CHAPTER 6

PROPERTY RIGHTS AND EFFICIENCY OF MARKETS FOR ENVIRONMENTAL SERVICES

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Abstract. The origin of today's global environmental problems is a historic difference in property rights regimes between industrial and developing countries, the North and the South. Generally, resources such as forests and oil deposits are under well defined and enforceable property rights, mostly private property regimes, in industrial countries but they are under ill-defined and weakly enforced property rights, mostly community or state property regimes but de-facto open-access regimes in many cases, in developing countries. Ill-defined and weakly enforced property rights lead to the over-extraction of natural resources in the South. They are exported at low prices to the North that over-consumes them. The international market amplifies the tragedy of the weak property regimes, leading to inferior solutions for the world economy. In developing countries, the conversion of natural resources regimes from community or state property regimes to private property regimes faces formidable opposition due to heavy dependence of local and poor people on these resources. The weakness of property rights in *inputs* to production, such as timber and oil, could be compensated by assigning well defined and enforceable property rights to products or *outputs*. The 1997 Kyoto Protocol provides an example as it limits countries' rights to emit carbon, a by - product of burning fossil fuels, but the atmosphere's carbon concentration is a public good, which makes trading tricky. Similarly, trading rights to forests' carbon sequestration services involve public goods. Markets that trade public goods require a measure of equity to ensure efficiency, a requirement different than the markets for private goods

1. INTRODUCTION

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 fundamental natural processes—such as the concentration of gases in the atmosphere, the planet's water mass, and the complex web of species that constitute life on earth. Scientists find that the most environmental damage has occurred in the last 50 years, the period in which the human species has consolidated its dominance of the planet and has embarked in an unprecedented rapid phase of industrialization. Our current global environmental problems originate from the tremendous industrial growth in the world economy since World War II. Fueled by abundant and inexpensive raw materials, most of which were exported by poor countries and imported by industrial countries, this industrialization has been voracious in the use of natural resources. In the last 50 years international trade grew three times faster than the countries themselves—and with them grew the international demand for

energy derived from fossil fuels, and the demand for other natural resources such as wood, which are extracted from developing countries' forests.

International trade in natural resources is directly implicated in the current global environmental problems. Most of the natural resources we use worldwide are extracted from developing countries, where they are usually held under conditions of ill-defined and/or weakly enforceable property rights such as state and community regimes which are in many cases de-facto open-access regimes, and end up being consumed in the rich industrial countries. In a divided world economy in which poor countries trade with rich nations, ill-defined and weakly enforceable property regimes of natural resources distort the market behavior, and these natural resources from developing nations are sold internationally at low prices. Low resource prices leads to poverty at home, and to over-consumption in the rich nations that import them. Most of the planet's carbon emissions come from oil that is burned in rich nations. The US, for example, imports most of its oil from developing nations—and it is the largest oil consumer in the world, generating 26% of the planet's carbon emissions. Now we know that carbon emissions could change the global climate and become catastrophic for the survival of the human species.

Even though international markets are currently at the root of the problem, this chapter suggests that they could also be instrumental in providing solutions. Global resource markets play a key role in the problem—and a solution may be found in markets involving global public goods, such as markets for trading the rights to emit. A word of caution is needed here. Emission markets that trade `rights to use the planet's atmosphere' are in reality trading global public goods, and as such very different from the markets that economists have known for centuries. Following our recommendations, global emission markets appeared in the United Nations Kyoto Protocol created in 1997 by 166 nations at the United Nations Framework Convention for Climate Change UNFCCC (Chichilnisky 1995, 1996; Chichilnisky and Heal, 2000). Markets for emission trading are key to the global environment—and global equity issues are important for the efficient functioning of these global markets. A resolution of the global environmental problems that concern us today depends therefore upon achieving a measure of equity in the global economy (Chichilnisky 1995, 1996; Chichilnisky and Heal, 2000). While often competing objectives, the notions of equity and efficiency now converge in a world economy that is increasingly dominated by goods and services based on environmental resources and on knowledge—both of which are global public goods.

This chapter examines the economic issues underlying the origins of today’s global environmental problems and will seek solutions. Markets are implicated in the problem, and are part of the solution, but economics needs to be developed further to understand and foster the functioning of markets involving privately produced public goods, such as the global emissions markets. To ensure the proper functioning of these markets new institutions are needed, as discussed at the end of this chapter.

