

The Missing Signal: How Ecological Prices Change Markets and Decision Making

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I. Overview: Scarcity and Market Prices

Asian and Pacific nations have become an engine of growth for the world economy. Yet they are increasingly vulnerable to environmental pressures and scarcities exerted by their growing economies and populations. The region is dependent on a wide range of ecosystem services, including provision of food and timber, minerals, water capture and filtration, flood mitigation and regulation of rivers, precipitation and hydrological systems. These services provide an important form of capital for regional

economies, and are becoming increasingly scarce. Yet there is increasing demand as regional economies and populations grow. The degradation of ecosystems continues because of a lack of explicit focus on the economic benefits that they provide. In standard markets scarcity increases prices, providing a signal to restrain use. But the signal is missing for ecological assets. Most of these assets have no standard market prices. Markets treat most natural resources and their services as free goods, since they were practically unlimited for many centuries. In a world economy where market prices measure economic progress, the missing signal puts at risk ecosystems services that are needed for human survival.

Ecological assets produce two distinct economic effects: (i) products and services that have a standard market price such as wood and food, as well as products and services that do not have a standard market price, also called (ii) externalities, which enhance or detract from welfare going over and beyond the market evaluation in conventional measures of GDP. An extreme example of (negative) externalities (ii) is the case of emissions of carbon that influence the stability of the climate, an important asset that by itself had no standard market price. The costs of carbon emissions cannot be evaluated directly because there are no standard market prices, but they produce a serious negative externality through the risks of climate change. Climate change has been called the worst market externality in the history of humankind (Stern, 2008). How to correct the externalities?

Ecological pricing is the answer, and is the basis for achieving green growth. Ecological prices provide the missing signal. They make safer, renewable energy more profitable than fossil fuels. Ecological prices were achieved by the carbon market of the Kyoto Protocol of the United Nations, which was voted by 165 nations in 1997 designed by the author, and became international law in 2005. The carbon price that emerges from the KP carbon market (between \$10 and \$30 per ton of carbon emitted according to the EU ETS) is an ecological price. It represents a market value for the negative externality that carbon emissions cause to the world economy, and makes clean energy projects more profitable all over the world, enhancing investment and creating new jobs. The carbon market is now trading \$165 billion annually at the European Union Emissions Trading System (EU ETS), and transferred \$50 billion from rich to developing nations – mostly to Asian nations – for profitable, private projects involving clean energy and the reduction of carbon emissions (World Bank, 2006-2009).

The article summarizes experiences where ecological prices have been successfully introduced at different scales -- such as global carbon markets and their impact on renewable energy, payments for ecosystem services in the Asia-Pacific region, and the sulphur dioxide (SO₂) market that trades at the Chicago Board of Trade and reduced acid rain in the US. The carbon market goes much beyond increasing the price of fossil energy: it provides profit incentives for green growth by making renewable energy more profitable, increasing rapidly the production of renewable energy, and attracting capital for clean technology projects in developing nations. It limits carbon emissions nation by nation, and allows over-emitting nations compensate under-emitting nations while remaining within a reduced world cap on emissions. The equity issue is addressed in the KP by differential rights to emit assigned to rich and poor nations; the latter have more rights to emit because they have under-emitted historically and now are the ones suffering most risks from climate change.

Similar but different methodologies can be used to introduce ecological prices for other natural services and products. The article shows how to introduce ecological prices to value externalities related to *forests*, *biodiversity*, *watersheds*, *indigenous knowledge* and *global airwaves*, Chichilnisky 1993a,b, 1995, 1997, 2009, 2010, Chichilnisky and Heal 1998, Chichilnisky and Sheeran, 2009. These are global public goods - global commons – that provide extraordinary value to humankind and yet have no value under standard market prices. The practical mechanisms proposed here can provide ecological prices and at the same time change the ways markets operate today. They create new and different types of markets that trade non – rival goods, for example, the concentration of carbon in the atmosphere or the biodiversity in the planet, which are one and the same for all of humankind. This feature transforms the structure of

markets, providing a new link between equity and efficiency that is not possible in standard markets, where goods are rival *par excellence*. It creates incentives for cooperation among nations, and may eventually transform the nature of capitalism

New market mechanisms are needed because we face new challenges that did not exist before. Until now critical resources such as clean water and clean air, ecosystem services, and other elements described in the Millennium Ecosystem Assessment have been considered unlimited, and therefore without economic value (Millennium Ecosystem Assessment Board (2005)). For the first time in recorded history humans are modifying the earth's metabolism: the planet's atmosphere, its water bodies, and the complex web of species that makes life on earth. This requires a new type of economics, and that we learn to measure economic success in a different way that is consistent with the new scarcities we face, and with the enormous value that the earth's resources offers to humankind.

Ecological prices do much more than increasing costs: they lead to green growth, they create positive economic profits from protecting ecological assets such as a clean atmosphere, biodiversity, watersheds, forests, fertile soil, and provide important ecosystem services. They create new jobs: China has become in recent years the largest exporter of windmill and solar equipment in the world. They can do so in a way that favors in practical terms the least developed nations and low income populations. In each case we discuss the key issues in implementation, what this means for people, and some ways in which it may work in a global scale.

II. Globalization: The Role of Ecological Prices

In a period of rapid globalization the emergence of developing nations is becoming a reality, with increasing participation by 80% of the world population in political and economic terms. The Asian Pacific region is now recognized as an engine of growth for the world economy. At the same time we are in the midst of one of the largest extinction events in the planet, 1,000 times higher than fossil records according to the 2005 United Nations Millennium Ecosystem Assessment, and the first that is caused by human action. This fact has important consequences for the rapidly growing economies in the Asian Pacific region. Extinction threatens basic live support systems such as air, the production of food and the availability of drinkable water. They are all under threat. Drinkable water is captured in *watershed* areas, and is purified by microorganisms that live in the soil. But the widespread use of pesticides, fertilizers and other chemicals by agriculture, residential use and industry, kills these microorganisms. Their extinction means we are unable to collect and purify water as before. As a result hundreds of millions of people suffer for lack of clean drinkable water and from debilitating illness, with costly economic and social effects. This impacts large cities in the Asian Pacific region, whose water supplies come from watersheds that are already under threat. Food production depends on fertile soils that are compromised by the extinction of micro-organisms that ensure fertility and plant growth. The decline of fertile soils decreases the ability to produce basic substances needed for life. To breath humans need oxygen that is produced mostly by living organisms such as algae in the oceans. Algae populations are stressed by the increased acidity of the oceans caused by human emissions of carbon dioxide as we burn fossil fuels for industrial production. The use of fossil fuels is increasing most rapidly in the Asian Pacific region where industrialization is taking place at the fastest pace in the world.

