equitable and fair share of the benefits from these economic activities. The outcome of the CBD reflects these sentiments by stating that access to genetic resources shall be subject "to prior consent" and on "mutual agreed terms" between IC and DC (Article 15). This suggests, that the negotiated contracts which in general will stipulate all access and financial conditions, will quite likely also include access licenses and/or permits (e.g., user fees).

In general, the individual national governments legislate the access to their resources -a right which they always possessed, but not always exercised- is, therefore, reaffirmed by the CBD (Article 15, section 1).

Furthermore, the CBD states that the results of research and development, including the benefits originating from the commercialization of genetic resources, as well as the results and benefits deriving from biotechnologies based upon the genetic resources provided by the DC, have to be shared fair and equitable and on mutually agreed terms (Article 15.7 and 19.2). This, however, implies that any aspect of the contracts, including the financial ones, cannot be determined unilateral by the DC supplying the genetic resources, but rather has to be the outcome of a mutually negotiated settlement for each individual project.

In addition, the CBD obliges all Contracting Parties not only to provide access to and transfer of biotechnologies which utilize genetic materials and do not significantly damage the environment, but also biotechnologies which are vital for conservation purposes and, thus, assist DC to fulfill their obligation under CBD (Article 19). Indeed, most IC have conceded this preferential access to their biotechnologies for the participating DC. Some provisions of these articles, however, have important implications of which the negotiators of

the CBD were not necessarily fully aware when they agreed that both distinctly different types of technologies, namely technologies for conservation of biodiversity and technologies for commercial uses of genetic resources, should be made available to all Contracting Parties. The availability and access of the first category of technology not only support the contracting nations to comply with the CBD's obligations, but also can be viewed as instrumental to maintain control over their genetic resources and, thereby, to enforce their national property rights. The other implication of the availability and access to biotechnology for commercial uses to all participating nations seems to suggest that the CBD considers these genetic materials as if they were actually the common heritage (or common international property), a fact the negotiating parties had refused to acknowledge.

Not surprisingly, the IC agreed to these obligations, because they are all subject to a significant proviso, namely all these obligations do not infringe on intellectual property rights, and technology transfers to DC and to their respective companies must also be compensated for their research efforts.

From the onset of the negotiations of the CBD it was obvious that the DC will not be able to afford the internationally expected conservation efforts on their own, and that, therefore, the IC will be obliged to finance the DC´s conservation programs. As in some other international agreements, the IC consented to bear the "full incremental costs" to meet the DC´s conservation objectives[3]. Moreover, these financial transfers have to be "new and additional" to any other already existing international assistance programs (Articles 20 and 21). This implies that the CBD establishes a legal commitment between the obligations of the DC to conserve the biological resources and the obligations of the IC to provide these new and additional funds for the DC´s biodiversity conservation measures.

During the negotiation sessions of the CBD there emerged opposing viewpoints between the IC and the DC about the institutional structure that would be selected to administer the "financial mechanism". The DC did not succeed in establishing a specific independent institution for biodiversity conservation nor could they reach a decision in their favour concerning the funds' distribution and allocation procedures. Instead, the IC advanced their position, since they control the funds, and requested that these funds should be integrated into the already operating Global Environmental Facilities (GEF), an institution which implements other projects as well that contribute to the improvement of global environmental quality. Thus, at present and until the Conference of Contracting Parties determines otherwise, the GEF will assume the functions of the required institutional structure on an interim basis (Articles 21 and 39).

As an preliminary assessment of the CBD, the Convention represents an remarkable achievement for the international community to arrive at consensus on the necessity for a global protection of biodiversity, on the need for additional financial assistance, and on an agreement -at least in principle- to provide access to and transfer of biotechnology and to exchange genetic resources. Thus, the CBD has the potential to become the essential precondition for biodiversity protection, but, as always, the problems lie in the details[4].

3. The Economics of Funding for the Protection of BD

3.1 The Funding Mechanism

The term biodiversity entered the public discussion as species extinction rates accelerated dramatically. Thus, the destruction of tropical rain forests (TRF) became an area of environmental degradation that has captured international media attention and can be viewed as metaphor for the decline of biodiversity. In the IC there is the perceived attitude to consider the biodiversity in the tropics as global environmental resources, and the host countries as both the beneficiary and the custodian of these ecosystems for the international

community. The implications of this belief are that the host countries are burdened with the responsibilities, besides their self-interests, to preserve the biodiversity under their jurisdiction almost regardless of the opportunity costs. The conservation of biological diversity in the DC is actually a matter of protecting entire habitats and large ecosystem regions rather than individual species of flora and fauna. The protection of large interrelated ecosystems with their biodiversity by DC, however, generates beneficial global externalities (Swanson, 1992, p. 250). Now, even if DC themselves and IC jointly would gain from the conservation programs in DC, complex problems of income (re-)distribution, equity, and efficiency may arise. Where global (beneficial or negative) ecological externalities are unidirectional, the country which is producing these externalities tends, without an international agreement, to ignore these benefits/damages "inflicted" on the international community. The destruction of the TRF serves here as example and is equated with the loss of biodiversity. If the "rights" to generate these externalities belong to one country and/or a group of countries, than the international community will have to provide incentives to DC to reduce and/or abstain from their ecologically damaging economic activities. In this respect the formal role of the CBD is to correct and to adjust the process of deforestation by taken into account also the global externalities, which individual countries tend to overlook. Thus, the vital problem of correcting global ecological damages is to achieve an international level of ecological-economic optimality through international cooperation, and yet there are sufficient incentives for individual countries to compromise an optimal outcome.

