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Economics is the driving force of today's widespread environmental destruction. Markets undervalue the earth's resources and compound their overuse. Since World War II the world has used resources voraciously. The situation can be described as the industrial countries overconsuming resources, which are overextracted and exported by developing countries and traded at prices that are lower than the social costs. Resource-intensive patterns of growth and trade are inefficient for the world economy, and lead to tragic misdirection of the Earth's riches. They should be replaced by knowledge-intensive patterns of growth. Information technology and the environmental agenda are two of the most important trends in the world economy. Together they can lead to growth that is intrinsically compatible with the environment.

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What is the economic value of the Earth's resources? The question is classical and has more than one answer. Market economies value goods and services by their market prices. These are the prices that clear markets, equating supply with demand. They simultaneously reflect costs of production and consumer preferences.

Under ideal circumstances market prices lead to efficient patterns of resource allocation, which cannot be improved so as to make everyone better off. These are valuable properties, buttressed by theory and by some economic evidence. Yet there is increasing unease today about the pricing of resources. Physical scientists question economic wisdom, and the matter has become the subject of popular debate.

Part of the problem is the lack of organized markets. The problem is acute in the case of water and air. There are no organized markets, and therefore no market prices, for either. In some cases, users pay for water, but the price is divorced from competitive markets, and therefore from efficiency. In the case of air, a further difficulty emerges: one individual cannot easily choose air quality independently from others. For such goods, called 'public goods', standard markets do not work well. Efficiency is lost. The problem of pricing resources is pervasive. In practice, many scarce and valuable resources have zero prices. For example the achievement of cleaner water and air have zero economic value in all systems of economic accounting used today.

Faulty prices compromise the evaluation of economic progress. For example, we burn fossil fuels to produce industrial output. This output has an economic value, but clean air does not. Therefore, burning fossil fuels has an unequivocally positive economic value, and counts as economic progress even as it pollutes the air and can cause climate change. A similar situation emerges with respect to the world's forests: the destruction of a forest in order to extract its wood or to grow agricultural products has an unequivocally positive value, and is counted as economic progress all over the world. This is a world increasingly concerned with the survival of its forests and with its clean air and water, this vision of economic progress defies common sense. It is now under close scrutiny. It has been pointed out that markets for environmental assets may never emerge, and that, even if they do, they may not act efficiently. Wider notions of economic value are being proposed by some, including myself, in an attempt to reconcile equity and efficiency, as well as to balance the weight given to the present and the future. This article cannot, and will not, cover all the issues, important as they are. It will discuss basic needs and environmental markets. As an organizing theme, I will propose that we must now focus on the choice between two fundamentally different, patterns of growth: resource-intensive and knowledge-intensive. One works and the other doesn't. Economic progress is not doing more with more; it is doing more with less.

Before suggesting solutions, however, one should understand the nature of the problem: what is driving our unease? Why is the question of economic valuation of the Earth's resources now timely and somewhat controversial? What is the source of the problem? To answer these questions a brief review of the situation is required.

The global environment today

Human beings, or their close genetic relatives, have lived on Earth for several million years. Yet only recently has human activity reached levels at which it can affect natural processes such as the concentration of gases (CFC, CO2) in the atmosphere of the planet, the stability of the global climate, and the complex webs of species that constitute life on earth. There is no consensus about the magnitude of these impacts, but it is widely agreed that, for the first time in recorded history, economic activity has reached levels at which it can alter the planet's atmosphere and endanger its biodiversity.

At the June 1992 Earth Summit in Rio de Janeiro, 150 countries chose three areas in which concerted international action is urgently needed - Biodiversity, Climate Change, and Sustainable Development -
Box 1. The North-South contrast

Most of the damage to the global environment originates in the industrial countries that house less than 30% of the world's population. The industrial countries use the overconsumption of environmental resources, which are largely underextracted and overexpended by the developing countries. About 70% of the world's carbon dioxide and most CFCs are emitted by the industrialized countries in the north. These countries have also substantially altered their climate: most of the world's remaining biodiversity and forests are in the developing countries, mostly in the South. The North-South contrast is striking: the average inhabitant of an industrial country consumes nine times more forest products, six times more beef, 16 times more copper, and a half times more wood and emits twice more carbon than the corresponding average person in a developing country. Replacing the North's pattern in the South, which consumes most of the world's resources, poses a threat to biodiversity and sustainability.