2. MULTIPLE PERSPECTIVES ON GLOBAL ENVIRONMENTAL PROBLEMS

Global environmental problems include the impact of Chlorofluorocarbons CFC's on the ozone's layer of the atmosphere, the loss of the planet's biodiversity, the problem

of acid rain, and the international transport of SO_2. Ozone depletion was successfully tackled by the international community through the Montreal Protocol of 1987, which restricted the use of CFC's in industrial products. With respect to greenhouse gas emissions, in 1996 the Intergovernmental Panel on Climate Change (IPCC) reported that human-induced emissions of carbon and other greenhouse gases have a `discernible effect on climate'. While some uncertainty still surrounds the scientific evidence on climate change, the risk of climate change is now known to be real, and potentially catastrophic. The greenhouse effect is a typical example of a problem of global commons, where no single country can tackle this problem on its own and an international cooperation is necessary.

2.1 Global Environmental Problems and Economic Incentives

Global environmental problems are driven by economic incentives. Human energy use contributes almost half (49%) of the green house gases while industrial processes contribute almost a quarter (24%). The two other sources of green house gases are deforestation (14%) and agriculture (13%) (WRI, 1990). Hence, the threat of climate change is driven by the use of energy that increases with industrialization. Across the world, energy is produced mostly by burning fossil fuels—leading directly to higher emissions of greenhouse gases. Biodiversity destruction is led by the destruction of habitat in forests—for economic purposes. Forests, where most known biodiversity resides, are cleared for the extraction of natural resources (such as oil and wood products) or for growing cash crops and grazing livestock. These products go mostly to export markets. CFC emissions that damage the ozone layer originate from industrial products.

While the causes of global environmental problems are economic, the initial effects are physical or biological. Because the effects are physical, economists underestimate them. Since the causes are economic, physical and biological scientists cannot find solutions. Hence, global environmental problems, such as climate change, require thinking and acting across social and physical disciplines, which is a major challenge in the era of dominance of compartmentalized approaches across different disciplines.

2.2 Global Environmental Problems and Population

Many believe that global environmental problems emanate from the enormous growth of human population on the planet. The term "population bomb," created by Paul Ehlrich more than twenty-five years ago, symbolizes this perspective. The view has been erroneously used to imply that the developing countries—whose populations grow on the whole faster than industrial nations—are the main source of danger to the global environment. The view is not without merit but misses the main point. Yes, global environmental issues are related to the human dominance of the planet. Indeed if there were no humans, the problem would cease to exist; this is what I call the `ultimate solution'. However the regions in the world with fewer humans and with lowest population growth are the ones responsible for most of the problems.

Developing nations have higher rates of population growth on the whole. However, it is widely known that developing nations and the regions of the world with the highest population growth are not the main cause of global environmental damage; they contribute far less to the global environmental problems than countries with lower population growth. This is because it is industrialization that causes the environmental problems we have today and not population pressures by themselves. The most industrialized regions have lower population growth, but are the main cause of biodiversity loss, carbon emissions, and CFC emissions. Data regarding the share of world carbon dioxide emissions, population, and GDP, for Industrial and Less Developed countries, is given in Table 6.1.

Table 6.1: Share of the Total World Carbon Dioxide Emissions, Population, and GDP (in terms of purchasing power parity) for Industrial and Less Developed Counties

Countries	Cumulative CO_2 emissions	Current CO_2 emissions	Population	GDP
Industrial	70%	60%	24.5%	68.5%
Less Developed	30%	40%	75.5%	31.5%

The data in table 6.1 clearly indicates that the usually drawn connection between global environment problems and the population is incorrect. Historically and currently, economic output is the major determinant of carbon emissions. Indeed, industrial countries account for 68.5 of world GDP and emit 60 to 70% of CO_2 emissions, though having only 24.5% of the population. Reciprocally, developing countries have 75.5% of the world's population, 31.5% of GDP and account for only 30 to 40% of CO_2 emissions. Hence, there is a direct positive relation between GDP and CO_2 emissions, but a direct negative relationship between CO_2 emissions and population. If the currently less developed countries eventually become the major polluters, it will be because of their industrialization, not their further population growth. Ehlrich's predictions of run-away population growth in the planet have in any case proven incorrect.

