Causes of Biodiversity Loss: a Human Ecological Analysis

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a Human Ecological Analysis

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Abstract

Important biological causes of the loss of biological diversity include the loss of habitats, the introduction of exotic species, over-harvesting of biodiversity resources, and homogenisation of species in agriculture. The common factor of all these elements is that they are human-driven. This paper analyzes the economic and social root causes behind biodiversity loss. The analysis is based on both theoretical considerations and case studies. It entails five axes:

(a) Demographic change: although from a theoretical point of view the relation between population pressure and the impact on biodiversity is almost obvious, no systematic attempt has been made so far to analyze this relationship in a quantitative way.

(b) Consumption and production patterns: global increases of energy consumption and the use of natural resources drive habitat conversion world-wide. In this part of the analysis, particular attention is paid to economic growth, poverty and land tenure aspects, as causes of biodiversity loss.

(c) Public policies entail three major elements: perverse policies that provide incentives which degrade biodiversity, failure to incorporate the monetary value of biodiversity into decision making and failure to integrate biodiversity concerns as a transversal element into policy.

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(d) Macro-economic policies and structures.

(e) Social change and development bias.

Although there is ample theoretical evidence of the economic, social and political causes of biodiversity loss, empirical evidence for most of these relationships is fragmented, meager or non-existent. More research in this area is imperative. It is also most questionable whether current nature-conservation policies provide sufficient answers to these root causes of biodiversity loss and are able to counteract the loss of biodiversity-related cultural values, biological species and ecosystems in an effective way.

Introduction

What is biodiversity?

Biodiversity is a contraction of "biological diversity" and refers to the number, variety and variability of living organisms. In its widest sense, therefore, it is synonymous with "Life on Earth". It embraces two different concepts: one is a measure of how many different living things there are and the other is the measure of how different they are.

Although many definitions of biodiversity exist, the most often-cited is provided by the "Convention on Biological Diversity" [1] in its Article 2. "Biological diversity" *"the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"* (Box 1).

What is biodiversity ?

According to the Convention on Biological Diversity, *"biological diversity* means the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" [2]. The term "biodiversity", thus, refers to the variety of all life on earth, and explicitly recognises how the interaction of the different components of ecosystems results in the provision of essential ecosystem services on the one hand, and social and recreational opportunities on the other, including being a source of inspiration and cultural identity [3].

A number of concepts have been developed in recent years relating to indicators and principles for biodiversity management, including "ecosystem integrity", "ecosystem health", "sustainability", and "resilience" (the ability of an ecosystem to withstand stresses and shocks). The variety of concepts and definitions that abound indicates the difficulties facing any attempts to establish a practical, working definition of biological diversity. Perhaps one of the simplest and most widely accepted definitions used is the conservation of the maximum number of species. But even then, there are difficulties, as it is not clear what actually constitutes a species. Some common concepts for differentiating species have been identified by Brookes [4] as:

- *biological species concept* – defines a species as a group of interbreeding populations isolated from other such groups;
- *morphological species definition* – defines a species according to a given set of common features;
- *evolutionary species concept* – defines a species by its shared evolutionary history; and
- *genotypic cluster definition* – uses genetic "gaps" to distinguish one species from another.

Each of these definitions tries to isolate a species from the wider concepts of ecosystems and biodiversity, but the variety of definitions in use indicates the difficulties in such an exercise.

Box 1: What is biodiversity ? [5].

This definition places emphasis on variability or heterogeneity, rather than on the objects displaying that variability. It addresses this variability at three hierarchical levels - genes, species and ecosystems.

Species diversity

The species is the basic unit of classification in biology. Although a species might be defined as a group of similar organisms that interbreed or share a common lineage of descent, there is no universal agreement on how to define a species. Even when the species is the basic unit, it represents only one level of a complex phylogenetic hierarchy: related species are grouped in genera, related genera in families, families in orders, and so on, up to the highest level, the kingdom, of which five are generally recognised at present (animals, plants, fungi, bacteria and protoctists). More schematically, the levels of biodiversity are listed in Box 2.

Species richness measures the number of species within a given area, giving equal weight to each one. This measure can be used at different geographical levels (a given area, a country and, ultimately, the world). It is still the most straightforward and, in many ways, the most useful measure of biodiversity. World-wide, just 1,75 million of the estimated 13 to 14 million species have so far been described. Most of these described species are only poorly known in biological terms. There is no comprehensive catalogue on the known species.

The number or richness of species is obviously a most incomplete measure of biodiversity. It is complemented by:

(a) Species diversity, which measures the species in an area, adjusting for both sampling effects and species abundance.

(b) Taxic (taxonomic) diversity, which measures the taxonomic dispersion of species, thus emphasizing isolated evolutionary species. The basic idea behind this measure is that biodiversity might be better measured at higher taxonomic levels (e.g. genera or families). The explanation is that an area with, say, ten species in the same genus is less diverse than an area with ten species, each belonging to a different genus.

(c) Functional diversity, which assesses the richness of functional features and interrelations in an area, identifying food webs along with keystone species and guilds.

However, not only diversity is of importance. Species endemism, that is whether a species is restricted to ("endemic to") an area under discussion, is equally vital. For example, islands typically have fewer species than equivalent-sized continental areas. They also usually have a higher percentage of species found nowhere else. In other words, they have lower species richness and higher species endemism.