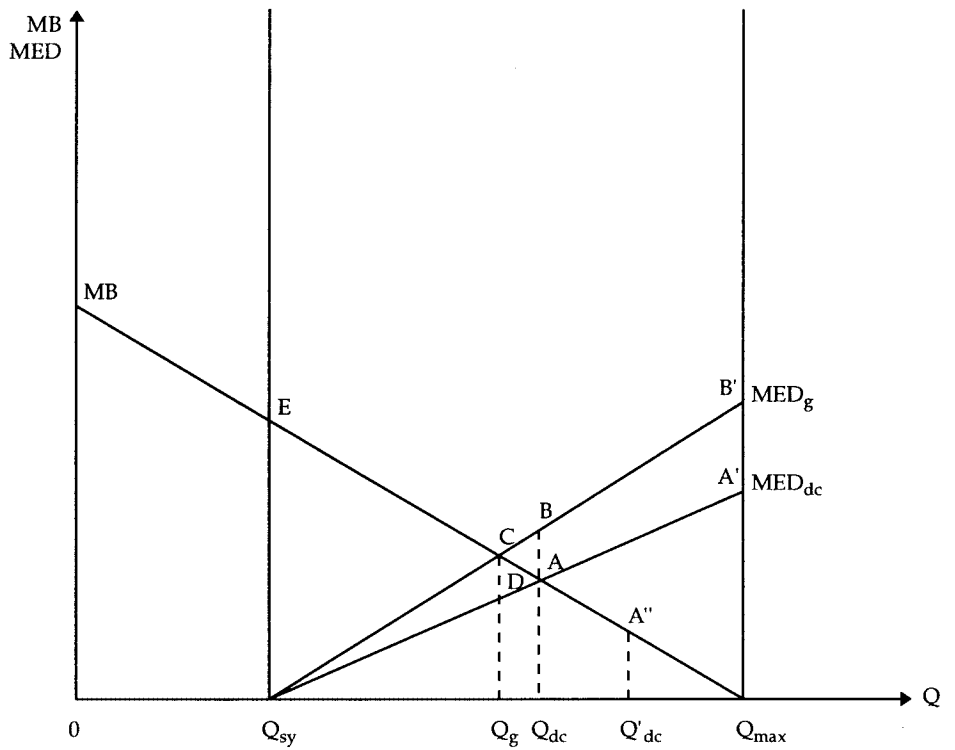
From the onset of the negotiation of the CBD it became apparent, that financial resources from the IC to the DC will be needed. Several innovative methods for achieving the various objectives of the Convention have been deliberated during the initial negotiation phase of the CBD, including an environmental fund financed on user fees levied on the use of genetic materials by the IC. In the end, the IC succeeded in pooling their financial means into the GEF, mainly because the smaller number and their already closed established socio-economic links and mutual interests provided the basis for a more cohesive interest group. Hence, the IC seem to control the institutional structure which administers the financial funds and, thus, enforces, the CBD's objectives (Stähler, 1994, p. 230).

According to Article 20, the IC are obliged to provide "new and additional" funds and to meet the "agreed full incremental costs" resulting from measures required to fulfill the convention's obligations. The "exact" amount of financial funds to cover the incurred "incremental costs", however, is -according to the CBD- an outcome of bilateral negotiation between the DC and GEF (or its successor institution). Article 20, section 4 reflects the antagonistic positions between IC and DC by stating that the implementation of the DC's obligations depends upon the fulfillment of IC's obligations, namely, the DC have only to execute their obligations of biodiversity conservation and sustainable use under the CBD to the extent that IC fulfill their commitments with respect to the provision of financial funds and the transfer of technology. Furthermore, the CBD provides only conditional protection of biodiversity by explicitly recognizing that "...economic and social development and eradication of poverty are the first and overriding priorities of the developing countries Parties". Thus, the Convention leaves ample room for conflict and negotiation.

A full cooperative outcome and a non-cooperative outcome of the conservation problem are depicted in Figure 1. For the sake of simplicity, it is assumed that DC are supplying biodiversity in the form of protected areas of TRF and IC are interested in its provision and protection. In addition, both parties possess full information about the domestic and global costs of deforestation and the foregone benefits of economic development. Figure 1 helps to identify the factors which determine the extent of the "incremental costs" and, thus,

Figure 1

OPTIMAL LEVEL OF DEFORESTATION, INCREMENTAL COSTS, AND COMPENSATION PAYMENTS



the magnitude of the required compensation payments. The marginal benefits of economic development (MB) and the marginal damage costs of deforestation (MED) are depicted on the vertical axis, while the quantify of destroyed TRF (Q) (e.g., measured in square kilometers per year) is illustrated on the horizontal axis (Müller, 1996, p. 200).

At least two cost categories are relevant for DC:

(i) These are the opportunity costs of foregone economic development if deforestation is prevented. This type of opportunity costs (or foregone economic benefits) may include, for instance, the foregone revenues of industries that could have operated in the TFR, such as cattle ranching, energy production, mineral exploration, and plantation agriculture[5]. It is plausible to assume that the MB decrease with increasing amount of deforestation, because e.g., soil productivity may decline with advanced deforestation and/or transportation costs may increase.

(ii) The marginal costs of environmental damages (MED) occur when human activi-

ties encroach on natural ecosystems and convert habitats of TRF to economic development purposes, e.g., in form of negative impact on climate, reduced soil productivity, industrial pollution, and/or loss of biodiversity[6].

MED_{DC} are the marginal costs for DC and MED_{IC} are the respective costs for the IC[7]. For example, the MED are zero at point Q_{SY}, where the rate of deforestation, OQ_{SY}, is identical with a sustainable yield level.

In a static context, Figure 1 shows the MB- and MED-curves and illustrates different levels of deforestation:

(i) At point Q_{max}, where MB=O, the DC maximizes its short-run unconstrained economic benefits, since the country is indifferent to the environmental damages which the process of deforestation generates.

(ii) The intersection of MB- and MED-curves of the DC in point A determines the optimal national level of deforestation, namely Q_{DC}. This national optimum, defined in the Pareto sense, depicts a lower rate of deforestation ($Q_{DC} < Q_{max}$).

(iii) The process of deforestation of TRF in DC generates international environmental externalities and these inflicted costs are depicted as MED_{IC} in Figure 1. The intersection of the MED-curve with the MB-curve in point C represents the optimal global level of deforestation per period, Q_g. The MED_g-curve which is the vertical summation of national and international MED-curves, lies above the MED_{DC}-curve because it is plausible to assume that global environmental damages of BD-loss are in absolute terms higher than these damages inflicted only to DC[8].

Now, if DC have to be persuaded to limit their deforestation activities to the global optimal level, Q_g, then it becomes necessary that the IC have to compensate the DC for their incurred "incremental" costs. The CBD, however, does not provide any definition and clarification of this term. Some economists define "...there 'extra' (or incremental) cost, (as) ...the difference between the costs of with (or alternative case) and the without (or baseline case)" (King *et al.*, 1995, p. 2). Or, e.g., DC incur incremental costs by protecting a higher level of biodiversity than it is their own national interests e.g., in Figure 1 point C instead of point A, and, therefore, this "added financial burden" should be allocated to the international community as a whole, so that the DC, implementing international relevant conservation programs, will be left no worse off economically[9].

The term of incremental costs remains conceptionally and empirically unsatisfactory, unless, according to the above definition, it only refers to the foregone economic benefits beyond the national optimal level of environmental protection (point A). Thus, the costs incurred by internalizing domestic environmental damages, e.g., a move from Q_{max} to Q_{DC}', which implies foregone economic benefits of the triangle $Q_{max}Q_{DC}'A''$, would not be considered as incremental costs! What are they? Since the term incremental costs apparently does not contain more explanatory value than the conventional term of foregone economic benefits, it will not be further used in this article.