2.3 Global Environmental Problems, the Concept of Basic Needs, and Sustainable Development

To address global environmental problems, in 1974 I introduced a way to measure economic progress that is different from GDP—the concept of development based on the `satisfaction of basic needs'. The basic needs approach does not assume GDP to be the defining feature of economic progress, but rather measures such progress by the satisfaction of the population’s basic needs. This concept was introduced to make economic development patterns more consistent with environmental constraints and was developed in empirical and mathematical studies undertaken in 5 continents, within the Bariloche World Model (1974, 1976). This led directly in

1987 to the Brundtland Report, which introduced the concept of Sustainable Development in the Earth Summit in Rio de Janeiro, Brazil. Sustainable development is based on the satisfaction of Basic Needs. But the Brundtland report links the basic needs of the present and those of the future: the definition proposed here for Sustainable Development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987)

2.4 Global Environmental Problems and North–South Issues

After World War II, the US economy accounted for 40% of world output, following the destruction of Germany and Japan. Today the US share is back to 25%, as it was before the war. Following World War II, the US pattern of economic development became a global benchmark. Based on rapid industrialization, it was fuelled by a deep and extensive use of natural resources, in this sense being a “frontier” type of growth. Important global institutions were created at this time (the World Bank, the International Monetary Fund, the United Nations and the current system of National Accounts) whose metrics for economic progress reinforced this vision of resource-intensive economic development. Thus the Bretton Woods Institutions created by Lord Keynes played an important role in taking the American global. Keynes saw the role of these institutions as replacing wars by trade—using the differences among nations as a source of gains from trade. His dream succeeded beyond anyone's expectations and in the 50 years since the end of World War II, international trade grew four times faster than the world economy.

The rapid increase in emissions of carbon dioxide of the last fifty years has been due to the burning of fossil fuels linked to intensive energy use for production of goods and services in industrial nations. The globalization of the world economy since World War II has intensified a pattern of resource use by which developing nations extract most natural resources, exporting them to industrialized nations at prices that are often below replacement costs. Through the international market, industrial nations, which house less than a quarter of the world's population consume most forest products (pulp, wood); consume most products produced through the clearing of forests (cash crops such as cotton, livestock including beef and veal); and consume most mineral products (copper, aluminum, and fossil fuels such as petroleum (Table 6.2). Hence, the North's[1] economy represents the main driving force in global environmental problems, producing 60-70% of the world’s CO2 emissions (Table 6.1) and emitting most CFC’s, responsible for the damage to the earth’s ozone layer. Most emissions of greenhouse gases originate in energy use and production (including the production of electricity)—and a major share of the world production is located today in industrial nations. The South emits fewer greenhouse gases into the planet's atmosphere, roughly 30% of the world's total, even though it has about three-quarters of the world's population. At the same time, in the developing countries—which are geographically located on the whole in the Southern hemisphere of the planet—there is currently an intensive and extensive destruction of ecosystems for agricultural production and for mineral extraction, mostly directed towards export markets. Because the industrial countries have already exhausted most of their own forests in their own process of industrialization,

it follows that most environmental resources, such as forests and biodiversity are now found in the developing countries, where tropical deforestation is occurring most rapidly today.

Even though the South has most of the remaining forests and biodiversity, and has produced less damage to the global environment, it is more vulnerable to the ill effects of environmental damage, such as climate change, on its food production, living conditions, and rising of the sea level. The North therefore creates the most risks, but the South bears the brunt of the resulting damage. The origins of today's environmental dilemmas involve the historical coupling of two different worlds through the international market.

Table 6.2: Consumption of Natural Resources by Industrialized and Developing Countries

Resource	Country	1961-1965	1966-1970	1971-1975	1976-1980	1981-1985	1986-1990
Fossil Fuel (giga joules/ person)	Indust.	115.82	142.53	165.7	169.52	153.81	160.06
	Develop.	7.37	8.26	10.34	12.91	14.53	17.28
Alumi-nium (metric tons/ 100 people)	Indust.	5.99	9.00	11.89	13.50	12.56	14.13
	Develop.	0.13	0.23	0.37	0.51	0.58	0.69
Copper (metric tons/ 1,000 people)	Indust.	6.17	7.00	7.46	7.90	7.50	8.06
	Develop.	0.17	0.17	0.26	0.34	0.38	0.48
Beef and Veal (kilograms/ person)	Indust.	24.53	27.37	28.59	29.65	27.69	27.17
	Develop.	3.98	4.06	3.84	4.21	4.05	4.29
Cotton (kilograms/ person)	Indust.	6.91	5.32	5.30	4.70	4.77	5.35
	Develop.	1.93	2.29	2.40	2.29	2.76	2.60