Genetic diversity

Genetic diversity is the variation of the set of genes carried by different organisms: it occurs on a small scale among organisms of the same species, among closely related species such as those in the same genus, and among more distantly related species, in different families, orders, or kingdoms.

Genetic diversity might be characterised by a range of techniques: by observation of inherited genetic traits, by studying the chromosomes and their species specific karyotype, and by analysing the DNA information using molecular technology.

Global genetic diversity is extremely large. It has been estimated that there are some 10^9 different genes present in the world's biota. The number of possible combinations of gene-sequence variants in a population is so great that it cannot even be expressed in a meaningful way.

This amazing variation in the genetic code offers opportunities for evolutionary change, the survival of species, adaptations to a changing environment, and the formation of new species. More recently, biotechnology and crop or breed improvement programmes rely on the identification of genetic material giving rise to desirable traits, and the incorporation of this material in appropriate organisms.

Ecosystem diversity

Species exist in natural settings, within functioning communities and ecosystems, interacting with other species and the abiotic environment. Ecosystems function as entities with system-wide properties. Care about diversity must, therefore, also focus on system-wide aspects, such as dying coral reefs.

Different classification systems exist to describe ecosystem diversity. On a world scale, bio-geographic zones, biomes, eco-regions, and oceanic realms are used. On a smaller scale, one deals with landscapes, ecosystems and communities (Box 2).

Ecological Diversity	Genetic diversity	Organismal diversity
Biomes		kingdoms
Bio-regions	populations	phyla
Landscapes	individuals	families
Ecosystems	chromosomes	genera
Habitats	genes	species
Niches	nucleotides	subspecies
Populations		populations
		individuals
Cultural diversity: human interactions at all levels		

Box 2: The composition and levels of biodiversity [6].

Qualification of ecosystems on a global scale faces problems. A major reason for this is that they do not have a clearly delineated identity. They do not, in general, exist as discrete units, but represent different parts of a highly variable natural continuum.

To study ecosystem diversity at different levels, geographic information systems (GIS) are increasingly used, both during assessment and as a basic management tool.

Biological causes of biodiversity loss

Although biodiversity, in essence, has to do with genes, species and ecosystems, it is also related to issues far beyond the confines of biology. Understanding the threats to biodiversity and offering solutions to them necessitates insights from the socio-economic and applied sciences.

The major source of the recent interest in diversity of life on earth arises from the feeling of a rapid decline in biodiversity. Extinction of species is part of an evolutionary process. However, during recent times, extinction rates are ten to a hundred times higher than during pre-human times [7]. The main causes for this loss of biodiversity are:

(a) The loss of habitats. Table 1 provides data on human disturbance of habitats on a world-wide scale. The data show the significant impact of human activity on world ecosystems. For example, in Europe, only 15% of the continent is classified as "undisturbed", which is the lowest percentage world-wide. Loss of tropical forest is the most highly published aspect of this [8]. Elsewhere, rivers are impounded, coral reefs destroyed by dynamite, and natural grasslands are ploughed.

	Total area (km^2)	% undisturbed[1]	% partially disturbed[2]	% human dominated[3]
Europe	5 759 321	15.6	19.6	64.9
Asia	53 311 557	43.5	27.0	29.5
Africa	33 985 316	48.9	35.8	15.4
North America	26 179 907	56.3	18.8	24.9
South America	20 120 346	62.5	22.5	15.1
Australia	9 487 262	62.3	25.8	12.0
Antarctica	13 208 983	100.0	0.0	0.0
World	162 052 691			

1. *Undisturbed*: record of primary vegetation; very low human population density.
2. *Partially disturbed*: record of shifting or extensive agriculture; record of *secondary* but naturally regenerating vegetation; livestock density overcarrying capacity; other evidence of human disturbance (e.g., logging concessions).
3. *Human dominated*: record of permanent agriculture or urban settlement; primary vegetation removed; current vegetation differs from primary vegetation; record of desertification or other permanent degradation.

Table 1: Habitat and human disturbance by continent [9].

(b) The introduction of exotic species. Many are accidental, as with noxious weeds and insect pests. Others are deliberate. Foxes, rabbits and cats, which were taken to Australia aboard European ships, have decimated Australia's indigenous wildlife. In freshwater, the stocking of exotic fish for sport, or (rarely) for food, has caused at least 18 extinctions of fish species in North American rivers. Catastrophic changes in the fish biodiversity of Lake Victoria (East Africa) resulted from the introduction of Nile perch

[10]. Eucalyptus, which is indigenous in Australia, has been introduced in many tropical and subtropical regions in the world, where the tree merely behaves as a pest.

(c) Over-harvesting by (illegal) hunting, and the systematic cutting of wood for heating purposes, or charcoal production, are other reasons for biodiversity loss. The use of medicinal plants might illustrate this point. In the semi-arid rural area of Southern Cochabamba (Bolivia), it was shown that, out of 132 inventoried plants that the local people use for traditional medicinal purposes, 10 were threatened because of their intensive collection [11].

(d) Lesser-known causes are due to "knock-on" effects. Species that are co-evolved with another, such as plants with specialised insect pollinators, will go extinct if one of the pair goes extinct. When the last passenger pigeon (*Ectopistes migratorius*) died in the early 1990s, so also did two of its obligate parasites, two lice species [12]. Moabi (Baillonella toxisperma) used to be a common tree in West-Africa. The fruits are eaten, cooking oil is extracted from the seeds (karite) and the bark is used for medicinal purposes. For its reproduction, the plant depends on the elephants. Only these animals swallow and disperse the moabi seeds. The impressive reduction of elephants in countries such as the Ivory Coast, Ghana and Benin has had an important impact on the distribution of the tree.