Since the North has the lowest population growth, despite all publicity to the contrary, global environmental damage is, and always has been, inversely related to population growth. This trend could, of course, be reversed in the future, and regions with rapid population growth would produce most environmental damage 20 years from now.

and created corresponding 'Framework Conventions'.

Resource prices and overconsumption

On the whole, the situation today can be described as the industrial countries (the North) overconsuming environmental resources, which are overextracted in the developing countries (the South). While the North houses less than one-third of humanity, it consumes most of the world's exhaustible resources, such as fossil fuels, metals and minerals, and most of the renewable resources obtained from fertile land, such as wood, livestock and cotton. Contrary to common wisdom, the less populated regions cause the most global environmental damage. Box 1 summarizes the overall situation.

Mineral fuels provide an extreme case of delivery of a primary, nonrenewable resource from developing countries to industrialized countries. Nearly three-fourths of Southern exports of mineral fuels are sent to the North, and 60% of the North's consumption of mineral fuels comes from the South. Latin America exports mostly resources — indeed about 70% of its exports are resources — and Africa does so almost exclusively. The US, with less than 5% of the world's population, consumes an enormous quantity of materials: it has followed a voracious trend which accelerated after World War II (Ref. 8).

The pricing of resources is a crucial aspect of the problem. The world's rapid rate of consumption of fossil fuels is linked to the low international prices of petroleum. The same problem arises in the overuse of forests as a source of wood and wood pulp. The lower the prices, the higher is the consumption. Overconsumption is practically synonymous with underpricing (see Box 2).

How has this situation evolved? Why have we reached this pattern of overextraction and overconsumption of the world's resources, beyond the point of sustainability? Equivalently, why are the world's resources traded at such low prices?

Prices, basic needs and the measurement of economic progress

Do market prices fail to convey the true value of the earth resources? If so, how can we improve upon this situation?

These questions led me in the mid-1970s to create and develop "basic needs" as a central concept of economic development, and to be used as an empirical measure of economic progress in five countries in order to confront and sharpen standard measures in the areas where they fall short. Basic needs are those goods and services that are necessary for human effective integration in their societies, for example, food, shelter, education and health. They are to a certain extent culture-dependent. I proposed that the satisfaction of basic needs of the population should be a minimum requirement for economic progress, and explored the connection between basic needs and sustainable development across the world. Subsequently, my concept of basic needs became a standard aim of development. It is central to the concept of sustainability given in the Brundtland Report, and was adopted by 139 nations as an explicit objective in the United Nations (UN) Agenda 21, at the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro. Despite the international acceptance for basic needs-based development, the problem persists. The question remains: why have we reached this pattern of overproduction and overconsumption of the world's resources, beyond the point of sustainability?

The past 50 years

The onset of today's acute global environmental problems can be traced to the past 50 years. Economic activity has been the driving force, the leading cause of environmental degradation and biodiversity loss. The destruction of biodiversity over the past 50 years is comparable to, or at least leading to, a mass extinction event like the one that led to the disappearance of the dinosaurs. The emissions of greenhouse gases followed a similar pattern: from 1860 to 1950, worldwide consumption of fossil fuels for energy consumption released an estimated 187 billion metric tons of CO2; however, over the past four decades, the rate of emissions was eight times higher, amounting to a total of 558 billion metric tons of CO2 (Ref. 8).

Today's unease reflects the awareness that the environmental problems we face are new, or of an order of magnitude that was not apparent before. What happened over the past 50 years, and why?

The post-war world

Fifty years ago World War II was won by the Allies. The United States of America, which led the victory, emerged with almost 40% of the world economy, following the destruction of the Japanese and European economies. Today the US is back to its pre-war level, producing approximately 25% of the world's economic output.