Source: World Resource Institute (1993)

3. PROPERTY REGIMES, MARKETS, AND GLOBAL ENVIRONMENTAL PROBLEMS

3.1 North–South Trade and the Property Regimes of Natural Resources

What explains the pattern of North-South trade in which the developing countries are the main exporters, of fuels and natural resources, to the OECD countries. One

possibility is that there is a geographic coincidence, in which the developing nations are rich in natural resources. This explanation would view the pattern of world trade simply as a manifestation of countries' respective comparative advantages—as traditional theory of international trade would predict. But also playing a substantial role in this pattern of North–South trade is a historical difference between agricultural and industrial societies, a difference in the property rights regimes of natural resources which prevail in these two types of nations. In developing nations natural resources are typically held as state or communal property, for example oil deposits and forests in many countries are often government property. However, in many cases, due to ill-definition of property rights, high-transaction costs of enforcement of well-defined property rights, the lack of financial resources to enforce property rights, physical properties of natural resources, high dependence of local communities on natural resources, and non-complementarity between social norms and property rights, the state regimes become de-facto closer to open-access regimes (Kant, 2000). On other hand, well defined and enforceable property regimes, which are generally private regimes but also state or communal regimes such as forest property regimes in Canada, Italy, and even the USA (about one-third forests are owned by the government), are the dominant category of natural resource property regimes in the developed countries. This difference in property regimes has been shown to lead, through the international market, to a pattern of trade such as the one we observe between the North and the South, in which the latter export resources to the North even though they may not be resource-rich—the industrial countries may be richer in resources themselves.

In a world where agricultural societies trade with industrial societies, international markets can magnify the `tragedy of ill-defined and non-enforceable rights'—the over-extraction of natural resources that typically occurs under open access regimes. The resulting outputs (wood, cash crops, and livestock) are mostly sold in international markets (Barbier in Chichinisky, 1994). Both these natural resource exports and world's use of natural resources exceed what would be optimal or would occur if property rights were well-defined and were enforceable, the conditions which are generally equated with private property rights but can also exist under state or community regimes, and the attendant prices in the global markets are also below what would prevail with well-defined and enforceable rights (private property rights). International markets—even if they work competitively—fail to produce an optimal solution. International trade is therefore skewed, leading to resource exports from countries that do not have a true comparative advantage in resources—and resource imports in countries that do. The historical coupling of the North and the South through the international market leads directly to over extraction of resources in the world, to resources prices that are lower than replacement costs, and to over-consumption of these resources in the industrial countries that import them.

Figure 6.1 contrasts two different supply curves for resources in a domestic economy of the South and illustrates the problem of over-extraction and under-pricing of resources. The steeper supply curve is based on efficient supply behavior in (well defined and enforceable property regimes) private property economies. The price corresponding to each quantity supplied equals the marginal cost of extraction, ensuring a Pareto efficient solution. However, when property rights are not well defined and enforceable, some elements of open-access regime are present, the

supply curve of the resource is `flatter' than the private property supply curve (see Chichilnisky, 1991, 1994)2; at each price the country will supply more resources than it would under private property regimes, with the result that more will be exported than is optimal and that exports will be sold at lower than appropriate prices. Through this process, resource intensive trade leads to an increasingly divided North-South world.