Asian and Pacific countries and peoples are increasingly vulnerable to environmental pressures exerted by growing economies and populations. In an era of globalization voracious international markets for natural resources mean further pressures on natural resources. Asian and Pacific economies are the fastest growing in the world, and at the same time they include some of the world's largest exporters of timber, fiber, food and other natural products. The region's economies and societies are dependent on a wide

range of range of ecosystem services, including provision of food and timber, minerals, water capture and filtration, flood mitigation and regulation of hydrological systems.

Markets for the goods provided by nature (such as minerals and timber) do not usually take into account the environmental effects created by their extraction and use. It is often more profitable for ecosystem managers – be they individual land owners, communities or governments – to manage lands for immediate economic gain, for example to maximize timber sales. This misses the benefits that are due to externalities – as explained above – and requires policies that correct the situation. The resulting destruction of natural infrastructure, such as forests, watersheds and mangrove forests, is the cause of long-term economic losses, rising costs for mitigating environmental, and increased vulnerability of human populations. Pakistan’s current floods that affect 22 million people are a tragic case in point; they could have been avoided or contained with appropriate ecological management.

Ecosystems provide an important form of capital. The services they provide are in increasing demand as regional economies and populations grow, and the degradation of ecosystems continues because of a lack of explicit policy focus on the economic benefits provided. Recent studies in the Asian Pacific region demonstrate the economic justification for investment in natural capital in the region: watersheds in Indonesia (Munawir and Vermeulen 2007); uplands use in Bungo, Cidanau, Singkarak and Sumberjaya in Indonesia; Bakun, Kalahan, and Lantapan in the Philippines; and Kulekhani in Nepal, (Meine van Noorwijk and Beria Leimona , 2010), various ecosystems and service markets in the Philippines, (Villamor et al. 2007), and forests in Vietnam (Rankine and Wertz-Kanounnikoff 2008). These studies are based on the premise that, if the value of investment is demonstrated, the buyers will pay the providers and eventually the ecosystems will be protected. Many puzzle about why these studies do not suffice to promote the investment that is needed in natural capital in the region, why such studies do not suffice to protect valuable biodiversity and the ecosystems services that it produces. The reason is relatively simple. Lack of ecosystem prices means lack of profitability. The issue is how to orient the use scarce resources in the right direction. If the private sector finds that projects involving the destruction of ecosystem services – e.g. timber from a virgin Indonesian forest - are easier and profitable than projects that involve conservation of payments for ecosystem services, investors will take the easy route and will pursue the higher or more secure reward. In other words – voluntary programs that leave the decision to invest to the private sector may never work – or may work too slowly to make a difference. Private sector investors need to be able to compare projects involving ecosystem destruction with ecosystem protection, and the protective projects should be easily seen as more profitable, less uncertain and more desirable than the rest. For this, well defined user-limits are needed that are credible because the government and the law will enforce it. Voluntary projects do not satisfy this. Use limits must be compulsory. In addition one needs policies that simultaneously reward protective projects while punishing destructive projects: a carrot as well as a stick approach. All this can be achieved with the creation of ecological prices. These prices arise from markets for ecosystems and are based, first of all, on legal limits of ecological use and secondly, on the premise that the legally binding rights of the users can be transferred or traded so some can to buy rights of use above their limits (they are being punished for overuse) and others at the same time sell them when they are below their limits (they are being rewarded by underuse). This process creates a market price for the use of ecosystems, a “price signal” that broadcasts the cost to society of using biodiversity. This market price represents social cost and controls and reduces the extraction and the use of biodiversity for the production of goods and services. Biodiversity destruction becomes costly and undesirable, while conservation becomes profitable. At the same time the scheme remains always within firm legally binding – rather than voluntary – limits on use. Such markets do the job because they limit use, punish over-users, and reward the under-users, exactly as is required. The private sector then has no doubts of what is more profitable, safer, and what is the way to go. Protective projects become more profitable than destructive projects.

Below we discuss how to use an approach similar to the Kyoto Protocol to protect against the destruction of natural infrastructure, taking into account that there are fundamental differences in the environmental assets under consideration. We show how to correct the unaccounted for externalities in some in specific cases, and how to provide the correct economic valuation, *ecological prices*, by means of appropriate policies at the international, national and local levels. We focus on distributional issues that are key to the success of ecological prices.

III. Experience with Ecological Markets at a National, Regional and Global Level

Existing markets fail to provide values for biodiversity and ecosystem services because traditionally no market existed. It can be argued that no market was needed due to the abundance of natural resources. As scarcity increased, externalities arise. Now a person's consumption of fossil fuels impinges on someone else's enjoyment of clean air, and influences climate stability for others. This is new, until now we did not have such external effects on each other, effects that emerged in an increasingly crowded planet. A newly created scarcity for natural resources and their services became evident following a period of rapid and extensive use of biodiversity and natural resources since the middle of last century, after the creation of the Bretton Woods Institutions and the rapid globalization and industrialization that ensued (Chichilnisky 1996a,b). With scarce resources the lack of ecological prices or market value becomes a market failure or externality. Externalities are a major challenge. In producing food and industrial goods we use water and air and produce emissions and effluents costs that the market does not record; costs on water supplies, air, forests and fertile soils are not computed by traditional markets. Our systems of national accounts therefore do not reflect the real value of the biodiversity we are destroying and the ecosystem services they provide (Herrera and Chichilnisky 1976, Chichilnisky 1977 a,b). The procedures proposed here change the ways markets operate both locally and all over the world and can be used in particular to value and protect biodiversity, watersheds, and other environmental assets that provide important ecosystem services. These procedures provide a new basis for measuring economic progress by allowing the creation of market prices and a green GDP that value fundamental ecosystem services, while protecting also the lower income groups who could be disenfranchised through a standard privatization approach.

A first step to resolve this starts from *payments or rewards for ecosystem services (P/RES)*, which Wunder (2005) defines as follows: "a payment for environmental services scheme is a voluntary transaction in which a well defined environmental service (ES) is bought by at least one ES buyer from a minimum of one ES provider, if and only if the provider continues to supply the service (conditionality)." Constanza et al (1997) classify environmental services into 17 major categories with functions and examples, and estimate an average annual contribution of \$33 trillion USD worth of ES to human welfare. They include *provisioning* food, fiber, water, *regulating* climate, water supplies, *cultural services* that are recreational and spiritual and educational, and *supporting services* such as carbon stocks needed to maintain other services.

There is general agreement that the major ecosystem services are (i) watershed protection, (ii) biodiversity conservation, (iii) carbon sequestration, and (iv) provision of landscape and seascape beauty. The general conditions for payments for ecosystem services are that the transactions be "realistic, conditional and voluntary" (Meine van Noorwijk and Berin Leimona (2010).