(e) Homogenisation in agriculture and forestry; in particular, industrial agriculture and forestry use a limited number of species. Of the hundreds of species of edible potatoes available in South America, less than 20 are in commercial use in Europe. Although an estimated 7,000 plant species have been collected and cultivated for food, only 30 contribute over 90% of the entire global population's energy needs. The case of the banana (Musa spp.) is illustrative. Bananas are the fourth most important food source in the tropics after rice, wheat and corn. They are cultivated in nearly 120 countries. Farmers use only about 25 edible sterile banana varieties. The number of varieties is diminishing due to the spread of pests and diseases and the deterioration of the resource.

(f) Pollution and global environmental change also threaten the world's biodiversity. Climate changes affect the distribution of species. Plants that two decades ago were only found in

Southern Spain currently appear at the foot of the Pyrenees mountains, in the North of the country.

All these causes have one element in common: they are induced by human activity. This makes human activity the most important source of the current decline in biodiversity. Therefore, understanding the many aspects of human influences on biodiversity, and their underlying driving forces, is of crucial importance for setting priorities and counteracting the current negative trends.

A human ecological framework of root causes of biodiversity loss

This paper will deal with the main human ecological aspects of biodiversity loss: the root causes, selected economic and social aspects and the moral aspects.

The analysis of root causes is based on a paper by Stedman-Edwards [13]. Essential in her rationale is that the causes of biodiversity loss are indeed habitat loss and fragmentation. However, these drivers are influenced in turn by human resources use and pollution. She further identifies five societal root causes, which are essential in understanding biodiversity loss: demographic change, inequality and poverty; public policies, markets and politics; macroeconomic policies and structures; and social change and development biases. The framework on which this rationale is built is shown in Figure 1. The root causes appear on the left-hand side of the figure.

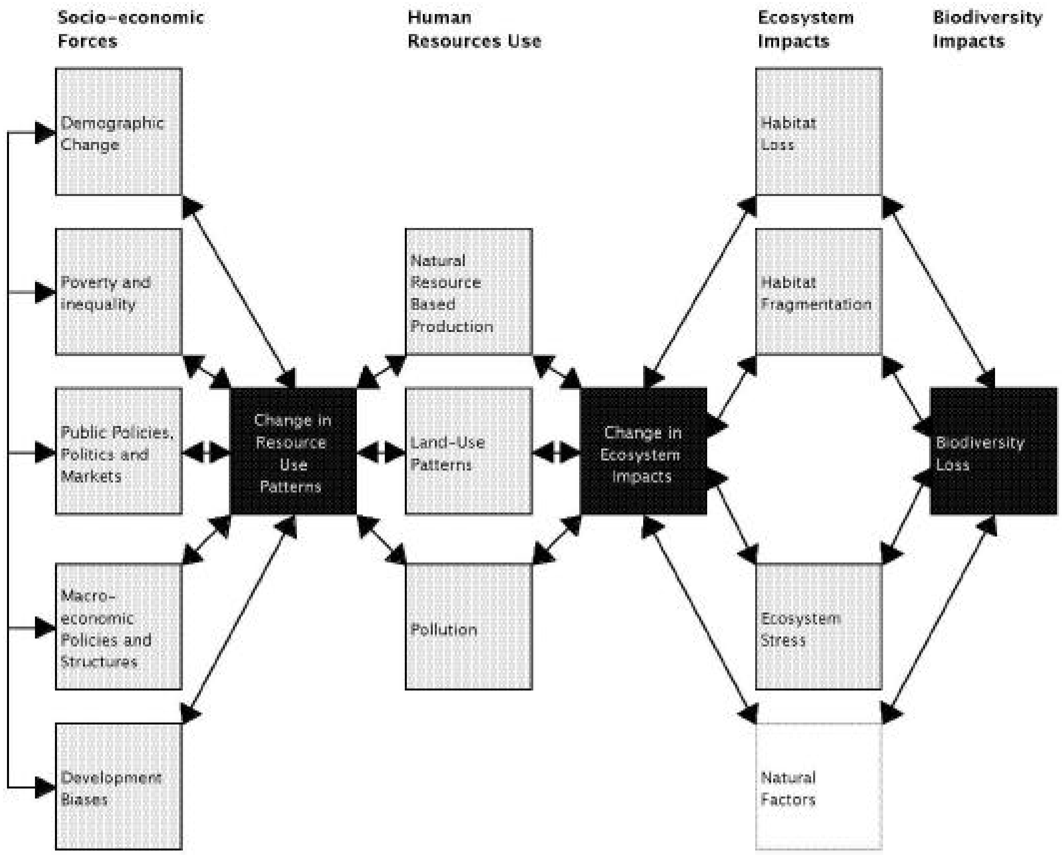

Figure 1: A root-cause framework for biodiversity loss [13].

Demographic change

Since December, 1999, there are officially 6 billion people worldwide. The world's population has more than doubled since 1960, and is growing at a rate of 1.6% a year. The global population is expected to reach over 8 billion in 2025 and to stabilise at around 12 billion people towards the end of this new century. The fastest growth rate is in Africa, currently growing at an annual rate of 2.9 percent and heading for a population of 3 billion people towards the end of next century, around five times the population of today (Table 2). In South America, the population increases at a rate of 1.7% annually.