If the DC have reduced their deforestation activities to the international optimal level, then it seems to be equitable that the IC have to make compensation payments at least of the amount equal to the area of ACD. Efficiency and equity considerations require that the beneficiaries, i.e., the IC, pay the occurring costs of maintaining the ecological capital with all its environmental services and functions, option and existence values that the IC derive from the protected TRF. The "beneficiary-pays-principle" (BPP) -a version of the victim-pays-principle- provides the ethical justification and/or obligation that demand the beneficiaries of environmental services to compensate

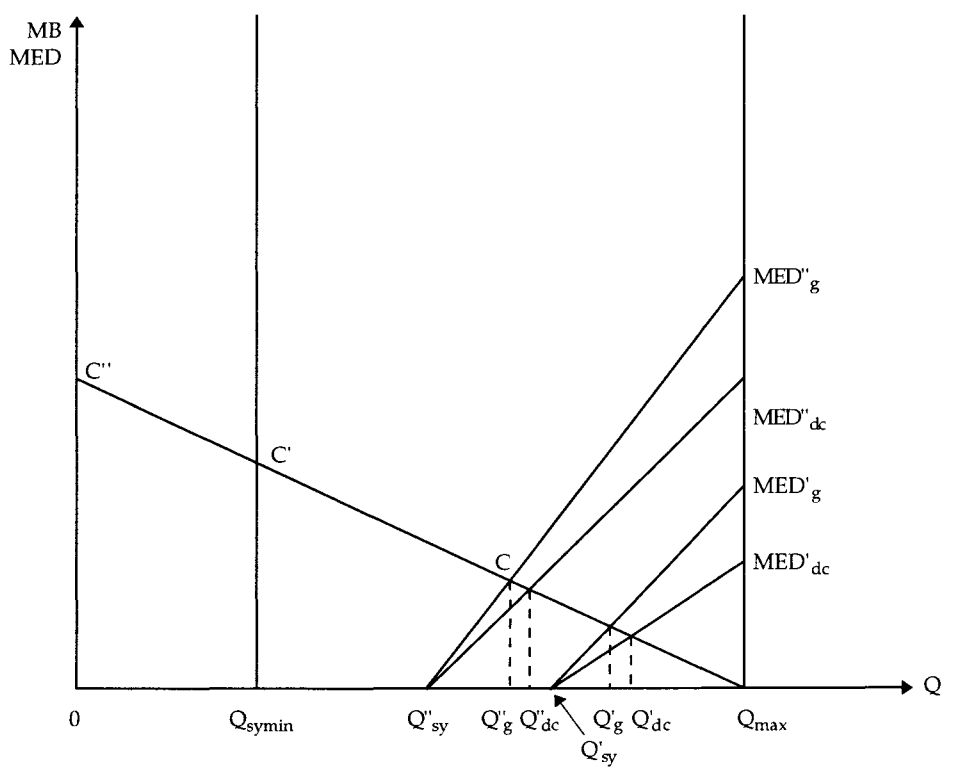
the DC for the occurring costs of protecting the TRF with its various services and functions and attributes that do not generate direct market benefits and/or revenues.

In point C at the international optimal level of deforestation, the total environmental damage costs for the IC are depicted by the triangle CDQ_{sy}, i.e., their costs are reduced by the area of ABCD. At this position, the DC incur a reduction of environmental costs equal to the area of ADQ_gQ_{DC}, and respectively their foregone economic development benefits are diminished by and amount $AQ_{DC}Q_gC$, or in comparison to point A, a net loss of economic benefits equal to the triangle ACD. Thus, this area represents the minimum amount of compensation payments that must be paid to make the DC as well off as at point A (or, in terms of the CBD, this amount could be considered as the "additional incremental costs"). The IC, in contrast, have improved their welfare by an amount which is described by the triangle ABC.

Figure 1 illustrates the national and international environmental damages associated with a given rate of deforestation in a static context. For the sake of clarity, the same curves are redrawn in Figure 2. If now the DC cut the TRF at a rate faster than the rate of regrowth (or sustainable yield), e.g., where

Figure 2

ENVIRONMENTAL DAMAGES ASSOCIATED WITH DIFFERENT LEVELS OF DEFORESTATION



Q'_g,is greater than Q'_{SY}, then environmental damages start to rise sooner. Only in point Q'_{SY} the MED_{DC} and the MED_{IC} are zero, i.e., the rate of deforestation is equal to regrowth, and, therefore, the stock of TRF, and, thus, the biodiversity which this stock incorporates, remains constant[10]. Even at point such as Q'_g the stock of TRF continues to shrink further, and, consequently, these curves move toward the origin and they rise next period already at a lower rate of deforestation than before, e.g., at Q''_{SY}, etc. The slope of these curves will also become steeper with each shift to the left, since the smaller remaining stock of TRF (and less stock of biodiversity), is associated with increasing amounts of environmental damages. Thus, if the rate of deforestation is not adjusted to a sustainable yield level, this dynamic process will continue. Only if the rate of deforestation is reduced to Q'_{SY} (for the initial scenario of MED-curves), or the Q''_{SY} (after the first adjustment), then this sustainable rate of deforestation will halt the process of further reduction of ecological capital and the loss of additional biodiversity.

In the above described process it is vital to realize that even what is defined in economic terms as an international optimal rate of deforestation, that this rate cannot prevent further decline of TRF-areas and loss of biodiversity.

The problem is that the maximum level of deforestation which is ecological sustainable or TRF-ecosystem-safe, e.g., a point such as Q'_{sy}, is not identical with the deforestation rate identified by the Pareto-efficiency criterion. Consequently, a level such as Q'_{sy} has to be regarded as ecological constraints to economic activities, if ecological sustainable economic development is the society's overall desired objective. It is possible, however, that Q'_g and Q'_{sy} could coincide, namely at Q_{symin}, where the area of TRF would be reduced to a critical minimum level and the ecosystem health would show dramatic signs of disintegration and an alarming accelerated rate of biodiversity losses, i.e., the environmental damage costs would become in graphically terms vertical and/or infinite. Obviously, a scenario which has to be avoided.

The consequence of this constellation for the compensation payments under the CBD is that ultimately the international community should pay on the basis of the BPP for the protection of -at least- a minimum stock of ecological capital, or, in this case, for a minimum area of TRF. According to Figure 2, this amount is determined by the area $OQ_{symin}C'C''$, where OQ_{symin} depicts the lowest deforestation rate that is just sustainable and prevents ecosystem collapse. The CBD is indeterminate concerning the minimum stock of ecological capital and the required amount of compensation payment.

Back to Figure 1, point C can be viewed as the "point of exploitation" of a bilateral monopoly and it is difficult to predict what will be the negotiated settlement. Both, the IC represented by GEF and the DC are in a bargaining position, and no simple rule determines which, if either, will get the better part of the bargain, i.e., not only the triangle ACD, but the whole area of ABCD could become the subject of the bargaining process. Even if the articles 20 and 21 may imply that the funds of the CBD should only be used for clearly specified conservation projects, and not for conservation in general, these articles actually limit the amount of compensation payments of the IC to the DC. Furthermore, there are problems associated with these project supports.