A practical lesson from case studies of projects in the Asia and Pacific region is that "regardless of success or failure..., payment for ecosystem services have been valuable as an entry point to invite stakeholders to think and take action towards sustainable and integrated watershed management" Munawir and Vermeulen (2007). The successes have been somewhat limited. It is generally believed that fundamental changes on how the stakeholders see their own roles, rights and responsibilities are

needed for payments for ecosystem services to work. This is a concern that can be dealt with by introducing well defined user or property rights so that the roles, legal rights and responsibilities of all the stockholders are well defined and protected by governments and the rule of law. At present all the key groups of stakeholders have legitimate doubts about whether voluntary payment systems can be made to work, Munawir and Vermeulen (2007). This concern is also alleviated by a market approach, because a market approach starts from setting limits to use, namely property rights, which governments enforce and the results are compulsory rather than voluntary in the sense that if one overuses the resource, one is forced to provide compensation, and if one under-uses the resource one is legally entitled to compensation. In market transaction one chooses what to trade, but when consuming more than what one has the right to do – or what users' rights or property rights allow one to consume - requires payment. This is not merely a voluntary transaction. Therefore the introduction of markets processes helps alleviate the concerns about voluntary transactions that emerge from the studies developed in the region mentioned above.

It is generally believed that fundamental changes on how the stakeholders see their own roles, rights and responsibilities are needed for payments for ecosystem services to work. At present the studies report that all the key groups of stakeholders have legitimate doubts about whether voluntary payment systems can be made to work, Munawir and Vermeulen (2007). Voluntary agreements are limited in scope and success and national projects – which are favored by the stakeholders – require more clarity and definition. For example Meine van Noordwijk and Beria Leimona (2010) state: “The domain for ‘voluntary’ enhancement of environmental services that can qualify for rewards or payments is the complement of the mandatory protection of such services through land use restrictions in sensitive areas and rules against pollution of air, water or soil (Swallow et al., 2009). As in many Asian countries regulation is ahead of compliance in many environmental laws, there is a need for national policy dialogues (Leimona et al. 2008b) to revise legal frameworks, p. 13. The lack of user rights – also known as property rights - on land is equally limiting for the success of biodiversity and ecosystem services projects – as stated in this article. Leimona et al. (2009) analyzed the potential for PES to have a significant impact on poverty reduction in the uplands of Asia and state. They state “At the local level a number of barriers to farmer tree planting and community based forest management have been identified, such as lack of land use rights, good planting material, know-how on tree management and access to markets for tree products”, see also van Noordwijk et al. 2008e and Roshetko et al. 2008), p. 22. The results from existing case studies in the Asia Pacific region presented above indicate the need for new approaches that involve better defined user rights on the use of natural resources or its services, have larger scale and involve national efforts with legal underpinnings, including property rights. This agrees with the successful experiences in the case of the climate negotiations that start from limiting the rights on the use of the planet's atmosphere. At present the UNFCCC is renewing the OECD nations' carbon emission limits agreed in 1997 and therefore the limits on user rights are in a state of flux from 2012 on.

The main message is that ecosystem services provide a fundamental link between the economic sphere of human activity and the biosphere -- but on its own this link does not suffice to get real results. In a number of studies in the Asia Pacific region all stakeholders have expressed legitimate doubts about the success of the current approaches and suggested that government action should help dispel uncertainty, scale up the efforts so that payments become meaningful and projects have real impact, and clarify and protect property rights as well as regulate enforcement of these rights. Governments and other stakeholders in the Asia Pacific region are already taking action to promote investments in natural capital.

Markets initiate with voluntary barter transactions. In this sense the payment for ecosystem services is a first step of market creation, and in the creation of ecological prices. It is simple and provides a practical initial approach to decision making on the management of resources and the valuing of these resources. It widens the range of stakeholders in sustainable natural resource management who are also potential investors. Markets work with scarcity. For very abundant products, such as ambient air, markets are not needed, as the abundance itself would naturally make the resource free. As biodiversity is quickly

becoming scarce, its economic value is emerging and so is the interest in realizing this value in economic terms through market transactions. This is why markets for biodiversity and ecosystems are considered now; the first publications ever proposing markets for biodiversity were Chichilnisky (1996a,b), (1997a), and Chichilnisky and Heal, (1998, 2000).

At a *national* level an example of a successful market mechanism is the sulphur dioxide or SO₂ market that was created in 1991 at the Chicago Board of Trade for implementing the US Clean Air Act, limiting and regulating the emissions of SO₂ in the US under the Clean Air Act requirements. The main emitters in the US are the electricity producing power plants. Each plant was assigned limits on SO₂ emissions and allowed to trade them, so an over-emitting power plant could buy “credits” and compensate an under-emitting plant. The total amount emitted in the US always remaining within a reduced total. This market is credited with achieving the desired targets levels of SO₂ at the national level relatively quickly, easily and inexpensively.

Market examples exist also at a *global* level. The carbon market of the United Nations Kyoto Protocol that was designed and written by the author in 1997 and was voted by 160 nations (Chichilnisky 1996a,b, Chichilnisky and Sheeran, 2009). The carbon market is very different from the SO₂ market. It became international law in 2005, is now trading in the EU ETS about \$165 billion/year, and it transferred since 2005 \$50 billion to developing nations for clean projects thereby reducing the equivalent of 30% of EU carbon emissions (World Bank, 2006-2009). These two are examples of markets for natural capital, and are known to be successful. They are based on compulsory limits on use. In reality all successful environmental policies require limits on use – for example, the Law of the Sea, the United Nations Montreal Protocol that successfully decreased and regulates nations’ emissions of chloro-fluorocarbon to protect the planet’s ozone layer, and the US Clean Air Act.

While proposing the creation of the global carbon market to combat global warming as part of the Kyoto Protocol (Chichilnisky 1996a; Chichilnisky and Heal 1998, 2000) the author also proposed a number of other global financial mechanisms for the conservation of biodiversity and ecosystem services, including watersheds and water services generally, forests and their biodiversity, genetic resources including traditional knowledge, and the use of the global spectrum for telecommunication services (Chichilnisky 1993a,b, 1994, 1996a,b,c), Chichilnisky and Heal (1998).