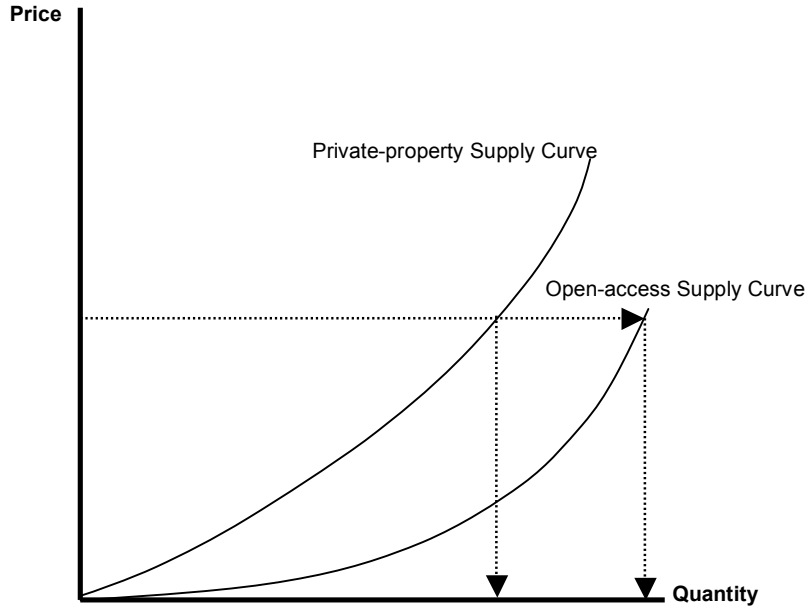

Figure 6.1: Supply Curves for Private Property Regime and a Property Regime with Ill-defined and Weakly-Enforceable Property Rights

3.2 Property Rights and the Atmosphere as a Sink

The problematic North-South trade patterns just discussed could be improved by improving the property regimes of natural resources in developing countries. History suggests that in any case, this would probably occur naturally in those countries that are undergoing a transformation from agricultural to industrial societies. However, privatizing of natural resources in developing countries may be impractical, due to various social and cultural factors, in a reasonable time frame. The world is trying to find a solution to the overuse of natural resources now in order to prevent biodiversity destruction and climate change—both of which are potentially catastrophic and irreversible events.

The lack of well defined and enforceable property rights (private property regimes) in natural resources, which are inputs to production, leads to the overuse of the planet's atmosphere, that is the "sink" in which the outputs are deposited. Over-consumption of petroleum as an input leads, for example, to the overuse of the atmosphere as a "sink" for the greenhouse gases that are part of the output. The

planet's atmosphere is held as "open access regime" in the entire world. Perhaps rather than privatizing on the input side, it would be possible to privatize on the output side, i.e. to privatize the use of the global atmosphere rather than privatizing the developing countries' use of natural resources. One would expect somewhat less conflict in the process of allocating property rights to the use of the atmosphere, simply because these are property rights that have not yet been defined so the problem is still in a more fluid state. This is in fact what happened in the 1997 Kyoto Protocol, which limited the rights to emit green house gases of Annex B countries—the industrial nations. The Kyoto Protocol is an international attempt to determine various countries' property rights to the use of the atmosphere as a `sink' for greenhouse gases associated with burning of fossil fuels and other industrial activity.

3.3 Global Emissions Markets, Efficiency, and Equity

Assigning property rights in the use of the planet's atmosphere is a first step. The Kyoto Protocol goes further, offering also a first step in the creation of global markets for trading such rights. These `global emission markets,' are a historical first. Emission markets by themselves are not new though they are still unusual—they have a short but successful history. In the US where the Chicago Board of Trade introduced tradable permits to emit SO_2 they have been deemed very successful and cost effective in the reduction in emissions of sulphur dioxide by power plants in the US.[3] But the Kyoto Protocol offered the first opportunity to trade a global public good—the use of the planet's atmosphere—by trading the rights to emit greenhouse gases.

Once global emissions markets are created—and it is expected that some time will pass before they are, the next challenge is to ensure that they be efficient. Successful markets require good regulation—the best in the world are regulated, not to restrict trade but to ensure healthy competitive conditions. For example, the Securities Exchange Commission (SEC) in the US is active in promoting the sharing of information in securities markets and penalizes `insider trading' in which asymmetric information exists. Efficiency of emissions markets however requires different conditions than efficiency of standard private markets. New economic findings establish that there is a deep connection between the distribution of property rights (rights to emit) and the efficient performance of markets with privately produced public goods—such as the use of the planet's atmosphere (cf. G. Chichilnisky and G. Heal 2000).

Efficiency in trading permits requires that more emission rights be given to the developing countries (i.e. than they would have under an auction system where such rights had to be purchased in the market, Figure 6.2)—just as provided in the Kyoto Protocol. Indeed, the Protocol places no constraints on the emissions right of developing nations—all its restrictions are on Annex B countries which are industrialized. Therefore it implicitly provides more emission rights to the developing countries. But what is the connection between efficiency in emissions markets and the emission rights given to developing countries? Conventional wisdom has been that the distribution of property rights does not affect the efficiency of markets. Standard economic thinking is that equity and efficiency are

independent of each other in competitive markets and indeed often orthogonal to each other as well. What makes this situation different?