	1960	1990	2025	2100	2150
World population (billions)	3.0	5.4	8.1	12.0	12.2
			% in:		

Asia/Oceania	57.0	59.4	58.6	57.0	56.8
North and South America	13.3	13.7	12.8	11.0	10.8
Africa	9.2	11.9	20.9	23.9	24.5
Europe	20.5	15.0	7.7	8.1	7.9

Table 2: Human population growth by continent [14].

Moreover, the population is most unevenly distributed and concentrated in cities along coastlines and inland waterways. Around 45% of the world's population is urbanised but this is unevenly split between the industrialised (over 70%) and the developing countries (just under 40%). However, the gap is closing and the urban growth rate in the latter was currently four times faster than in the industrialised countries and their urbanised area is predicted to double over the period 1980-2000 [15].

The relationship between population size, growth and density on the one hand and biodiversity loss on the other hand is complex. From a theoretical point of view, there is no doubt that these factors lead to pressure on land and aquatic resources, especially on food production, but also on infrastructure such as roads and housing. Concentrations of people in coastal zones and along other waterways can result in the destruction of, or damage to, terrestrial, aquatic, and marine biodiversity.

Also, from a historical point of view, the relation between demographic change and impact on biodiversity is obvious. During archaeological periods, increases in population have prompted changes in the pattern of land use through the institution of methods of agricultural production. Thus, with an increase in population, traditional societies, previously dependent on hunting and wild plant gathering, found it necessary to turn to agriculture, initially in the form of shifting ("slash and burn") cultivation, then to long fallows, and eventually to permanent cultivation, including the introduction of permanent livestock.

In general, population growth is associated with the growth of resource consumption and degradation, expansion and intensification of land use, increasing poverty, exploitation of marginal lands and the breakdown of traditional resource-management systems. At the local level, population growth is often the result of urbanisation, displacement and migration. Local population growth directly affects the use of resources and their degradation and often drives habitat conversion in areas important for biodiversity conservation. At a global level, population growth is continually raising the consumption of resources (see next section).

In spite of this theoretical and circumstantial evidence, no systematic attempts have been made to analyse the relationship between demographic change and biodiversity in a quantitative way. Whether countries with more rapid rates of population growth have more rapid rates of land conversion is uncertain [16]. However, some correlation between population density and land use exists. Countries with high population densities have converted relatively more land to agricultural use. Latin American and African countries with high levels of fertiliser use (an indication of agricultural intensification) are generally those with high population densities. At the local level, however, the relationship between population density and land use is not so apparent in many cases. Further work is needed to understand the linkages between population change and biodiversity loss.

Production, Consumption, Inequality and Poverty

Patterns of production and over-consumption are important causes of biodiversity loss. For example, global increases in consumption of energy and natural resources drive habitat conversion and over-use of ecosystems worldwide. Per capita consumption of materials and energy is the highest in Organisation for Economic Cooperation and Development (OECD) countries, followed by countries with economies in transition. This is illustrated in a convincing way by ecological footprint analysis. This analysis indicates e.g. that the total demand of nature by a modal US citizen equals 10 time the demand of a local Indian or Nigerian [17]. Lowering materials and energy consumption from existing levels will reduce pollution and extraction processes, which damage biodiversity. Unfortunately, however, economic systems today tend to encourage higher consumption and production rates and fail to take biodiversity and environmental requirements into account. At the existing high levels of consumption, particularly in the industrialised countries, there is an urgent need to increase the efficiency of resource use. This might be the first step to alleviating the pressure on the environment and on biodiversity.

Economic growth might itself be a cause of environmental degradation. Although in theory it is the ratio of demand for environmental resources to economic activity which matters from an efficiency point of view, in practice, economic growth indeed leads to increased use of energy, resources and biodiversity degradation.

The importance of production and consumption patterns as fundamental drivers of environmental degradation and biodiversity loss has been sharply discussed in chapter 4 of

Rio's Agenda 21. More than 10 years after the United Nations Conference on Environment and Development (UNCED), making consumption and production patterns more sustainable seems to be one of the most difficult areas to be addressed by governments worldwide. Nevertheless, a broad range of instruments is available to do the job. For example, the removal of perverse incentives and the use of environmental taxes can help to internalise costs and move towards full market pricing. Education about the impacts of consumption is equally crucial for modifying consumption patterns. Eco-labeling and product/service certification are useful tools for making the consumer understand the impacts of consumption on biodiversity loss. For society, these instruments are particularly useful when they support sustainable production processes. Also, the impact of international trade policies and regimes on sustainable production processes is of extreme importance. Economic globalisation should be weighed against environmental destruction. To deal with the debt-biodiversity relation, dept-for-nature swaps are an attractive instrument showing the advantage of short term results.

The Plan of Implementation of the World Summit on Sustainable Development (2002) stated that changing consumption and production patterns was an area where only most limited progress was made on implementing Rio's Agenda 21. It therefore advocated, among others, the above-mentioned instruments.

In third-world countries, many development policies, programmes and projects threaten biodiversity. Plastics are more abundantly used in cities in developing countries than in OECD countries. Especially after the fall of the Berlin Wall, economic growth and free-market economics became the prevailing credos worldwide.