The creation of markets for biodiversity and ecosystem services poses unique challenges. Biodiversity takes different forms around the world – typically involving different species and different type of ecosystem services in different areas. By contrast, a ton of carbon emitted is the same the world over, and distributes uniformly and stably over the entire planet. The gas distributes uniformly over the entire planet so the CO₂ concentration is the same at any point in time in Madrid, New York or Delhi. It is therefore easier to develop global markets for CO₂ emissions, with the unit of trading being “a ton of carbon”. The same policies used for CO₂ or SO₂ may not be applicable to biodiversity and ecosystem services. There is additionally a general view that markets ‘privatize public goods’ and subordinate distributional issues to profit purposes. Nothing could be more dangerous and counterproductive in the case of water: the wanton privatization of water resources could imply that only the rich can drink, for example. Distributional effects are discussed below and how to resolve the issues that markets could create.

The challenge for policymakers is how to redress the policy focus in the Asian Pacific region, which requires first to fully appreciate the strategic significance of the issue and the policy options available, and the need for local as well as regional and even global policies to address the problem. Local policies are important but do not suffice. Biomass and water regulation services are considered local or regional services, but a large proportion of goods produced by agriculture, forestry, fisheries and mining require the help of local ecosystems but are produced for the international market. Resources such as timber, industrial production such as textiles, and technology products such as consumer electronics are actively

traded internationally, exported by the region. Ecosystem services require therefore regional and global action simultaneously, which is a policy challenge. This article addresses the question: how can investments in natural capital support inclusive and sustainable development when taking into account both local imperatives constraints and global demands. This includes the issue of job creation in the region, among other benefits. The article identifies priority actions and opportunities for promoting investments in natural capital as a basis for green growth. It shows how similar methodologies can be used for different environmental services and products, creating ways to value important externalities that have no standard market prices.

IV. Three Principles for Ecological Pricing of the Commons

Below we describe specific strategies for a market based approach to biodiversity and ecosystem services. This includes specific examples of watersheds and biodiversity conservation in the Asia Pacific region. The ultimate aim is to help organize the use of the local and global commons, in principle and in practice, during a period of rapid regional development and globalization that is stretching the limits of regional and global resources.

The use of markets to conserve natural capital and ecosystem services are relatively new to policy makers. They were first proposed in a UNDP UNESCO publication Chichilnisky (1996b) and in Chichilnisky and Heal (2000). The main challenges are loss of water and biodiversity and the corresponding ecosystem services. They are linked with increasing poverty. So far no market mechanism has fully addressed these problems. Indeed, there is a general concern that markets are connected with privatization and privatization leads to distributional problems in the use of resources. We will therefore suggest specific mechanisms that satisfy fundamental principles that have not been mentioned together before and, in my view are needed for the successful creation and implementation of fair and sustainable ways of conserving ecosystems. The mechanism illustrated here are opportunistic. They are chosen to show how to satisfy the fundamental principles suggested below and to illustrate in practical terms how they will work. We present specific examples in the areas of watershed protection, biodiversity conservation, indigenous knowledge and global airwaves first introduced in Chichilnisky 1993a,b, 1994, 1995-6; 1996 a,b, 1997 a, Chichilnisky and Heal 1998. The overriding topics are global “commons”: water, biodiversity and ecosystem services.

We start from the premise that the sustainable use of ecosystems and the services they provide makes good economic sense, as regional projects have confirmed, but we lack institutional ways to realize this economic value. We emphasize therefore the institutional changes that are needed to accommodate and manage a critical change in the physical assets that took place since the middle of the 20th century when industrialization in the rich nations and globalization rapidly accelerated and took a life of their own (Chichilnisky 1994, 1995-6, 1996a,b, 2010a). The findings are not limited to the Asian Pacific region; recent work has provided examples in other regions of the value of ecosystem services to human societies, and how this value could be realized in practice (Asquith et al 2008; Bulte et al. 2008; Corbera et al. 2009, Koellner 2009; Pagiola 2008; Sanchez-Azofeifa et al. 2007; Engel 2008; Wunder 2008; and Sell 2006, 2007, see also OECD 2004. Most research shares a concern about the inability of current economic systems to realize this local value in practice. The purpose of this article is to tackle the missing links, namely the missing ecological prices and the global aspects of the problem of ecosystem loss as well as the global financial mechanisms that could overcome the enormous gap between the value of these services for our species as a whole, and the lack of financial resources for conserving them and ensuring their fair and sustainable availability across the world.

Property rights are essential to resolve the problem, and if properly handled they can help create efficient markets, redress erroneous market prices and the weakness of GDP, and even redistribute resources as needed to overcome the global divide between rich and poor nations and income groups (Chichilnisky 1994, 1996-5, 1996a,b; Chichilnisky and Heal, 1998, 2000). The article does not attempt to aggregate local ecosystem values into global values. The purpose is rather to explain why a local solution is often unable to resolve a local problem, requiring a global treatment instead. The carbon market provides a successful illustration of the type of governance we have in mind, involving allocating and trading global property rights on the global commons (Chichilnisky 1993a,b, 1995-6; Chichilnisky and Heal 1995, 1998, 2000). We may extend this now to other important ecological assets. These represent unique types of economic goods, which are privately produced but not rival in consumption. Indeed many ecological assets such as the composition of gases in the planet's atmosphere, its water bodies, and its biodiversity, are global public goods *par excellence* in the sense that they are not rival. They are the same for all humankind. Our economic institutions, such as markets, must be adapted to the change. Markets that trade global public goods are different types of market with new challenges and new opportunities for action (Chichilnisky 1993a,b, Chichilnisky and Heal 1994, 2000).

The carbon market and its Clean Development Mechanism (CDM) offer a unique combination of market efficiency and equity that is appealing to industrialized and developing nations alike (Chichilnisky 1993a,b, 1994; Chichilnisky and Heal 1995, 1998, 2000). The carbon market trades the rights to use of a global public good that is privately produced –the carbon concentration in the atmosphere. Such markets are fundamentally different from the private goods markets that were used until now. For example they link equity and efficiency in unexpected ways that certainly do not hold in standard markets for private goods. This unusually challenging but attractive combination made the signing of the Kyoto Protocol possible in 1997, and helped achieve its ratification into international law in 2005. The industrialized nations liked the efficiency of the market solution, while the developed nations focused on the emissions limits from the OECD nations that are needed for the market to function. The same combination of equity and efficiency will be essential to the future of the carbon market of the Kyoto Protocol and its CDM after 2012. A similar blend of equity and efficiency is also critical for designing successful systems of international payments for ecosystem services and for other solutions that can conserve important global ecological commons. The blend of equity and efficiency exemplified in the Kyoto Protocol has been controversial with OECD nations, but it remains essential to achieve successful global financial mechanisms for international payments for ecosystem services. Because of the critical importance of biodiversity and ecosystem services for human survival, these new types of markets will become increasingly important over time and eventually alter the core of the global economy. It is possible that they will end up transforming capitalism during the 21st century (Chichilnisky 2010a).