The IC favouring GEF as the interim financial mechanism, assuming that GEF could help also to overcome the potential moral hazard problems. Intentional environmentally damaging behavior could become an issue in multilateral negotiation processes, since the amount of compensation payments is based upon foregone economic benefits, the quality of environmental protection measures, and/or environmental damages. Therefore, there are sufficient incentives to withhold information and/or to supply "manipulated" data. GEF with its already existing scientific and technical expertise could play an important in this process, namely it can reduce, but not eliminate, the

"subjective" elements in the negotiation process of project funding. The national sovereignty of countries, however, limits the possibilities of GEF's control and monitoring activities. Thus, it can be rational and in the short-run interest of DC to exploit a potentially available discretionary range and to deviate from a negotiated and mutually agreed upon program of biodiversity protection (Stähler, 1994, p. 230).

Some DC, therefore, may provide only areas with low biodiversity and/or low quality protection of biodiversity -i.e., they offer so-called "lemons"- in cases where complex control problems exist, because GEF is unable to distinguish and verify the quality of the DC's protection efforts, and thus, pays financial support for assumed high-quality environmental protection. These discretionary ranges in the quality of biodiversity protection can be regarded as a function of the difference of the existing information asymmetry between the DC and GEF and, furthermore, of the credibility of sanctions and of punitive actions by GEF if a violation is confirmed. In this case, the funding agency possesses only the threat of changing the contract partner, i.e., the respective DC. These sanctions, however, are relatively ineffective and self-defeating, since it is in the interest of the IC to protect larger biodiversity rich areas. For example, if the ecological indicators for a given region are very detailed and unique, then even GEF's threats for contract breaches are less than credible, because due to ecosystem uniqueness of a specific region, biodiversity protection has to be provided[11]. In other cases, where no regional uniqueness exists, i.e., substitution possibilities among various regions are available, GEF can reduce, but not completely eliminate the discretionary elements.

Finally, it remains doubtful whether GEF as funding mechanism for the CBD will ultimately be successful in preserving large ecosystems, including their biodiversity. Environmental projects alone are not sufficient for large-scale preservation, since such atomistic funding support policy cannot protect relevant and vital large stocks of ecological assets. The threat of substantial biodiversity losses and of the irreversibility of these losses demands that the international community has to develop substantially more comprehensive, consistent and extensive funding mechanisms which have to overcome the present limitations of GEF.

3.2 The Evasiveness of Economic Valuation

Any mainstream economic approach which attempts to assign economic values to biodiversity, is derived from an ethical framework that is based on utilitarian, anthropocentric and instrumentalist principles. The approach is utilitarian in that goods in general, and biodiversity in specific, only matter to the extent that consumers want them; it is anthropocentric in that only human are assigning values, and finally, it is instrumentalist in that ecological goods and services are utilized as instruments to enhance human satisfaction (Randall, 1988, p. 218). This approach emphasizes consumer sovereignty which allows private individuals to be their own judge of what is desirable for them. But what happens if these individual consumer preferences are unstable, capricious, or easily subject to manipulation, or (perhaps, more relevant in the case of biodiversity) what if the consumers even do not know their own preferences? In these circumstances should the valuation process based on the preferences of "experts", and if so which "experts" and who selects them? Thus, valuing biodiversity in economic terms is at best a challenging task.

The conventionally employed dichotomy decomposes the total economic value of an ecological resource into its use value and non-use value. The use value is subdivided further into the direct use value and indirect use value, including the option value, while the non-use value may include categories such as existence value and bequest value. (Pearce *et al.*, 1994, p. 19; Munasinghe, 1992, p. 229). Due to the various functions, structures, and interdependencies of ecosystems, this procedure is

rather simplistic and impracticable and it appears, therefore, to be more appropriate to view the large variety of values received from ecosystems rather to be a continuum ranging from effortless priced tangible benefits (e.g., food) through values associated with less effortless priced goods and services to values, such as aesthetic and nature experiences, existence and bequest values, and/or moral and spiritual values which may escape completely monetary valuation (Bingham *et al.*, 1995, p. 75). Thus, any economic approach which strives for the "exact" monetary value of biodiversity and/or ecosystems will eventually conflict with ethical and moral positions that question the rights of humans to become the judge of other species' survival.

In the center of neoclassical environmental economics are economic values of biodiversity and of ecosystems, but it is not obvious from a scientific point of view, why these economic values should have any different weight or have more importance than values derived from other social or natural sciences in the debate about an appropriate conservation policy with its supreme goal to prevent the destruction and/or extinction of ecosystems and its species. Theses conservationist ideas, supported by many environmental groups have influenced the debate for a convention on biodiversity, but it appears that ultimately conventional economic rationale, assessment and economic interests have predominantly shaped the text of the CBD.

For example, the obvious economic benefits of a vast availability of biodiversity for the biotechnology industry are specifically that a "sufficiently" vast stock of biodiversity reduces substantially the research and development costs for this industry, since the naturally available biodiversity provides an extremely productive *in situ* stock of genetic resources. In general, the preservation of biodiversity provides also an insurance value in the sense that biodiversity plays an important role in the amelioration of fundamental uncertainty and risks in ecological-economic system changes. In this context, the function of biodiversity rests on its properties to stabilize ecosystem resilience[12]. In conventional terms, insurance is understood as a means of pooling actuarial risk. The risk, however, referring to alterations and changes in the functioning of the interrelated ecological-economic systems may be estimated in a actuarial sense, but in most cases, these risks are too evasive and inestimable. Furthermore, in reality, neither the set of consequences of economic interventions on the functioning of a joint ecological-economic system nor the probabilities of the occurrence of each consequence are known (Perrings, 1995, p. 72). Consequently, the problem is not one of risk, but of uncertainty. Hence, the protection and provision of biodiversity serve as insurance against many ecological risks and uncertainties, but it is impossible to calculate the actuarial monetary values[13].

The fundamental problem for decision makers is, therefore, that the market prices which most frequently are used as the main scarcity indicators of a joint ecological-economic system are actually very imperfect indicators of the opportunity costs of committing particular components of biodiversity and ecosystem to economic uses. It is (almost) impossible to determine the accurate economic value of any component of an ecosystem, let alone the aggregate value of an ecosystem, including its biodiversity. At present our knowledge is insufficient almost about any gene, species, and/or ecosystem's function to estimate its economic value. Even in the relatively "closed" subsystem, such as the market system as it is viewed by mainstream economics, economists, have a poor record of accurately describing what is happening and, an even worse record on short term forecasting based on readily available data, such as employment, investment, money supply etc. It is difficult to comprehend how economists could, dealing with huge, interconnected open ecological-economic systems, determine the present net or future value of any part of mega-ecosystems and including its biodiversity! In addition to the available monetary values which economists are able to determine for a relatively

small number of species, they employ the option value concept to calculate the economic value for species of presently unknown worth. With this concept, economists attempt to determine the economic value which society should place on the possibility that future discovery and enhanced knowledge will make economic useful that species that at present is considered without economic use. Thus, if the extinction and/or destruction of some species and functions of biodiversity take places now, such potentially useful discoveries are precluded.