There are several reasons for thinking that poverty, particularly in situations where people depend directly upon consumption of biodiversity or other natural resources for survival, is a cause of habitat loss. Estimates of the coincidence of poverty and environmentally marginalised places depend directly on the definitions of poverty and marginality employed and, therefore, vary widely. Nevertheless, it has been estimated that 60% of the world's poor live in areas of low agricultural potential, which can be equated to ecological vulnerability. Poverty prevents people from assuming long-term economical and environmental attitudes. Poor farmers, fishermen, nomads and other users extract what they can from the environment to support themselves. These populations have little time or resources left to invest in resource conservation and management.

In general, there exists a vicious circle of poverty, resource degradation and further impoverishment. Land degradation - both a result and a cause of rural poverty - has direct and indirect impacts on biodiversity as it forces changes in production patterns, migration and frontier expansion. The poor are disproportionately located in marginal lands and fragile ecosystems. Moreover, the poor are thought to make particularly damaging use of the environment when traditional systems of resource management break down as a result of socio-economic change.

Particular attention has been paid to questions of land tenure. Poor farmers often have no tenure or uncertain tenure of their land, which leads directly or indirectly to inefficient use of resources and environmental degradation. In Mexico, some 70 to 80 percent of the 40 million hectares of the country's temperate and tropical forest is located in ejidos -communal farms- divided into family or individual plots. For the past 40 years, inhabitants of the ejidos have converted forests into agricultural and pasture lands. This helped to make Mexico one of the countries with the highest rates of deforestation in the world.

The view that poverty relief must have precedence over environmental concerns is gradually being replaced by the idea that poverty relief and sustainability are closely linked. In other words, development must precede environmental concern or clean-up should be replaced by the idea of sustainable development.

Structural adjustment programmes (SAPs) and the huge debts of the developing world are often cited as fundamental causes for resource use and habitat and biodiversity loss. The view of the world's leading economic institutions is mixed. SAPs, for example, often require the removal of economic distortions, such as subsidies, which encourage prolific resource use, and may favour biodiversity conservation. On the other hand, SAPs may encourage an increase in export drives, which induce land conversion for export crops or favour the culture of international cash crops over indigenous species. In the same way, external debt may encourage a similar export-oriented policy in an effort to secure foreign exchange to meet debt repayments.

Public policies at the national level

There is very little doubt that government policies significantly impact biodiversity, both positively and in destructive ways. With regard to the causes of biodiversity loss, three main types of policies have been described:

(a) Perverse policies that provide incentives that degrade biodiversity. Tourism, agriculture, forestry, energy, mining water, transport, construction and communications sectors can have adverse impacts on biodiversity.

In the Maldives, coral reefs are destroyed and threatened by the fast-expanding diving tourism and the obtention of materials for the construction of houses.

In Germany, agriculture is the main sector responsible for endangering species. Agriculture has been identified as the source of a threat to 513 species, 72 percent of species on the Red List of threatened and endangered species [18].

Mining is traditionally a most impacting sector on the landscape and on biodiversity. In the Ghanaian gold-mining sector, which is mainly concentrated in the tropical south-western region of the country, attempts exist to counteract the effects of the surface clearing, which is the basis of mining activities. Companies are forced to re-green the deforested areas after mining activities. The companies do so, however, using plants from the international catalogue of the Food and Agriculture Organisation (FAO) rather than the original indigenous plants.

In the Brazilian Amazon, development projects have included large-scale road building, mining, dams, and colonisation schemes. In the lowland tropical forest of the Chapare region of Bolivia, 55 percent of the original forest were cut down and the land use changed between 1988 and 1998, after the government decided to promote this region for agricultural development. Oil concessions, coca plantations and a number of crops such as pineapple, pepper, maracuja, banana and palm, which are advocated as alternatives to the coca plants, replaced the original forest. However, after depletion of the soil, huge areas left behind are prone to erosion [19].

In the fast-developing Halong Bay area in Northern Vietnam, 40 percent of the land cover changed during the period 1988-1998. The main element of change in this area was the original dense forest, which declined rapidly: of the 2010 ha cover in 1988, only

335 ha remained in 1998. Dense forest mainly changed to degraded and secondary forest [20]. Box 3 provides more details about the study quantifying this type of fast developmental changes.

Halong bay is the core area of the Quang Ninh province (Northern Vietnam) that borders China on the North and the Gulf of Tonkin on the East. Quang Ninh is one of the areas in Vietnam characterised by rapid economic, social and environmental development. Using LANDSAT TM images, land cover changes during the period 1988-1998 were studied [20]. The changes were classified into three main groups: coastal features, natural land features and human features. These main groups were further subdivided into 22 different mapping categories.

The study shows that by 1998, 39.9 per cent of the 1988 land cover had changed. The results also indicate:

(a) a fast expansion of the human features: during these 10 years, the area of urban settlements doubled and the area for coal-mining activities increased by 75 per cent.

(b) the coastal area changed in a complex way, driven by expansion of urbanisation, aquaculture activities, agriculture and mangrove expansion (replanting and natural colonisation of tidal flats without vegetation).

(c) the original dense forest in the area rapidly declined: of the 2,010 ha cover in 1998, only 335 ha remained in 1998. Dense forests mainly changed to degraded and secondary forests.