V. Three Principles for Successful Ecological Prices

In 2006 the United Nations Environment Program and the international union launched an initiative for research options for an international payment for ecosystem services (IPES) mechanism with special emphasis on biodiversity and a broad range of ecosystem services. Following this initiative, in February 2008 at a meeting of United Nations Environment Program IPES group in Geneva, the author proposed the following principles that must be followed by any successful ecological pricing mechanism:

- It should bolster ecological conservation and sustainable use resources across the world
- It should be financially self- sustaining and profitable, requiring no aid or donations for its implementation.
- It should address the basic needs of developing countries and more generally those of low income groups and local communities.

The three principles just presented are demanding, and they may seem impossible to achieve. But the Kyoto Protocol shows the way. The carbon market of the Kyoto Protocol is an example of a successful global market mechanism that satisfies all three principles. The Carbon Market provides a carbon price signal that 'rewards' carbon reducers & 'penalizes' excessive emitters, thus helping to avert the risks of global warming. It is self funded and profitable, requiring no donations to be executed. And through its CDM, it reduces the gap between the poor and the rich nations, the global divide (Chichilnisky 2010a). This is consistent with Article 4 of 1992 UNFCCC, the Climate Convention.

According to the World Bank (World Bank 2007, 2008, 2009), by the beginning of 2010 the carbon market had traded \$165 billion and its CDM executed \$50 billion in productive investment on the soil of developing nations while reducing the equivalent of 20% EU annual emissions.

In sum, the Kyoto Protocol thus satisfies the three key operating principles:

- Fosters sustainable development
- It is self funded and profitable - requiring no aid or donations for its execution
- Helps reduce the gap between the poor and the rich – the Global Divide – since its CDM transfers significant productive resources to lower income communities

In the following we propose examples of global financial mechanisms that emulate the Kyoto Protocol in the sense of helping realize the economic value of biodiversity of biodiversity and ecosystem services – while conserving the resources in a sustainable fashion.

One may ask - why don't these markets exist? The answer is relatively simple. It is because markets require 'property right' allocations to function. Unless we know 'who owns what' – namely unless we know what are the prevailing property rights - we cannot and do not trade, markets do not exist and there are no market prices. Think of the automobile market. Nobody would buy a car unless it had a clear title. The 'property rights' for a car must be defined before there is a sale. There would be no automobile markets if people had no property rights on cars. As simple as that. And without an automobile market, there would be no market price for automobiles, and nobody gain from producing cars, we would barely produce any cars. We would have few or no cars. This is exactly the problem we face with biodiversity. We lack property rights on biodiversity, therefore we lack markets and market values. Nobody 'produces' biodiversity because there is no way to assign value and no way to gain from that activity. This is why biologists' good intentions about creating payments for ecosystem systems are just that – good intentions – and have failed so far to raise the funding needed to preserve ecosystem services. They will continue to fail since they have no basis of reality without well defined property rights.

In sum, since most of the world lacks property rights on watershed services -- a market on watershed services does not exist and cannot exist. And since the market does not exist, there are no market prices for watershed services. And without market prices there is no way to translate an abstract notion of economic value derived from human needs, into a practical economic reality of dollars and cents.

The policy implications are relatively simple. We need to allocate users rights – also called property rights -- on biodiversity and ecosystem services before their market value can be realized. User rights need not be title to land or other fixed property, which can be quite contentious – but rather (as is the case in the Kyoto Protocol) user rights that have never considered or allocated before. For example, the rights to emit CO₂, SO₂, or CFCs, the rights to fish, the rights to explore a forest for natural resources such as petroleum as in the case of Ecuador and its Yasuni initiative, or a similar initiative in Brazil with respect to exploration of the Amazon forest, the rights to use DNA from a forest's products, the right to use DNA information from members of a tribe. Such rights were not considered before, and some are akin to

“intellectual property” rights rather than property rights on solid assets. The point is that user rights or property rights on the use of biodiversity or the ecosystem services are needed before markets can exist, before their services can be traded, and before market prices and real economic value can emerge. This is the simple point that is missing in all the good willing studies and projects around the world that attempt to put values on ecosystem services. They will eventually fail without well defined property rights. Payments for ecosystem services cannot be “voluntary” – this is not going to work reliably and in a scale that matters. This is the reason why we have such problems realizing the true value of ecosystems and their services. New institutions are needed to adapt to the new world in which we live.

The reason why we observe inaction with respect to watersheds is that there are no well defined user rights on watershed services, and therefore there are no market prices for those services. And without market prices the value of a watershed exists in a physical and a metaphysical sense, but not in an economic sense. To overcome the problem we need the equivalent of the Kyoto Protocol in terms of the use of watershed services across the world. This is a rather difficult task for many reasons, one of which is the enormous diversity of the watersheds and the services they provide, which are generally local services. In addition, there is a fundamental difficulty in assigning such property rights without further consideration to equity issues. Nothing could be more destructive than to define private property on the watersheds of the planet in a way that prevents access to lower income groups. The following sections will suggest a way to overcome these problems. A critical aspect of the solution will be to find ways to define ecosystem services as a uniform global commodity that can be easily traded, and to allocate property rights and to design markets in a way that satisfies the overriding principles of equity and efficiency that were proposed above.

Investments in natural capital can provide both opportunities for, and challenges to, equitable poverty reduction benefits. In the following examples we discuss key challenges and important approaches for maximizing the benefits for poverty reduction. The possible negative impacts of ‘privatization of ES’ in will be discussed, as well as possible mitigating measures, in each case using the principles proposed above. The participation of communities in the mechanisms proposed provides a balance between privatization and reduction of poverty that is at the core of the global environmental dilemmas of our times.

Example 1: Global Watershed Fund

The principle behind this mechanism is to aggregate the services of large numbers of different watersheds across a region or the world, bundled into one global financial asset that can be called ‘global watershed services.’ Typically the watersheds considered for this scheme would be include those providing water services destined to cities with populations of more than 1 million people (Chichilnisky 1995, Chichilnisky and Heal 1998).

The precise mechanism of implementation for the proposed solution involves: creating a system of property rights on the use of the global environmental asset (a global ‘bundle of watersheds’) and related markets that can generate appropriate flow of revenues and allow people in industrial and developing nations to benefit. One way to build a nation financial system for the profitable conservation of watersheds is to create a public-private corporation that owns rights to the watershed services under consideration, with strict covenants. The property rights we propose are therefore the ownership of the watershed services – rather than the property rights on the land or the biodiversity itself. Each nation can create property rights to these services, for example the rights to use the watershed services of a number of watersheds in each nation, the watersheds that provide water services to all cities with at least 1 million inhabitants in the nation. These are new property rights -- rights that do not exist today. How does this work in practice? Below is a precise map for the process to be followed, part of which was proposed

earlier by the author in other publications (Chichilnisky 1993a,b, 1994, 1995-6, 2010a; Chichilnisky and Heal 1995, 1996a, 2000).