One additional, yet important facet of the option value is that it could compass equally all values, i.e., use value, existence value, amenity and/or morality values. As time passes, society may gain more knowledge in all these aspects, and this advanced knowledge may lead to new use values for species, or to a new level of aesthetic appreciation, and/or society's existence and morality values may alter and some species may enjoy in the future a morality value or increased morality value that society is not now aware of. Thus, if assigning monetary values to these option values is a challenging task, the conceptual situation is in reality much more controversial. Actual estimation of option values in monetary terms can take place only **after** species, genes and/or function of ecosystems have been identified. Thus, some "today" guesses have to be developed about the uses that these species might have, followed by assigning some monetary values on those potential uses, and, furthermore, guesses are required about the probabilities of such discoveries occurring in the future (Norton, 1988, p. 202). This is a daunting task.

With respect to the use values and option values of biodiversity, a plausible difference has been made above between the option value of species and the option value of biodiversity in its aggregate in relation to the ecosystems' functions and services. It seems obvious, that biodiversity possesses an option value of its own at the ecosystem level, because it provides the foundation and options for future economic development -i.e., for human survival- from the functions and services of productive and integer regional and global ecosystems. Consequently, the option value of biodiversity in relation to the ecosystem is potentially huge, actually indeterminate -unless it is a nebulous meaningless monetary expression of a human survival value (Smith, 1996, p. 193).

More fundamentally, even if conventionally market failures are assumed to be fully correctable and market valuations are attainable in the "short run", questions have emerged about whether markets are able to generate economically efficient intergenerational time paths, and thus, can provide corfect market valuations, even in theory, due to the fact of "missing markets". Bromley stated, "...the existence of a market still requires the willful coming together of two consenting agents to exchange for mutual gain" (Bromley, 1991, p. 87). Only in the case of overlapping generations, this "willful coming together" is feasible. Thus, for all other situations markets are literally missing. Some economists have assumed that such a "direct" contact between generations are not necessary to achieve efficiency because intervening markets will fulfill the same function (Solow, 1974, p. 1). Bromley argues, however, that the intervening markets will only perform very incomplete this function, and, therefore, the theoretical argument of missing markets makes it questionable that market systems are able to achieve intergenerational efficiency and, consequently, market valuations provide doubtful bases for valuing biodiversity and ecosystems. Thus, in addition to the deficiency of economic theory, the complexity and interdependencies of ecosystems on which all economic activities depend upon prevent us from knowing with any degree of precision and certainty how long economic development can continue without causing regional and/or global ecosystem collapse.

As an interim result, it seems fair to state that with the ratification of the CBD **no** change of paradigm in national and/or international conservation policies of biodiversity

took place. The CBD failed to stress the ecological or biophysical constraints in the concept of sustainable development, instead the monetary assessments and benefits of biodiversity -despite their evasiveness and indeterminateness- are re-emphasized. Thus, it becomes clear as in the case of biodiversity in general, or as in the case of the Amazon in specific, that a fundamental and drastic revaluation and re-thinking of development and of the political order that supports this process, are required. The question, therefore, has to be asked: is the objective of the CBD to secure biodiversity and ecosystem integrity, or rather to maintain the political order and the economic system that benefit in the short run from the ecological de-accumulation process? Obviously, conservationists fear the later, but want to believe the former.

4 Preferential Access to Genetic Resources and Biotechnology

Until the negotiation for the CBD began, genetic resources have been economically exploited without any payment to the countries or to the indigenous people that originally provided them. The "common heritage" regime and the principle of open access to genetic resources were generally accepted and even recognized by the U.N.-system, e.g., in the FAO-agreement "Undertaking on Plant Genetic Resources of 1983"[14]. For example, European explorers discovered plants such as potatoes and rubber in South America, but never paid compensations to these indigenous peoples from whose ancestral territories these plants originated. Since these plants were considered as a gift of nature, nobody could claim to have created or invented them, and, therefore, nobody possesses rights to demand payment for them.

If preservation of ecosystems were costless, all genetic resources would be maintained. Since the pressures on ecosystems, however, increase due to alternative land uses, the opportunity costs of biodiversity protection and preservation grow as well. In general, two approaches, namely the *in situ* and *ex situ* approach, are available for the protection of genetic resources. The *in situ* approach refers to the method that protects the genetic diversity in its ecological habitat, whereas the *ex situ* approach is a method that removes the genetic resources from its ecosystem and keeps these resources in a managed and artificial environment such as zoos, botanical gardens, and/or germplasm banks. The *ex situ* approach appears to be more cost-efficient, but it is only applicable to a small selected, already know fraction of species, and, thus cannot be used to species whose existence still unknown. Furthermore, the *ex situ* approach is no substitute for the *in situ* method, since the *ex situ* method preserves only selected species and not complete ecosystems in its entirely and, thus, cannot prevent the irreversible loss of genetic resources that are depending upon the symbiotic relationships within their natural habitats and ecosystems (Reid *et al.*, 1993, p. 7).

The attitude concerning the control of genetic resources is now challenged. Population pressure and poverty in many DC are now threatening those valuable ecosystems, and thus, if these societies who possess the power to raze complete ecosystems rich in genetic resources are not compensated adequately for these products and services that may be obtained from them, they will have little motivation and/or incentive to protect them.

In essence, the CBD establishes the principle that the countries possess the sovereign property rights in their genetic resources and that these resources cannot be exploited by other countries without prior informed consent of the country of origin. Thus, it is not surprising that the access-related issues became the most contested in the CBD-negotiation process. In particular, the DC made their participation in these negotiation conditional upon the inclusion of certain obligations of the IC related to three types of access: access to genetic resources, which the DC demanded to have recognized as subject of their sovereign property rights; access to relevant technology, in particu-

larly to biotechnology; and, finally, access to a fair share in the benefits ultimately generated by the commercial use of the genetic materials provided by the DC. Article 15, section (1) of the CBD has reasserted "...the sovereign rights of states over their natural resources, (and) the authority to determine access to genetic resources rests with the national governments and is subject to national legislation". The access is conditional to prior informed consent by the Party providing the genetic resources, and must be on mutually agreed terms (Article 15, sections 4 and 5). Research activities should be carried out "...with the full participation of, and where possible in (i.e., in the territory), such Contracting Parties" supplying the genetic resources (Article 15, section 6).