In more detail, the investigation of the evolution of the national land features shows that:

(a) the limited area of natural dense forest which remained in 1988, after a period of intense deforestation, is even more dramatically reduced. Of the 2,010 ha of dense forest in 1988, only 335 remained in 1998.

(b) the expansion of the areas for the non-indigenous eucalyptus and pine plantations is remarkable. The increase of 85 per cent (almost 4,500 ha) is, at the same time, the largest area of gross change during the period studied.

(c) the tree cover and the nature of the natural ecosystems changed substantially. Overall, the forest cover was reduced by more than 4,000 ha. However, within this picture, the contribution of plantations is increasing.

The data show that these rapid development patterns are associated with important losses of biodiversity. Policies determining this type of development are a major cause of biodiversity loss.

Box 3: Rapid loss of natural landscape features in the Halong Bay area (North Vietnam) [20]

All these examples show how government policies can be most devastating to biodiversity. These policies have in common the fact that they serve traditional development goals, such as industrialisation, export expansion, increased food production and poverty relief. In most of these cases, natural resources provide a cheap way to support economic growth.

(b) Failure to incorporate environmental values, including the value of biodiversity, into the decision-making process. According to the free-market economic rationale, environmental values, including the value of biodiversity (loss), should be fully reflected in the price of a product or service. The underlying assumption is that, if the value of biodiversity is made fully evident in the price mechanisms, this will reduce degradation substantially. At least in theory, governments can compensate for this type of market failure by imposing taxes or levies. There are, however, different problems:

(-) Calculating the price of biodiversity loss is not easy. Different methods have been proposed and most of them have been used with more or less limited success. But none of these methods can capture the full value of biodiversity quantitatively. The fundamental reason for this is that biodiversity embodies an insurance value for the generations to come, which is never taken into account. Moreover, valuing biodiversity is faced with serious ethical problems [21].

(-) Probably, a sustainable use of environmental resources through market regulation is only possible when the resource base is small, the possibilities for substitution are limited, and the control over resources is tight. Some traditional societies fulfil these conditions, but few still maintain the control over their environmental resources. New users, such as the colonists in Chapare (Bolivia), do not meet these conditions, given the insecurity of tenure, the apparently extensive frontier, and open access to environmental resources.

(-) Imposing taxes for environmental reasons coincides with fundamental psychological problems and lobbying practices. In Belgium, an environmental tax law, voted by more than two-thirds of the parliamentarians in 1995, has hardly been implemented after subsequent lobbying by industry and related groups. The main reason is that price adjustments will influence existing production patterns too profoundly. Curative measures were therefore preferred over preventive interventions on the product market.

Markets related to forest biodiversity include timber and non-timber products. Among the latter, a wide series of fruits, vegetables, snails, honey, mushrooms, nuts, seeds, a wide range of micro-foods, pharmaceuticals and cosmetics are found. But the forest also offers many environmental services. These services include soil fertility enhancement, protection from erosion and against floods, regulation of water supply and the protection of biodiversity.

Traditionally, no one pays for these services : they are considered as “common”. Early valuation attempts include taxes and land-owner rights. More recently, in the face of budgetary constraints and increasing liberalisation, many governments have increased their use of market-based instruments to value biodiversity. Examples of these market-based instruments used to promote improved forest management include new revenue systems based on stumpage value, reform of subsidies, tax exemptions, performance bonds and the promotion of forest certification. A set of new economic instruments has recently been launched in this context. It includes bio-prospecting rights to investigate the potential applications of biodiversity in the pharmaceutical or cosmetic sector; biodiversity credits; research credits; biodiversity concessions provided to environmental Non-Governmental Organisations (NGOs); tradable development rights and conservation casements.

(c) Government failure to integrate environment in development policy. Since there are pervasive links between economic and environmental quality, most economic policies affect the environment in one way or another. Therefore, it is imperative to incorporate the environmental dimension in all sectors of policy making as a transversal concern in decision making.

Effecting this integration in all sectors of a given economy and relevant subsets of the political process was, to a large extent, the hope of the environmental movement in the late 1980s and its advocate for sustainable development. Policy integration is also acknowledged in the Convention on Biological Diversity [1], which states in Article 10 that: *"Each Contracting Party shall, as far as possible and as appropriate: (a) Integrate consideration of the conservation and sustainable use of biological resources into national decision making"*. Moreover Article 6 (b) requires the states to *"integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies"*.

In practice, however, the integration of environmental concerns as an over-arching theme in all policy domains seems difficult to reach and is known as "integration failure". There are different reasons for this phenomenon. However, lack of information, environmental awareness, decision-making inertia and a too-limited societal basis constitute the major causes. A major instrument to incorporate biodiversity concerns in decision making on plans, programmes and policies is strategic environmental assessment (SEA). However, worldwide, integrating SEA in policy is a slow process. It is a missed opportunity that, in contrast to Agenda 21, the Plan of Implementation of the World Summit on Sustainable Development (WSSD, Johannesburg, South-Africa, 2002), does not recommend the use of SEA.