The so called "Coase theorem" has shown that equity and efficiency are unrelated in those markets that have the capacity to internalize externalities. This means that where externalities exist, assigning property rights and allowing them to be traded leads to Pareto efficient solutions no matter what is the initial distribution of property rights. The textbook case is the property rights to pollute that are assigned to a factory producing `soot' that interferes with a laundry's capacity to produce clean clothes. The externality here is the `soot'. One compares the rights of the factory to emit soot to the rights to clean air of the laundry itself. Coase showed that at the end of the day it does not matter who gets the rights to pollute or to breathe clean air; as long as property rights are assigned clearly and the parties are allowed to trade them, the market solution will be Pareto efficient. Of course, the assignation of rights does affect the welfare of each of the traders and therefore the equity of the situation, but it does not affect the efficiency of the market solution. Why does this widely accepted result not apply to our case? Why is equity in the assignment of carbon emission rights connected with the efficiency of markets?

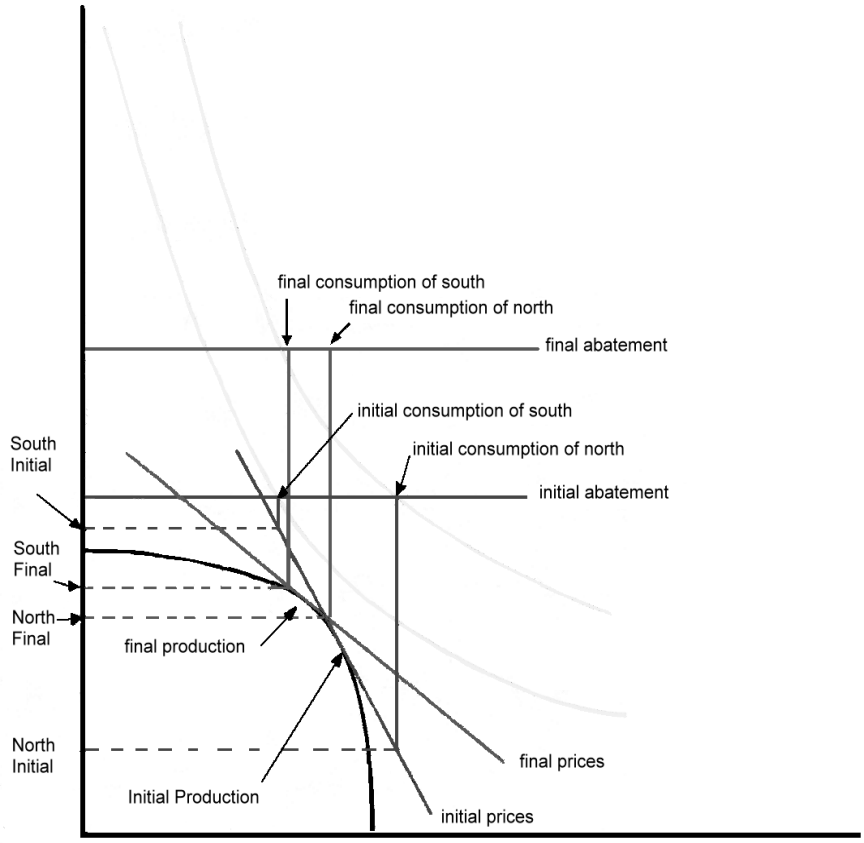

Figure 6.2: Redistributing initial property rights on emissions yields a net Pareto improvement for both the North and the South

Global emission markets for CO_2 are different, because they involve a global public good, namely the quality of the atmosphere of the planet as measured by its concentration of CO_2. In Coase's case, the initial distribution of rights does not matter because he considers markets involving private goods, goods that are 'rival' in consumption, such as soot. The soot that the factory deposits on the laundry's clean clothes is `rival'—whatever soot is deposited on one shirt, it is not deposited on another shirt. The situation however is different in the case of CO_2, which spreads very evenly and stably throughout the entire planet's atmosphere, requiring 60 years to decay. These are physical properties of carbon dioxide, which do not depend on social organization. They make carbon dioxide concentration a global public good: the result is that everyone in the planet is exposed to the same concentration of CO_2, in China as well as in South America, Europe or Australia The concentration of carbon in the atmosphere is the same for all—it is a global public good. And markets that trade the rights to emit carbon are therefore markets trading a global public good. Carbon dioxide is in addition a different kind of public good (or "public bad")

from the traditional category of public goods produced by governments, such as roads and law. Carbon dioxide is produced by individuals as a by-product of private activities such as heating one's home or driving one's car. Trading of carbon emission rights exemplifies a market for privately produced public goods, an unusual market, of a type that economists are not used to. Such markets are increasingly important, however, because they include also the trading of knowledge rights. Like carbon concentration, knowledge is a privately produced public good and one that is fast becoming the most important input of production in advanced societies. Markets with privately produced public goods are new and different but should not be considered exotic. They are possibly the most important type of markets in the new century.