In addition, Article 15, section 7 requests the Contracting Parties to take various appropriate policy measures "...with the aim of sharing in a fair and equitable way the results of research and development and the benefits arising form the commercial and other utilization of genetic resources... ". In effect, the CBD has strengthened -at least in an international agreement- the position of biological diversity rich DC with respect to financial pay-offs of genetic research, and, indeed the DC could prevent access to their genetic resources if a *quid pro quo* in terms of an equitable share of such proceeds is not settled in advance.

Article 16, sections 2 and 5 covers the access to and the transfer of technology, including biotechnology and stresses them as "essential elements for the attainment of the objectives of this convention... ", while at the same time recognizing the reservations of the IC in the areas of intellectual property rights. Article 16, section 2 asserts that the access to and transfer of technology to DC should "...be provided and/or facilitated under fair and most favourable terms, including on concession and preferential terms... ". There is, however, no general obligation to grant preferential terms unless it is mutually agreed, or where appropriate in accordance with the financial mechanism outlined in Articles 20 and 21. Thus, the principle of "mutual agreement" serves again as a major reservation and/or check for these obligations.

Article 19 focuses exclusively on biotechnology. It includes obligations to enact measures to provide for "...effective participation in biotechnological research activities", and " ...to promote and advance priority access on a fair and equitable basis, especially developing countries, to the results and benefits arising from biotechnologies bases upon genetic resources", provided by the DC (Article 19, section 3), but these "obligations" again are very vague and do not guarantee access for the DC to these benefits[15].

Since there is a huge market potential for genetic manipulated products the DC, wishing to commercialize their genetic resources, have either to develop economic and institutional links through which to transfer the genetic materials to foreign companies that possess the necessary know-how in research, genetic engineering, and marketing, or the DC have to obtain such biotechnology expertise themselves[16].

Within the framework of the CBD, one emphasis has been on the features of efficient contracts that could provide incentives for preservation. The preferential access to biotechnology implies that the DC will al least partially exempted to play license and/or patent fees for biotechnological processes and/or products. Since most inventions in the biotechnology industry are the outcomes of cost -and capital- intensive research efforts with genetic materials, the industry expects that patents and intellectual property rights should prevent imitative production by potential competitors which could create disincentives to develop new products. Since there exists no generally accepted explanation concerning the required conditions for and the determinants of inventive processes, conventional economics assumes that these activities will only take place under conditions of imperfect product markets. Thus, companies offering innovative commodities expect to receive rents sufficiently high to cover the sunk costs of their research and development activities. Increased compe-

tition on these markets, therefore, may undermine the profitable barriers -created by patent laws- which are protecting rents and providing incentives for future innovative activities of the biotechnology industry. Patent rights are, however, only incomplete instruments to prevent threats of license-free product imitations[17]. Since the economic literature does not provide definite results whether the protection through patent rights will cause over- or suboptimal protection of innovative activities, it is, therefore, inconclusive to assess how preferential access obligations under the CBD will affect the future development of the biotechnology industry worldwide (Stähler, 1994, p. 233).

The Contracting Parties of the CBD are confronted with the same issue when they have to assess the appropriate amount of compensation for the concession and preferential access to biotechnology. The IC's companies which are requesting compensations for the provision of biotechnological know-how are in control of asymmetrical information, i.e., they possess more accurate information about their biotechnological research and development activities and the potential commercial value of their pharmaceutical products than the DC. Consequently, they may provide only "manipulated" information with the aim to keep a larger share of the royalties to be paid, i.e., the IC want to earn additional rent (Stähler, 1994, p. 233)[18]. Even if the biodiversity rich DC would possess the technological know-how and human capital expertise to operate biotechnological production processes, the IC still could hamper the dynamic growth of their industry by imposing trade barriers, e.g., in form certain product standards, on those biotechnological products which the DC envisage to export.

Furthermore, simple contract arrangements for the access to genetic resources in DC are unlikely to be workable, because genetic resources cannot be purchased/sold in just one single transaction. It is quite likely that large quantities of genetic raw materials are required as prerequisite for biotechnological research to develop new products. During the initial research phase maybe limited quantities may be sufficient, but if test results give reason to believe that new pharmaceutical products can be developed, additional and larger quantities of the genetic resource may become necessary. Thus, it appears to be impractical to gather large quantities of various species of genetic materials before any biotechnological research is undertaken. Sedjo views the process of collecting genetic resources "...as a lottery containing a vast number of genetic 'tickets'... " each with a different potential economic payoff (Sedjo, 1992, p. 204). Some estimate that only one in 10,000 different genetic materials collected may eventually lead to a commercial product (Simpson *et al.*, 1992, p. 2). This implies, that researchers experimenting with genetic resources will need a continuous access to the natural habitats.

The necessity for a continuous access may cause another set of contractual problems between the buyers and sellers, and complicates the determination of the "appropriate" amount of compensation, since factors such as perceptions, expectations, and strategic behavior may influence the contractual arrangements as well. These factors could comprise risk aversion between the IC and DC, conflicting anticipation of future revenues, moral hazard issues, e.g., based on asymmetrical information between buyers and sellers to cheat on royalty payments, and concerns about future continuing availability of genetic resources. For example, contractual arrangements which provide a substantial up-front payment for the right to collect genetic resources over an extended time period may not be advisable, since once this payment is paid out, the supplier of genetic materials has no further incentive for habitat preservation[19]. Certainly, one option would be to include clauses in the arrangements to the effect, that the DC have the obligation to protect the habitat from which the buyers are collecting the genetic samples. In many cases, however, these promises may not be honoured, and since neither the buyers nor the agency of CBD possess any enforcement

mechanism, except the use of moral suasion and exclusion form the fund. It seems, therefore, that contractual arrangements that allow modest up-front payments with royalty provisions contingent on biotechnological discoveries provide the DC with continuing incentives to make biotechnological innovations more likely by preserving their ecosystems as permanent suppliers of genetic resources (Sedjo and Simpson, 1995, p. 84).

An additional aspect relates to the problem of economics of vertical integration. The biotechnological production process, including marketing of the new products, comprises several stages of commercialization of genetic resources. Contractual problems can be avoided if one side of the Contracting partners controls all or almost all these stages -i.e., vertical integration- from collecting genetic resources, extracting chemicals, testing and developing new drugs, to marketing and distributing.

A complete integration in the commercialization process of genetic resources by one Contracting Party is improbable to happen, because DC rich in biodiversity have economic self-interests in at least controlling some stages of this process. For example, the DC may get involved in collecting and classifying of genetic resources, extracting of chemical compounds from these materials, and even testing some of these derived chemicals. There are some obvious interests why DC may get involved in this commercialization process. One of them is the issue of comparative advantages, for example in collecting activities. It is very likely that the DC possesses better information and knowledge about the location and distribution of the genetic resources on their territories. Another reason why DC might want to control some part of the commercialization activities is to reduce the cost of monitoring the economic and research activities of the IC. The IC may not volunteer all the information of the biotechnological innovation and commercial success obtained from the genetic resources, and, thus, may attempt to conceal the "true" profits from the sales to avoid paying a fair share of these profits to the DC, as obliged under the CBD. The DC may find it, therefore, advantageous to set up their own research facilities with the purpose to augment their knowledge about the potential economic value of their genetic resources and to strengthen their bargaining position with respect to the IC.