After the war major international organizations were created: the UN, and the Bretton Woods institutions — the

Box 2. Resource extraction and environmental damage

Resources are an important source of export revenues for developing countries. However, their extraction can produce major environmental damage. An example is the saltpan mining project in Baja California by Exportadora de Sal, a Mitsubishi subsidiary. It mines salt destined for the international market from an area in which thousands of grey whales migrate to breed, a reserve that is the site of the state of New Hampshire, and registered with UNESCO. This project is opposed by the local Cucapah Indians because it could produce irreversible damage to this migratory species by destroying their breeding grounds, as well as destroying the whales and fisheries that are crucial for the livelihood of the local communities.

Petroleum is another example — an important source of revenue for developing countries. However, oil exploration and extraction contribute to environmental damage in the producing countries. For example, about 50% of the export revenues of Ecuador come from petroleum. Exploration and extraction are largely responsible for extensive deforestation in Ecuador's Amazon forest. About 60% of the population of Ecuador is indigenous and opposes oil exploration and the attendant deforestation.

Overconsumption comes from the US. The price of petroleum varies widely across countries: US consumers pay about 2.5 times less per liter in the US than in Japan and some European countries. The use of petroleum in the US is correspondingly much higher. The US consumes about 25% of all the petroleum produced in the world, and emits about 25% of the world's carbon dioxide, which is almost all of petroleum emissions come from Latin America—Mexico, Venezuela and Ecuador — even though the US is much richer in fossil fuels than those countries are. About 50% of the known recoverable fossil fuel deposits in the world (petroleum, coal, shale oil and natural gas) are in US soil. 

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Box 3. Industrialization and property regimes

In many of the new industrialized countries, industrialization was preceded by the privatization of common property resources. During the period of industrialization, population became large and mobile, and traditional property regimes often worked better in the conservation of local resources than did common property regimes, which become open access de facto. For example, in the United Kingdom, industrialization was preceded by a major change in property rights—the privatization of the commons. The privatization was traced back to the Wessex Act of 1363 in the UK and a good example. The US context is similar and compared to the levels of restriction in developing countries with well-developed property rights on this resource, such as Mexico. This is true even though the US has enormous reserves, which Mexico does not have. The US has about 50% of all the world’s known recoverable fossil fuel deposits,14 while Mexico’s resources are expected to become exhausted early in the twenty-first century. Although the US uses its own resources more carefully, it is the largest consumer in the world, the difference between production and consumption is made up by imports. The US economy is today the largest single importer of oil in the world, consuming about 25% of the world’s production yearly.

International Monetary Fund (IMF), the World Bank, and the General Agreement on Tariffs and Trade (GATT). These organizations implemented the vision of economic growth of the leading nation, the USA: a very resource-intensive pattern of growth corresponding to a rapidly expanding frontier economy, and the domination of nature through technological change. After World War II, the Gross National Product (GNP) was adopted as a universal measure of economic progress. It is the sum of a country’s net value of production of all goods and services computed at their market prices.

Valuing economic progress

Today all countries report their economic performance to the UN based on GNP. Yet some of the most fundamental resources without which humans could not survive, such as water and fertile soil, have zero weight in the GNP. There are no organized markets for water, and therefore no market prices, even though according to World Bank reports, usable water is today one of the most scarce resources in developing countries. Similarly, there is no market and no market price for atmospheric and water bodies and its atmospheric cover, have zero economic value.

International markets have contributed to the problem of misvaluing resources. Since the end of World War II, the world’s economy has grown at a very rapid pace. However, international trade outstripped the overall growth of the world economy by a factor of three. This had important consequences, because most of the misvaluing of resources occurs through international markets. Petroleum is a case in point. In most of the world, petroleum is national property. Its extraction and exports are controlled by the host country. However, there is no accounting for the exhaustion of the resource base, the depletion of the asset itself. Destroying a forest to export wood or pulp increases GNP and counts as economic progress, in a world concerned about the preservation of forests and their biodiversity, economies values deforestation and the destruction of biodiversity as unequivocal progress. Why?