We propose a step by step mechanism. The first step is to determine the mechanism within each nation, with respect its own watersheds, the second step is to describe how this extends to an international system of watershed rights, and the third step is show how an international agreement offers financial possibilities to cover costs and produce profits for a watershed solution to be (i) self supporting, (ii) benefit local communities and lower income groups, while (iii) encouraging conservation of the asset (Chichilnisky and Heal 1998). Each step contains incentives to help implement the other steps – they all work together to achieve the global objective of the institution we propose.

Before going into details, it is worth explaining how the creation of a financial mechanism can create incentives for the conservation of an asset. This point is not generally understood, but it is important in this context. Consider the owner of a valuable home who needs cash. Without a mortgage market--as is the case in Turkey, for example--the only solution is to sell the house, or to chop its bricks one by one and sell those, thus diminishing or destroying the value of the asset. This is analogous of the situation in developing nations today with respect to their valuable biodiversity, as Ecuador's plight – the Yasuni Initiative - to the international community has recently made clear. Ecuador proposed to stop exploiting petroleum with international corporations in its part of the Amazon forest, if the international community would offer it compensating funds. Once a mortgage system is introduced, the home owner can borrow money based on the value of the house. And the creation of mortgage markets as a financial institution encourages the conservation of the asset since now the bank who offered the mortgage loan and the owner have an incentive to preserve the house's value. A similar situation arises with the financial mechanisms proposed here. Now for the step by step details.

A first logical step is for a nations' government to allocate property rights to a newly created corporation(s) – the “watershed corporation” - which should be owned as a public/private commercial venture(s) (Chichilnisky and Heal 1998). It is important to mention that the property rights we propose are not to rights to the watershed nor the watershed land itself – such rights would make the problem almost impossible to resolve -- but rather the rights to benefit commercially from the services of the watershed in producing clean drinkable water and under strict legal conditions, also called ‘covenants’, that ensure that the corporation will restrict the use of the land in the watershed area to avoid all agricultural, residential, commercial use, or any other use than could conflict with the production of watersheds services. This may seem restrictive but in fact it is similar to what was done in New York City for its watershed in the Catskills, in New York State, in the 1990s (Chichilnisky and Heal 1998). The “covenants” described above will typically forbid or limit (i) the use of fertilizers and pesticides and limit or forbid (ii) other environmental effluents and stress factors that can damage the biodiversity in the watershed, and (iii) allow the unimpeded the continuation of the watershed's biodiversity services for the purpose of water catchment, filtration and erosion control. This is also similar to the process followed by New York City with respect to its Catskills watershed (Chichilnisky and Heal 1998).

In terms of the equity and the efficiency of the initial distribution of rights, in this model the corporation could be owned and managed by its stockholders and these should include representatives (i) from the local communities, (ii) the government, (iii) the private sector, represented for example private investors, and possibly also by (iv) environmental groups representing the interests of the “future”. This implies that local communities and low income groups will automatically participate in and benefit from, the commercialization of the watershed services. All the stockholders (including private investors, local communities, the “future”, and the government) will share the profits or gains from the corporation. The initial endowments are to be decided by law makers in each nation – in the context of international agreements for the purpose of these allocations that are described in more detail below.

The creation of new property rights by itself can generate substantial revenues to fund R&D efforts, to the benefit of biodiversity conservation, and of low income communities in each nation. Here is the exact mechanism I have in mind to guarantee the adequate level of funding and the appropriate selection of R&D projects. A watershed corporation should be endowed with the rights to sell water, including if appropriate sell water to the government for distribution to its citizens. In reality water provision services are a profitable business worldwide, and the allocation of property rights on the watershed services is in each nation a valuable asset that the government can allocate in exchange for demanding covenants for protection of biodiversity. To obtain funds upfront to subsidize R&D and operations, the corporation that is endowed with the watershed services can sell bonds and equity that are backed by its assets, so as to be self funded. Indeed, this is a generalization of what happened in the case of the New York City Catskill watershed, where the government of New York sold bonds to pay for the R&D (Chichilnisky and Heal 1998), the purchase of land and the operations of the watershed protection in the Catskills including the covenants already described that protected biodiversity (microorganisms in the soil of the watershed, in particular). Furthermore, for equity and efficiency, the government can allocate the property rights to ensure that the public - private watershed corporation contemplated here would have rights to own - and to profit from - the savings created by using ecosystem services rather than artificial plants to capture and filtrate water. Such savings can be considerable, for example in the Catskills watershed the creation of an artificial filtration plant was valued at about \$6 billion while the watershed could do the filtration if unimpeded, at no cost. This means that the watershed corporation would own an asset valued \$6 billions – which will help the sale of bonds or equity in the world’s capital markets (Chichilnisky and Heal 1998).

The next step is to explore the participation of the international community in facilitating the national system of watersheds corporations mentioned above, and in particular the execution of the 3 overriding principles enunciated above, which should be at the core of international agreements – for example Article 4 of the UNFCCC that is at the core of the “shared but differentiated responsibilities” in the 1992 Climate Convention. The international community can provide incentives for an international agreement that will require each nation to take action and create watershed corporations as described here, in the form of financial incentives for the international system as a whole as described below.

So far we described the role of a government restricted to the watersheds in its own nation. In the case of ambiguity, for example if a watershed extends across nations, the issue falls naturally into the realm of international agreements. A government’s actions towards its watersheds, as explained above, are taken in the context of international action, similar to the action taken in the Kyoto Protocol. The biodiversity in the world’s watersheds is of international value to humankind as a whole, even though it is distributed across nations, cities and towns, and is different in each case. Think of polar bears, dolphins and penguins. Their genetic survival is recognized to be of international importance. The same is true for the microorganisms that populate watersheds and provide water services globally. How can the international community provide incentives for each nation to take action and create watershed corporations as described here? There are substantial financial incentives for the ‘bundling’ of watershed corporations and their assets across the world. It is the “law of large numbers” at work. Its financial desirability is demonstrated by the existence of successful hedge funds (e.g. the Swiss Pictet Water Fund) that specialize in water services investment across many nations. In each nation, the watershed corporation(s) will own substantial assets and can be substantially profitable. The financial assets that it creates, such as bonds and equity on the corporation, can be sold in the global capital markets – called for example Water Hedge Funds. The corporation can create liquidity for its services through IPOs and secondary markets. But the bundling of several watershed assets is even more profitable than each is on their own, since the risks become lower as more watersheds are considered at the time. This is specifically what statisticians and financial experts call the law of large numbers.