At present there is emerging a variety of contractual arrangements for the commercialization of genetic resources which may include different conditions for risk distribution, for incentives of preservation of natural habitats, etc. During this trail-and error period IC and DC are experimenting with different contractual arrangements and divisions of the activities necessary for the commercialization of genetic resources. Even it is unlikely that only one form of efficient contract arrangement may ever evolve, however, it is paramount that these contractual arrangements are credible, fair, and enforceable, because the absence of these would provide disincentives to conserve and/or preserve irreplaceable and unique ecosystems.

5. Will Commercialization of Genetic Resources reduce Biodiversity Losses?

As mentioned above, the CBD did not lead to a paradigm shift in national or international policy of biodiversity protection, instead it rather re-emphasizes the anthropocentric values and uses of biodiversity. The extraction of economic benefits from genetic resources receives, therefore, high priority and in this respect the use of biotechnology is envisaged as the central instrument. Furthermore, the intended "privatization" should help to facilitate the trade with these genetic materials. Consequently, the CBD promotes international free trade in genetic resources and biotechnology, and stresses the relevance of property rights, in particular the intellectual property rights, for countries rich in biodiversity.

In the preceding section it has been alluded to the ways how property rights to the

use values of genetic materials may provide economic incentives for biodiversity protection. In the following it will be analyzed whether the evidence substantiate the opinion that the existence of an appropriate system of property rights will actually generate economic incentives to slow down the process of biodiversity decline.

Despite some cases of high revenues generated from commercial products developed by the biotechnological and pharmaceutical industries, it would be mistaken to use these gross earnings as the representative value for genetic resources in general. For example, the drugs, derived from the Madagascan periwinkle plant, generated approximately US$ 100 million annually in gross revenues alone for the pharmaceutical company Eli Lilly (Farnsworth, 1988, p. 94). This number is sometimes falsely quoted as the value of this particular genetic material. The gross revenues of a final product, however, cannot be used as an approximation of the potential market value for unprocessed genetic materials in the country of origin, because in most cases biotechnological industries are employing highly capital intensive production technologies and the production process takes several years to develop a marketable drug[20].

The empirical evidence of the commercial values of unprocessed genetic materials is quite scanty, and the available information suggests that the expected financial revenues from the sale of genetic resources are unlikely to become a financial panacea for the DC. In view of the high value added in the biotechnological industries, the (still) relative large availability of unprocessed genetic resources, and the quite low probability that any particular genetic resource will eventually become a commercial product, the DC will probably collect only relatively small payments for access to their genetic resource base despite the expected growth of the biotechnological industry worldwide. For example, for the agricultural sector in USA, Barton estimates that the royalties for unprocessed genetic resources sought by DC might amount only to less than US$ 100 million annually (Barton, 1991, p. 339). Or, even for the biotechnological industry in general, the potential revenues from the sale of genetic materials for DC are less than anticipated in view of this industry's worldwide generated sales of about US$ 200 billion per year[21]. Other studies suggest that only nominal compensations for collecting genetic materials were paid to the providing DC, and these payments range from US$ 50 to US$ 1,000 per sample received (Sedjo *et al.*, 1995, p. 86).

If these payments, however, are sufficient only to recoup the collection costs of genetic materials, then obviously no "resource rent" exists. Without realized, the commercial values of genetic resources are about zero, and, despite the existence of an property right system, there are only limited economic conditions. Thus, a necessary prerequisite for property rights, and hence commercialization, to provide economic incentives for the protection of biodiversity is that ownership of these -private or public- entitlements reflects economic values. If not, property rights alone do not provide incentives for the protection of biodiversity. Furthermore, the commercial value of a particular genetic resource may be further eroded, it this resource lacks uniqueness, because it can be located in many different regions or countries. If this is the case, then the relative redundancy explains why owners will not receive any scarcity rents. In addition, there is the issue of incomplete systems of property rights, or, if they exist, then there may be the problem of deficient enforcement. Under either prevailing situation, there exists actually an open access regime to the genetic resources, and, therefore potential resource rents would be reduced to zero and resource prices would cover still only collection costs. Thus, the economic incentives for protection of biodiversity would be quite minimal.

This situation could become more aggravated if "poaching" occurs and genetic resources become contraband to be sold on international black markets. It is quite possible to imagine a situation where adjacent countries sharing a mega-ecosystem -such as the Ama-

zon region- but one of these countries is either selling the genetic resources very reasonable and/or not protecting the specific information about these genetic resources, and, therefore, is preventing the adjacent countries from materializing economic gains from developing their genetic resource based industry[22].

As an interim conclusion, it can be summarized that biodiversity prospecting could generate revenues for the biodiversity rich DC, including for the local communities, but the amounts involved are quite likely marginal in comparison to the market value of the final commercial product. Furthermore, a substantial time span may elapse before significant revenues may be generated from these genetic resources, if any due to the high probability of failure that no drugs may be derived from these resources. Given the magnitude of revenues generated by the biotechnological industry worldwide, even a relatively small percentage of these revenues could mean still substantial revenues for DC. Thus, if DC are developing and improving their biotechnological capacities, biodiversity prospecting and the biotechnological industry have the potential to become an important sector of their economies. The revenues, however, generated through international trade will remain nevertheless woefully inadequate to finance the protection of biodiversity on a large scale internationally.

Besides the financial aspects of commercialization of genetic resources there is also the technological aspect of this process and its impact on biodiversity. It is a prevalent misconception to assume that biotechnological development will automatically support biodiversity conservation. The core of this problem is related to the fact that biotechnologies are essentially technologies for producing uniformity in genetic materials. The diversity of industrial strategies and the diversity of species and plants within the global life-support system are not identical, and market competition can hardly be viewed as a substitute for ecosystem's evolution in the creation of biodiversity. Industrial strategies and production, however, can bring forth diversification of commodities, but they cannot enhance nature's biodiversity. For example, the seed industry uses heterogeneous genetic material from many different natural habitats as inputs to develop "new" commercial seeds, but the commodity "seed" that is sold to the agricultural community is characterized by uniformity (Kloppenburg, 1988, p. 117). In pursuit of economic efficiency, it appears that biodiversity is incompatible with economic efficiency and productivity, which demand uniformity and monocultures with the aim to capture the economies of scale. This leads, however, to the paradoxical situation in which biotechnological manipulations of genetic materials contributes to the decline of biodiversity. The irony of this process is that it reduces the very resource stock on which the biotechnology industry ultimately depends upon[23]. For example, forestry development programs, such as sponsored by the Tropical Forestry Action Plan, have introduced monocultures of industrial species like eucalyptus which have contributed to the decline of regional specific species. The argument advanced most frequently in support of these monocultures is that they generate high yields and grow fast. The fast growth of eucalyptus, however, refers only to the growth of pulp wood, while the yields in terms of non-woody biomass, e.g., the leaves and branches as fodder for cattle, are low or even zero[24]. Thus, biotechnological innovations, for example in the areas of agriculture, forestry, and animal husbandry, are production processes which lead to more widespread uniformity and become, therefore, a major threat to the protection of biodiversity and sustainability. It appears that the "Biodiversity-Biotechnology-Biobusiness-Biodiversity Protection-link" is in economic terms very feeble to generate sufficient funds for biodiversity protection and in scientific terms very tenuous.