Growth and trade based on inexpensive resources

After World War II, two major theories of economic growth and trade were developed and rapidly diffused. One was the theory of optimal economic growth (of the type made familiar by Robert Solow)15 that originated in the US. It has an ever-expanding view of the economy and of the economy’s use of resources, which parallels the US pattern of development. It defines an optimal steady state as a path along which population growth is exponential, with a potential exponential increase in the use of resources.

The second is the theory of international trade based on comparative advantage, which originated in Sweden.16 This theory was widely applied and developed in the US after World War II. It recommends that developing countries should emphasize resource exports and labor-intensive products, while importing technology and capital intensive goods.

These two theories advanced a vision of development based on unlimited and inexpensive resources. Even today this view is prevalent in the US; it is much less accepted in Europe and Japan. In the US, inexpensive oil is seen as the basis for economic growth,17 almost a birthright of its citizens, a right for which wars can be, and are, fought. Any attempt to redress this view meets with political failure.

These theories of growth and trade have had major implications for the way we use and trade resources in the post-war period. The World Bank and the IMF provided strong incentives to developing countries to follow resource-intensive development and recommended exporting more resource-intensive products as a precondition for loans and other important economic incentives. The IMF still makes the same recommendations today to Russia and Mexico.

The limitations of export-led growth based on labor or resource intensive exports have been known empirically, and have been formalized theoretically, for some time.18-20 Yet the theory of traditional comparative advantages is largely uncontested today in Latin America and Africa—the two continents that have fallen behind in terms of economic growth in the past three decades, while following resource-intensive patterns of production and exports. Even today, a protected intensification of South American mining in the Andean region is viewed as a source of riches for the region and called the new "El Dorado". A doubling of Latin American resource exports to US$25 billion by the end of the decade, mostly through the granting of generous and unobstructed exploration and extraction permits, is heralded as a triumph of markets and economic progress. By contrast, the theory of traditional comparative advantages has never taken hold in the successful "tiger" states of Asia: Hong Kong, Singapore, South Korea and Taiwan. These countries never quite accepted this way of thinking. Instead, they have instead a view of dynamic comparative advantage; instead of basing their growth on resources or cheap labor, they shifted swiftly into technology-intensive products. The three members of the Association of Southeast Asian Nations (ASEAN), Indonesia, Malaysia and Thailand, are also interesting examples. Malaysia took the resource-intensive route but rapidly shifted to technology-intensive development. These countries represent a stark contrast to Africa and Latin America, and confirm a new vision of development and trade that is gaining ground17-22, and to which we now turn.

Traditional comparative advantages

Is it true that developing countries have a comparative advantage in environment-intensive products, such as cash crops and minerals, and in dirty industry, which uses clean air intensively? If so, does efficiency dictate that this comparative advantage should be exploited, to everyone’s benefit? In sum, is there a fundamental contradiction between economic gain and environmental preservation?

The answer to these questions is no. The export patterns we observe in developing countries do not follow the law of comparative advantage, nor any other law of economic efficiency. Nor is the world better off in economic terms when the South specializes in the export of resource-intensive products, which damage the environment. The whole thing is a tragic misunderstanding of growth and trade. The correct answer to this question is simple, and it leads to a new theory of why
Box 4. Property rights and international trade

When the property rights on environmental resources, such as forests, are ill-defined, at each price the country offers more resource-intensive goods, such as wood, to the international market. The country has an apparent comparative advantage, even when there is none. This argument explains why countries trade with each other based on differences in property rights regimes between the trading regions. Countries with ill-defined property rights in resources, such as most developing countries, will export resource-intensive products that are associated with higher income property rights, the industrial countries. There may be no gains from trade. Yet the exporter country is not better off, nor is the world better off when the developing countries specialize in resource-intensive products. The gains are merely derived from increased levels of resources.