International agreements can help regulate groups of various national watershed funds. They may require nations to provide the property rights and the infrastructure specifically defined above, in exchange for

financial participation in the global profits of the watershed sector thus created by international agreement. For example, India may not be willing or able to create a watershed corporation on its own. This may require financial expertise and funds availability and access to global capital markets that it cannot provide by itself. Allocation of land may not be possible. But in conjunction with a number of other Asian nations, India could participate in the creation of an \$1 trillion Asian watershed fund that provides access to capital markets to sell bonds, and equity in each nation's watershed corporations (as described above). There are already profitable water funds that own hundreds of millions in watersheds assets, showing that the activity can be and indeed is profitable, but their objectives are private profits and not conservation (Chichilnisky 1993a,b, 1995-6; Chichilnisky and Heal 1998). The procedure just described shows how the creation of the new property rights nation by nation – in accordance with international agreements on watersheds -- can generate substantial revenues to the benefit of the private and the public sectors in each nation, in particular in developing nations where water supplies are under stress, in a way that (i) supports the conservation of biodiversity in watersheds, (ii) protects the fair access to clean water services by low income groups within each nation, (iii) provides profitable returns to the private and the public sector, and specifically to local communities that participate and co-own the watershed corporation, and (iv) encourages private/public investments in this crucial global water infrastructure. The negotiation of how each nation system of watershed corporations integrates into the international watershed fund is left to diplomatic routes, but it is not any different than any other international negotiation with costs and benefits for all involved.

By creating the appropriate corporate design, all the overriding principles presented above can be satisfied in this example. First of all the entire enterprise can be self funded. It is relatively easy to attract global funding for water funds: The “PCTET Water Hedge Fund” in Switzerland has a similar structure, although it operates as a private hedge fund, as mentioned above, and it is proof of the fact that water services are a profitable line of business that attracts already considerable global investment. However, no nation has created the property rights that are proposed here, and so far the profits have gone only to the private sector. Furthermore, having no covenants, as described above, current water service providers do not protect the biodiversity of the watershed. In any case, the watershed corporation proposed here can be self funded. The second principle, sustainable development and sustainable use of the watershed is guaranteed by the covenants described above, and its biodiversity can ensure substantial profits for the corporation by offering filtration and water flow services at no cost. Finally through international agreements that encourage an appropriate distribution of property rights on the stockholders of the corporation –including local communities, government and the private sector entities – one can assure that both equity and efficiency conditions are met.

The above proposal is rather innovative and may be demanding to implement, but it benefits all and this includes the private sector. It can be done, and the sooner we start the better. The critical aspect of this scheme is to develop an international effort to ensure that the nations of the world offer their support in the form of designing and enforcing the covenants described above, and allocate property rights to corporations and stakeholders of the type described above on the savings derived from using natural capital rather than artificial plants – such as the expensive artificial water filtration plants that can run into the trillions of dollars for the world as a whole (Chichilnisky, 1995, Chichilnisky and Heal, 1998)

Example 2: Global Forest Fund

A second example of a global financial mechanism is a private/public corporation that aggregates the services of large numbers of forests across the world, bundled into one global financial asset that can be called ‘global prospecting services.’ A blueprint for this is a development of the Costa Rican InBIO - Merck agreement, which is discussed in Chichilnisky (1996, 1997), and has led to substantial forest conservation results so far in that small and innovative nation. Merck did not develop any significant new drugs in the context of the InBio agreement – possibly because the forest landscape contemplated was too small, another reason for the globalization of the instrument proposed here. However the lump sum paid

by Merck went however into the In Bio laboratories provides an international model of international cooperation to be promoted. The forest was preserved in part by the creation of a national park with the help of the Rockefeller Foundation years before the Merck-in Bio agreement was signed.

The financial mechanism proposed here can be structured in different ways. In analogy with the case of the watershed corporation, international agreements are needed to reap the benefits of the financial mechanisms proposed here. Without them, the Costa Rica example will remain limited to a few nations and a great opportunity will be lost until, perhaps, it is too late.

How to encourage and create an international agreement for the 'global bio-prospecting' of ecosystem services? The first step is to define nation by nation limits or covenants on the use of forest - based biodiversity. This can be achieved by computing the per capita "forest biodiversity content" of consumption in each nation, based on so called "forest footprints" local or national. This means that rather than computing the use of forest biodiversity for local production, say, in the US or the EU, one would compute the consumption of forest biodiversity per capita by the average US or EU citizen -- including the forest content of imports from other nations, directly and indirectly. Such measures exist in rudimentary form and it is difficult but possible to generalize them and create a unit that can be agreed internationally as a first step (Chichilnisky 1995). The next step is to achieve an international agreement on the limits that science will find appropriate to achieve sustainable development adopting a rate of extinction that is closer to evolutionary standards rather than to exceptional extinction events globally, as is our period in the history of the planet. Of course there will be difficult value judgments in all this; this is to be expected. But an institution that parallels the IPCC in the Climate Convention can and should be created to provide input from scientists all over the world to reach a minimum consensus, as soon as possible. Proposals for a Biodiversity version of the IPCC have already been advanced within the United Nations Convention on Biological Diversity (CBD).

In advancing towards this goal, it will be helpful to encourage economic motives and align market objectives so that there can be gains as well as losses for the private sector as a way to encourage the type of institutions that need to be created worldwide. How to align business interests and profit motives to encourage the institutional changes needed? There are several possible ways, and one is as follows. A Public-Private corporation(s) can be created which is assigned by national governments the property rights on the marketing and further developments of the services of each of their forests' biodiversity -- with strict covenants or limits imposed in their respective nations to restrict their use for commercial, agricultural, residential purposes, or any use that threatens conservation of the asset. The new corporation owns the property rights on the health services that are derived from the intellectual property obtained from the forests specimens, worldwide. As in the case of the watershed corporation described above, to become self funded, the forest corporation can sell bonds and/or equity that is backed by its assets in global capital markets. To achieve success in global capital markets, it is important and may be necessary to aggregate the assets across many nations as this enhances the value of the assets, decreases financial risks, and increases their attractiveness to global investors. The global investor will be offered bonds or equity based on the global biodiversity of the world's forests, and their derive health benefits used for commercial purposes. We know these health services have a large commercial value, involving hundreds of billions in sales worldwide (Chichilnisky 1996, 1997). The forest corporation can also do an Initial Public Offering and become a 'public corporation', so as to trade in secondary capital markets, thus acquiring further liquidity and accessing larger pools of capital worldwide.