Hence, by emphasizing biotechnology and commercialization of biodiversity the CBD might have contributed to accelerate the process of reductionism and fragmentation of ecosystems into their marketable parts so that they can be treated as mere inputs. The commercial

reductionism might be convenient for economic concerns but it will threaten the global life-support system. Thus, how much and how well biotechnology and biodiversity prospecting will contribute to the ecological sustainable economic development to a particular country, will ultimately depend upon the DC government' and institutions' political will to set up and implement the required policies. In sum, despite all its limitations and omissions the CBD is still a remarkable agreement, but realistically it can be regarded only as a first step of an onset of a hazardous mountain climb.

6. Conclusions

The protection of biodiversity is an objective of paramount global importance: But does the CBD provide hope for DC, including their indigenous peoples, and for the conservation of biodiversity, or, is this convention, despite all the efforts of the international community, just another international agreement without any real consequences? Given the political parameters and the size and the complexity of the task, the CBD represents a substantial achievement and contains provisions that have potential to be transformed into concrete measures towards an ecological sustainable economic development pattern. In the core of the CBD are the principles that: governments agreed on the urgency for a more global and comprehensive approach to protecting and to using genetic resources; the need for additional and new financial assistance to DC; and an agreement -at least in principle- to exchange genetic resources for access to and transfer of biotechnology.

In essence, the CBD stresses clearly an anthropocentric and utilitarian approach to the protection of biodiversity, and supports the process of turning genetic resources into marketable commodities. This position, obviously, creates antagonistic tensions between the objectives of preservation of biodiversity and commercialization of biodiversity. But by just backtracking for a moment, one realizes that environmental deteriorations, destructions of habitats, monocultural agriculture, depletion of fish stocks, etc., are all intricately linked to the present economic system, the technology, and to the international state of inadequately implemented environmental policies. Thus, by offering the assets of biodiversity as resources to (mainly) commercial interests, we are in the process of entrusting "the agents of environmental destruction" with safeguarding our global ecosystems and biodiversity, and ultimately our long run survival. Although the CBD has created an essential precondition for biodiversity protection, but it clearly failed to achieve a paradigm shift in government policies required to conserve biodiversity and to implement sustainable uses of genetic resources.

NOTES

1. Initially the government of the United States of America refused to sign the CBD due to the pressure exercised by its biotechnology industry. Recently the Clinton Administration joined the Convention, but upheld provisions for the protection of its industry.
2. Convention on Biological Diversity, p. 192. This paper focuses mainly on articles which have direct economic consequences. For a detailed legal interpretation see e.g., de Klemm (1993).
3. See e.g., the Montreal Protocol on Substances that Deplete the Ozone Layer.
4. For a detailed assessment of the CBD in political science terms, see Suplie, 1995.
5. In reality, some of these foregone economic benefits are not to the full extent an economic loss for DC, since many of these companies are foreign owned and the benefits are expatriated. See the very informative article by Swaney and Olson, 1992.
6. A recent threat to the ecosystem integrity of TRF are e.g. the uncontrolled polluting activities of oil exploration by companies from IC, like the U.S.- Occidental Petroleum Corporation in the Río Tigre region in the Peruvian Amazon (Der Spiegel, 1996, p. 180).

7. The MED-curve of the IC is not separately drawn.
8. For the sake of simplicity a separate curve, representing only international damages, is omitted in this figure.
9. Benedick added this qualification in his definition of incremental costs (King *et al.*, *op. cit.*, p. 2).
10. For the sake of simplicity, it is assumed that MED_{DC} and MED_{IC} are starting to rise at the same point.
11. A recent World Bank study attempts to classsify terrestrial ecoregions of Latin American with respect to biological distinctiveness and uniqueness (Dinerstein *et al.*, 1995).
12. Resilience is defined here as a measure of the magnitude of disturbance that can be absorbed by the ecosystem without changes in its present features, or also as a measure of the magnitude of disturbances that can be upheld before the system loses its predictability (Perrings, 1995, p. 71).
13. In the case of agriculture, biodiversity provides insurances against the risks of productivity loss, since biodiversity supplies genetic materials for "rejuvenating" the relatively few commercially used crop varieties and seeds.
14. The "International Undertaking on Plant Genetic Resource" (FAO, 1983) is a non-binding agreement among governments.
15. For detailed interpretation of the articles of the CBD see e.g., Shine, C. and P.T.B. Kohona, 1992 or de Klemm, C., 1993.
16. Sensing the prospect of a profitable biotechnology industry, the Bush-administration launched 1992 an initiative which allocated US$ 4 b annually to biotechnology research. During the time period 1991-92 the revenues for the U.S. biotechnology industry increased by 28% to about US$ 8.1 b (Munson, 1995, p. 7).
17. For a detailed discussion on patent rights and biotechnology, see e.g., Juma, chapters 2 and 5, 1989 and Swanson, 1994, p. 231.
18. If an agency acting on behalf of the CBD, e.g., GEF, is obliged to decide on an appropriate compensation, then in this case of an "arbitrated" compensation there exist the danger of initiating reductions of future innovative activities by the IC, if their financial demands are not met.
19. The most advanced case of biological prospecting and contractual licensing agreeements is the example of the Instituto Nacional de Biodiversidad (INBio) in Costa Rica with Merck & Co (Aylward *et al.*, 1993).
20. Di Masi estimates that it requires on average about US$ 230 million and 12 years to develop a marketable product (Di Masi, J.A. *et al.*, 1991, p. 107).
21. For a detailed discussion of empirical studies see Reid *et al.*,1993 (chapters 1 and 2).
22. Futhermore, it is possible that unscrupulous companies intentionally select the least-protected or least-organized (and/or in collusion with corrupt officials) country for their operations with the purpose to mine this DC's genetic resource stock and sell these resources internationally before the DC is in the position to correct the situation.
23. It has to be realized that biotechnology and biodiversity, with its genetic information, are complements, not substitutes, in the production process.
24. Monocultures are susceptible also to diseases and pests (Shiva, 1991, p. 46).

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