Under these circumstances, export-led policies based on resource-intensive products lead to apparent gains from trade, even when trade leads to actual losses. A similar argument holds for products that are not competitive in some markets. For example, Mexico exports timber to the US even though it has no comparative advantage in wood products. The US, a major timber consumer since the 1970s, has 30% of the recoverable fossil fuel resources on the planet.

Countries trade resources, and how these resources are valued. It hinges on differences in property rights in the trading regions.

Property rights and industrialization

Many traditional societies have successfully managed their common property resources, such as fisheries and forests, using traditional forms of governance. The term 'common property' refers to ownership that is shared by a group, rather than individual ownership. An example is the common tenancy system of management common lands in Japan, and the system of sea tenure in the North East of Brazil. These traditional systems require a small and stable population, where penalties from antisocial abuse of resources can be administered effectively and, if necessary, across generations.

Such systems of resource management tend to break down in the period of industrialization in which outsiders move into the common property area, outsiders who can easily move out and avoid penalties. During the process of industrialization populations become large and mobile and can easily escape penalties from overuse. Well-managed common property is transformed into unmanaged common access resources, which can be had for the taking. A 'first come first served' system prevails.

Property rights explain prices and trade

When a pool from which a resource is extracted, such as a forest, is treated as open access, the only cost computed is the cost involved in the actual extraction. Often this is just the time and energy it takes to cut and remove the tree. The cost of replanting the tree to ensure the continuation of the forest is not considered.

The loss of the services that the forest provides to human settlements, such as providing an ecosystem for biodiversity, shelter, stable climate and food are not computed. Similarly, in the extraction of a natural asset such as petroleum, the only costs computed are those of exploration and extraction: the exhaustion of the resource base itself; that is, its depreciation, is not counted as it is in the case of private property. Nor are the costs from deforestation during the process of exploration for petroleum, for example in Ecuador's Amazonas. Because costs are under-valued, the net benefits from extraction are overstated. At each market price, more is extracted under open access regimes than under private property regimes or under traditional managed systems. Hence, the resource is overextracted, it dwindles and often disappears.

The country with open property rights offers more of the resource to the international market than is efficient. At each market price the quantity offered is greater with open access than it is with private property. This leads to an apparent comparative advantage in the production of environmentally intensive products, even when there is no real comparative advantage (see Box 4).

This explains why developing countries, which have on the whole ill-defined property rights for environmental resources, export resource-intensive products even if they have no comparative advantage in such products. It explains why resource-intensive products such as refined oil, wood and food are exported at such low prices, below real costs. Resources are overconsumed by the countries with well-defined property rights and overproduced by those with ill-defined property rights. As a result, the world economy consumes an inefficiently large quantity of resources. This is called green accounting (see Box 3). The procedure requires, however, that environmental assets be priced correctly. How is this to be achieved?

Environmental markets and prices

Where will prices for forests, water, biodiversity and clean air come from? Economists say from tree markets. There is a lot of merit as well as optimism in this premise: under ideal conditions, market prices lead to efficient outcomes that represent the preferences of the population. Water markets are currently emerging in California, the Chicago Board of Trade already trades rights to emit SO2, and I recently proposed global markets for global CO2 emissions.

But we can't trade unless we know what we need property rights on forests, water, air and biodiversity. Can we carefully parcel out the universe and assign property rights on each piece? This seems a tall order, perhaps too tall for the world.

Box 5. Green accounting

A proposal that is currently under consideration by the UN is to modify the system of national accounts to incorporate environmental costs. Green accounting is the practice of deducting environmental costs from the calculation of the GNP. For example, the national accounts would depreciate the value of the stock of forests and minerals extracted, in much the same way that private individuals and corporations depreciate the value of their own stock of assets when reporting their personal or corporate income.