Macroeconomic policies and structures

The impact of international markets on prices of biodiversity resources is of core importance in regulating their use. This impact is even more significant with an increasing globalisation of the world economy. Nevertheless, the role of macroeconomic factors in biodiversity loss is difficult to quantify, given the large number of intervening variables between global and national economies and local decisions about resource use. To analyse the role of macroeconomic factors as drivers of local resource-use patterns, two main lines of thinking prevail today:

The neo-classical view suggests that "improvements" in a government's macroeconomic policy, such as trade liberalisation and exchange-rate deregulation, will improve resource-use patterns. Trade liberalisation and free-trade regimes can have positive impacts on biodiversity when free trade is associated with the reduction or removal of distortions and, when prices reflect true values of biological resources, free trade can improve their allocation. Or phrased in another way: where proper policies for environmental protection and sustainable development are in place, trade liberalisation will co-implement and reinforce those policies. Where they are not, trade liberalisation will exacerbate existing environmental problems and promote development that is not environmentally sustainable.

The second line of thinking is driven by political economy. This theory focuses on macroeconomic structures. It posits that changes in macroeconomic policy, without changes in the underlying power and market structures, may worsen resource-use patterns.

The analysis of cases shows that there is truth in both of these approaches. It equally shows how complex the link between macroeconomic policies and the environment is. Nevertheless, in relation to biodiversity, a set of specific comments is important:

(1) Uniformity: the shift toward production for large, often global, markets drives towards uniformity in the products. Mono-cropping, mechanisation and increased use of chemical inputs, often a prerequisite for participation in these markets, replace more diverse ecosystems and small-scale farming methods. They all lead to a reduction in the diversity of crops and supporting species.

(2) Log export bans: have been used in the past. They were based on the argument that reduced harvesting would be induced by the artificial reduction in export demand. Because of the complexity of macroeconomic mechanisms, in countries such as Costa Rica and Canada, the experience with this instrument is mixed. However, limited or more directed export bans that focus on restricting exports of logs derived from old-growth forests may avoid the potential of adverse environmental effects.

(3) Species trade restrictions: The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) reflects the consensus of its 130 Parties that selective trade restrictions are necessary to protect species that are threatened or endangered by trade. Empirical evidence suggests that trade measures taken under this agreement are effective. In Zimbabwe, the Convention had a clear impact on the elephant population. In its turn, this seemed to create the necessity of controlled hunting and ivory trade as a correction of the Convention mechanisms.

Culture, social change and development bias

Development is widely understood as an increase in consumption and production and the committed use and transformation of natural resources. Even when this social change is politically and economically driven, there also exists a social and cultural preference for this type of development. Culture has a direct influence on the population, economic activities, settlement patterns, political structures and other factors affecting biodiversity. It is undeniable that the failure to incorporate sustainability, including biodiversity conservation, into the current development paradigm, has to an important extent a cultural basis.

Culture influences biodiversity at different levels:

(1) In many places there is a cultural bias against natural areas, which are seen as uncivilised and underdeveloped. This might explain the enormous land clearing which has taken place in Europe since the Middle Ages and in the Americas since Europeans arrived there. A similar cultural outlook sees indigenous peoples, and their resource-use practices, as being in need of development and civilisation. This driver of colonialism until the 1960s has led to the complete destruction of traditional societies and the protection they afforded to biodiversity.

(2) The prevalent current development strategy stresses liberal markets, reduced government intervention, and private property. The model justifying this economically focussed strategy claims a linkage between developed economic (capitalist) and political (democratic) structures and concern for conservation. They are presented as a package. Whether this ideology is correct can be doubted. For instance, the bias of many developing countries in favour of urban over rural areas and in favour of industry over

agriculture reflects this understanding of development and does not necessarily include an effective bio-conservation policy.

(3) In this process, traditional cultures are being lost. These indigenous cultures have very different relationships with resources. Sedentary peoples, in particular, have developed systems of taboos and prescriptions related to resource use that both protect and enhance biodiversity. The modernisation of these traditional societies leads to loss of traditional knowledge about sustainability and the "undiscovered" values of biodiversity (such as medical cures or diets based on micro-foods) and the disruption and loss of traditional institutions for managing resources. An example of the cultural context of biodiversity for indigenous people is described in box 4. The research among the Impeti-Emberá in the Republic of Panama shows that they give importance to biodiversity in a context that reflects the utility of plants for the community. This provides complementary information on the value system scientists have developed to evaluate biodiversity.

The importance of culturally determined traditional knowledge on biodiversity can be illustrated using a study carried out among the Emberás in Panama [22]. The members of this indigenous group are of South American origin and currently live in Panama and in Columbia. Their total population is about 50,000, of which 18,000 live in Panama. Of the five main indigenous groups in Panama, the Emberás are considered to reflect their traditional life styles most closely.

The research aims to define the importance the Emberás give to rare plant species. Using various methods ranging from workshops to formal questionnaires, participatory observation, and ecological inventory, it was possible to establish the list provided in table 3. This list is based on data gathered by the contribution of over 90% of the 50 households in the area of study.