Market efficiency in the case of privately produced public goods requires an additional condition which alters fundamentally Coase's conclusions; this is the Lindahl, Bowen, and Samuelson condition whereby the marginal rate of transformation equals the sum of the marginal rates of substitution among the traders. In effect this means that the marginal private benefit to the firm or individual from the activity which causes an emission is equal to the sum of the marginal private costs (damage) to all those who are negatively affected by it. This latter condition derives from the `non rivalness in consumption' characteristic of public goods—at the end everyone consumes the same amount of the public good. In the present case, everyone in the world is exposed to the same concentration of carbon dioxide in the atmosphere.

This additional condition required for efficiency `over-determine.' the market equilibrium. Therefore while market solutions exist, they are not efficient in general. New policy tools are required to reach and implement efficient market solutions. It turns out that the distribution of property rights across nations on the global public good, is the right tool and has the right dimensionality to solve this problem. Distributing properly these initial rights to emit allows one to reach solutions that clear the markets and are, simultaneously, efficient in the use of the global public good. This, in a nutshell, explains the tight relation between efficiency and equity in markets for global public goods.

Equity is an important consideration for developing nations in the climate negotiations. Industrial countries have emphasized, instead, market mechanisms and economic efficiency as their own priority. The unexpected connection that we discussed between equity and efficiency may therefore provide a way to reconcile the priorities and interests of the North and the South. Since North-South conflicts of interests have led to debate and delays in ratifying and implementing the Protocol, an overlap in interests of the North and of the South is welcome. However, the connection between equity and efficiency that emerges here is new in economic terms, and it is not still completely understood. More economic work remains to be done, academic as well as diplomatic and political. Properly interpreted and implemented, however, the Kyoto Protocol may signal the way to a sustainable future.

4. CONCLUSIONS

The origin of today's global environmental problems is the historic difference in property rights of natural resources in industrial and developing countries, the North and the South. The lack of well defined and strongly enforceable property rights leads to the over-extraction of natural resources in the South. These resources are exported at low prices to the North that over-consumes them. The international market amplifies the problem of property rights, leading to inferior solutions for the world economy (Chichilnisky 1994). Updating property rights on natural resources faces formidable opposition. However, the lack of property rights in *inputs* to production could be compensated by assigning property rights on *outputs*. The 1997 Kyoto Protocol is a right step in this direction. Yet trading emissions rights is tricky, because the quality of the atmosphere is a *public good*. Global emissions markets are therefore different from the market of private goods. A measure of equity is needed to ensure efficient trading in these types of markets (Chichilnisky 1996, 2002), and is fortunately built into the Kyoto Protocol.

In addition to carbon sequestration, biodiversity and watershed services are among the other most valuable services that forests provide. Here again, assigning property rights to localities or nations on the use of genetic blueprints that are obtained from their forests would be a step in the right direction. Biodiversity, as any other form of knowledge, is a public good and therefore the observations made above about the properties of markets with privately produced public goods will apply (Chichilnisky and Heal 2000).

New institutions are needed at the global level to implement these solutions. In Chichilnisky (1999), I proposed the creation of an *International Bank for Environmental Settlements*, a self-funding institution that would help administer the rights to the global public goods such as the assignment of emissions rights on a global scale. This institution would have as mandate to derive economic value from the environment—such as economic value carbon sequestration services, and genetic blueprints from developing nations' forests—without destroying them.

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[1] Most of the industrial countries are located in the Northern hemisphere, and are therefore often referred to as "the North".

[2] Using a game-theoretic approach introduced in Dasgupta and Heal (1979) to explain the Nash equilibrium.

[3] Other examples of environmental markets are mentioned in Chichilnisky (1996) and in Chichilnisky and Heal (2000).