Green accounting could help in reducing the misuse of resources, and their excessive extraction by reporting the costs from extraction more accurately. Under green accounting, the export revenues are higher, but the increase is only a fraction of the asset exposed is subtracted from the equation. This can help correct the problem of lack of property rights on resources, which reduces the misleading view of considerable advantages and gains from trade by overstating the net, value of extraction and exports. Green accounting can make a large difference in reporting economic performance in resource intensive countries. The GNP of Costa Rica and Mexico were recently recomputed using this practice, and they both dropped to a fraction of their former level as computed from standard practices.
urgency with which some feel the environmental problem must be tackled.

**Efficiency and equity in environmental markets**

Even if the universe was parcelled out successfully, a problem remains: how to distribute property rights? How to assign its pieces across people, regions or even across generations? This is a problem of equity. It is generally of no importance for the economic efficiency of competitive markets with private goods, as they are usually defined, although of course it matters on ethical grounds.

However, the neat separation of efficiency and equity may not work in markets in which environmental assets are traded. It is important to understand why. Often it is not possible for different individuals to choose different quantities of environmental assets independently from each other, as required for efficient markets. For example, the concentration of CO₂ in the atmosphere of the planet is relatively uniform and stable, and everyone in the planet is exposed on the whole to the same concentration. The total biodiversity in the planet, regardless of the way it is measured, is the same for us all. These constraints are physical, not economic or legal. For this reason, biodiversity and CO₂ concentrations are often called 'public goods', and their sources are 'global commons'. These are, however, unusual public goods in that they are produced privately.

A new finding is that only particular 'equitable' distributions of a given total of property rights can lead to efficient markets in those markets with privately produced public goods. It was recently established that only with such distributions of property rights one can ensure that market prices will lead to efficient allocation of resources (see Box 6).

**Knowledge-intensive growth**

Property rights must be sorted out properly for environmental markets to achieve efficiency. This requires careful market design, and will not be achieved immediately. In emergencies, taxes or bans on the trading of species that are close to extinction may be necessary. Examples include trade in elephant tusks, in tiger parts, in US box turtles, commercial hunting, and more recently the meat trade in the UK. Trade in human parts has related aspects. Humans' irrational cruelty to animals — and to each other — admits on occasion no other restraints.

Is it possible to rectify patterns of trade and development without interfering with free trade? To a certain extent this is possible. The trade strategies followed by the Asian Tigers — Japan, Korea, Taiwan, Hong Kong and Singapore — and more recently the Little Tigers, such as Malaysia, provide good examples. These countries have moved away swiftly from traditional comparative advantages, such as labor-intensive and resource-intensive products, into knowledge-intensive products, such as microprocessors, consumer electronics, communications, financial products, and many other technology-based products. These knowledge-intensive sectors are the most dynamic sectors in the world economy today.

A possible development strategy is to emphasize knowledge-intensive rather than resource-intensive sectors. This economic strategy was introduced formally a few years ago, and received further impetus from the empirical evidence of world development, some of which is discussed here.

The knowledge-intensive sectors listed above require human capital and know-how rather than large plants and equipment. Furthermore, these sectors often compete, and therefore efficient the computer hardware industry is a good example.

The skilled labor required for knowledge-intensive sectors is available in many developing countries (Box 7). It is well known that Mexico is currently a producer of electronic products such as microchips and software, and that India could become one of the largest exporters of software in the world. Software is very labor-intensive and suits the Indian and Mexican economies as it does not require large capital outlays. More recently Baradast's government announced its determination to transform the country into an information age society in less than a generation, based on its excellent educational system.

**Conclusions: information and resources**

Knowledge-intensive growth is successful in economic terms. It drives the most dynamic sectors in the world today. For the purposes of this article, however,
its most important aspect is that knowledge-intensive growth does not require intensive use of the environment. It is intrinsically compatible with the global environment.

Information and resources appear to be the most important trends in the world economy today, and if properly understood and harnessed, could lead to economic prosperity that is harmonious with the global environment.

How will all this affect the economic value of the Earth's resources? As we change our emphasis away from resource production and exports, the world's available supply of resources will decrease. Therefore resource prices will increase. This means that resources will be better valued, and this is as it should be. By underlining the Earth's resources we undervalue ourselves.

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