Spanish name	**Scientific name**	**Use**	**Number of plants counted**	**Harvest frequency**
Bejuco motété		Food baskets, posts for houses, hen cages	13	4

Bijao	*Calathea latifolia*	Wrapping buns and tamales, utility baskets, wrapping food covered with salt, hats	272	1
Pita con espinos	*Aechmae pubescens*	Thread	55	2.5
Nawala	*Carludovica palmate*	Structural elements for decorative chunga baskets, chaume, utility baskets, wrapping for buns, bellows, hats	553	2
Chunga	*Astrocaryum standleyanum*	Decorative baskets, posts for houses, food, sugar presses, ornamentation for the shaman's home, hoe blades, spears	466	2
Wagara	*Sabal mauritiiformis*	Chaume, posts for houses	361	5
Jira	*Socratea exorrhiza*	Flooring, fencing, *para cinta y chuso*	644	5
Uvita	*Bactris coloniata*	Pliers, food, arrows, construction materials	2071	3
Jagua	*Genipa Americana*	Body and hair painting, soothing skin lotion	9	2
Maquenque	*Oenocarpus mapora*	Pillions, utility baskets, food, ornamentation for *jaïbana* houses, beverages, chaume, sugar cane press heads, flooring, oil	92	5
Balsa	*Ochroma pyramidale*	Stairs, dolls, river rafts for cargo, plates, pillows	504	5

Malagueto	*Xylopia fructescens*	Construction materials	56	5
Cedro espino	*Bombacopsis quinata*	Boats, boards	32	3
Cedro amargo	*Cedrela odorata*	Boats, boards	70	3
Nispero	*Manilkara sp.*	Construction materials, axe handles, food	0	6
Chiru		Traditional Emberá woodwind instruments	1	6
Kidave	*Manettia reclinata*	Substance for the purpose of hardening and protecting teeth	0	6
Bejuco real	*Heteropsis sp.*	Food baskets, binding for the construction of materials, hats	0	6
Pita sin espinos	*Aechmea setigera*	Food	0	3
Tinta roja		Dye for chunga fibres	0	2
Cocobolo	*Dalbergia retusa*	Animal sculpting, construction materials, black dye for chunga fibres	0	2
Trupa	*Oenocarpus bataua*	Oil, beverage	0	3

Table 3: List of Plant Species deemed Cultural Priorities by the Ipeti-Emberá Community*

* The number of plants is based on a sample of 50 quadrants of 24 meter-diameter each and represents the total number of individuals found. The frequency of use was obtained by a questionnaire administered to all households in the village. The answers are coded as follows: 1 – weekly harvest; 2 – monthly harvest; 3 – annual harvest; 4 – biennial harvest; 5 – infrequent harvest, about once every five years; 6 – rare or non-existent harvest.

Twenty-two plant species were ascribed a significant traditional value by the villagers; without exception, all of these plants have a use. Eight tree and eight palm species used to build houses and for various domestic purposes (basket-making, food, thread) were found. Three species provide raw materials for Emberá craftwork - one of the largest sources of income for the community. Finally, three species are important for their symbolic or spiritual value.

The study then searched for a relationship between species abundance and importance. The abundance of the plants was determined by sampling 150 24-metre-diameter quadrants. The abundance of the plant species on the Ipeti territory varied between zero and 2071. Six species were counted with more than 200 individuals, and five more were present in the quadrants by more than 20 individuals. For eight species, fewer than 10 plants were found. The Emberá were unanimous in considering four plant species to be particularly important: chunga (fibre for woven baskets), guagara (roofing for the huts), jira (flooring in the huts) and kipara (a vegetable dye used in body painting). The ecological inventory showed that, while 3 palm species are found abundantly, kipara is rare, with only nine individuals counted. The researchers concluded, therefore, that there is no relationship between utilisation, importance and abundance.

The whole of the research shows that the Emberá place importance on biodiversity, or rather on the renewable resources that are its most tangible expression, according to a value system fundamentally different from that of scientists. The value of biodiversity seems to be intimately linked to the utility of a species.

Box 4: Plant species of cultural importance for the Panamanian Impeti-Emberá [22]

These findings should not lead to an over-romanticisation of indigenous cultures. Far from all these societies live in a sustainable way. Moreover, the readiness with which many of them embrace the Western production and consumption methods is noticeable. But, they offer many examples showing that alternative cultures that have sustainability and biodiversity protection embedded in their social organisation gradually change to incorporate the Western development model.

Conclusions

The human ecological analysis looks for the reasons for biodiversity loss beyond the often-cited biological causes, such as habitat loss or the introduction of exotic species. By pointing out the economic and social drivers of habitat loss and related biodiversity threats, the human ecological analysis provides a most useful complement to the biological analysis of the biodiversity problem.

Although there is ample evidence for the theoretical background behind the policy, economic and social drivers of biodiversity loss, experimental evidence for most of the causes of this loss is fragmented, meager or non-existent. Although many of these relationships are complex, it is imperative to enhance research on the causal links between biodiversity loss on the one hand and economic policy, production and consumption patterns, culture, internalisation of environmental costs, globalisation of the economy and poverty and inequality on the other hand. Theory alone offers insufficient arguments to tackle the current root drivers of biodiversity loss.

Of core importance in this discussion is the question as to whether conservation policies will be able to compensate for the current fundamental root causes of biodiversity loss. Current policies in this area include Rio's Biodiversity Convention, the CITES Convention to limit trade in endangered species and a wide array of national policies on nature conservation. Both the international and the national policies are characterised by a great deal of reactive reflex towards the drivers of biodiversity loss. Few regulations, such as the Biodiversity Convention and its royalties aspect proposal, entail proactive measures. Moreover, the Biodiversity Convention is outstanding in that it is not only targeted towards conservation, but takes the different dimensions of sustainable development into account. It is, therefore, important to develop more mechanisms and regimes of this kind, not only to prevent further degradation of the biodiversity resources, but also to reverse the current trend of continuous loss of biological species and cultural assets.

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