As an example, consider a public - private corporation that owns and profits from bio prospecting services around the world. Costa Rica's example involves a partnership with Merck who shares the property rights on the use of the samples derives from the forest for medicinal purposes. The corporation will own prospecting rights but not property rights on the land or the biodiversity itself, this is important since otherwise sovereign interests could be violated. It owns rights to "land use" & "biodiversity resource use" rather than the rights to land or biodiversity, namely the services of its assets and not the underlying assets

themselves. The “services” can be owned by local communities, as well as by private investors, and government can share an interest in the corporation in exchange for imposing the appropriate covenants that create the biodiversity conservation and its commercial value. Financial assets such as bonds or equity on the world’s forest corporations can be sold in global capital markets, called for example Forest Hedge Funds. As already mentioned for one corporation at the time, a Forest Hedge Fund could become public through an IPO to obtain liquidity and finance its operations, as well as trade its equity in secondary markets.

In addition to being self funded, appropriate corporate design is needed to allocate appropriately, through international agreements, the ownership or stockholding in the corporation(s) to (i) governments, (ii) local communities and (iii) the private sector (private investors). Such forest corporation(s) can ensure not just the sustainable conservation of the asset – namely the forests’ biodiversity services – but can also make substantial profits. Some of these returns will return to the local communities who are shareholders, thus satisfying the three overriding principles of (i) sustainability, (ii) self funding, (iii) equity and efficiency that were proposed above. It should be noted that some of the structure proposed here can be put in place before the international agreements are achieved, providing important case studies and demonstration or pilot plants for the ultimate international agreement that is sought.

Example 3: Traditional Knowledge

This example would eventually lead to an international agreement by the nations of the world to seek a sustainable conservation of a valuable global public good: ‘traditional knowledge’ that is usually transmitted verbally and is at risk to disappear at present due to the fragmentation and rapid extinction of local cultures and languages around the world. In addition to health services, the market value of the knowledge includes historic and cultural assets such as poetry, literature and music, and anthropological knowledge of human systems and their genetic backgrounds. The critical step is to find a way to make the owners of traditional knowledge participate actively and initiate the process, and make knowledge widely available while honoring through modest license fees the contributions of the authors, thus satisfying the three principles stated above: (i) self funding, (ii) promoting sustainability, and (iii) promoting equity and efficiency.

The background is as follows. For many thousands of years, indigenous people across the world have created a large body of traditional knowledge that embodies their wisdom, their culture and their historical heritage. Their entire social organization is built upon this knowledge, and honors their heritage. It is recognized that some of this traditional knowledge has become commercially valuable across the world. It produced enormous gain to the pharmaceutical industry worldwide. About 60% of all medicines sold across the world derive from natural plants and treatments. They are increasingly used to treat and cure a wide variety of diseases, ranging from the common headache to asthma and various forms of cancer. Indigenous knowledge is therefore of great value to humankind. Yet little or none of this commercial value has been realized to date by Indigenous People (IP); this is well documented and it is a sad reflection on human organization. This proposal starts from the recognition of the enormous value that IP knowledge has created over thousands of years, and the need to foster and protect IP contributions and rights.

Indigenous knowledge and heritage is verbally transmitted. Since most indigenous groups are being displaced from their natural habitats across the world, their people suffer severe economic pressures and their numbers dwindle, the knowledge that they embody is itself at risk of disappearing. The entire globalization process of the world economy is intensifying these pressures, and increasing the vulnerability of verbally transmitted knowledge. We must face the fact that traditional indigenous knowledge, with its immense value to humankind, is at risk of disappearing soon. An additional risk in that in recent years States and transnational organizations have utilized Treaties (such as the Convention on Biodiversity CBD and the Food and Agricultural Organization FAO Treaty on Genetic Resources) to

claim both traditional knowledge and title to the world's biodiversity and genetic resources. These international agreements expropriate indigenous knowledge and local communities', but do not include indigenous communities as signatories. Under the principle of free, prior and informed consent (**FPIC**), organizations of IPs would have to be involved at the inception stage of the project proposed here to ensure that their interests and concerns are taken into account.

Indigenous people are community oriented, and their community - oriented culture adds further risks to the knowledge they produce. Because indigenous people seldom rely on 'private' property, they have no patents or licenses, and derive little or no gain from the valuable body of medical knowledge that they have created over thousands of years. Indigenous rights are not respected by people from industrial societies who rely most of all on private property rights.

It is important to recognize the collective rights of the IP have on their territories and their biodiversity via their traditional knowledge. No attempt is made here to emphasize a private property approach and individual rights at the expense of community rights, since the traditional IP rights on territories and biodiversity have been and continue to be collective. This proposal is fully consistent with this fact. At the same time, with no economic incentives for preservation, there are little resources allocated to preservation of the IP's valuable knowledge, and for the collection and recording of the valuable information that their heritage embodies. This adds to the risk that indigenous knowledge may disappear soon. How to protect against this risk? A solution to this problem involves use of up - to - date Information and Communication Technology (ICT) to gather, organize and record digitally (verbally and visually) the body of knowledge and cultural heritage that the world's indigenous people have produced over the millennia, as well as recording its source of origin. This project would complement other projects on the use of Information Technology for the purpose of training indigenous people in performing Advocacy within international organizations.

The project suggested here is large and ambitious, as it could encompass thousands of indigenous groups across the world, and thousands of years of their orally transmitted heritage and knowledge, including their own genetic information and their habitats'. It could therefore take several years to complete – and in its size it could be similar to the so called "human genome" project that was recently completed, encompassing hundreds of people across the world. However, while the project aim is large we know that, with proper organization, state - of - the - art information and communication technology is perfectly able to gather and record this information as appropriate. There are no technological challenges.

There may be organizational challenges, however, as part of the project would provide a basis for indigenous people to establish property rights for their knowledge. This may entail licenses or patents. It is true that indigenous people do not rely on 'private property' within their own societies. The property rights that are contemplated here however, are in relation to outsiders using their knowledge. Therefore, this would not touch or alter in any way the traditional communal rights that have always been used within indigenous groups. The entire project would view indigenous rights in a new light, and with favorable commercial implications for indigenous groups. As such, and since the issues are global in nature, it may require the participation of international organizations to establish and help protect those newly established rights. Furthermore, trading those new indigenous rights would be an interesting market approach that could benefit indigenous groups the world over in a way similar to the benefits that have been obtained from reservations from entertainment zones. This however would require appropriate regulation to ensure fair markets and transparency. It should be emphasized that this would in no way detract or interfere from the IP traditional system of collective property rights, as it would only pertain (as in the case of entertainment zones) in the process of commerce with outsiders.

The supervision and organization of these activities could be a natural role for the United Nations, or for other international organizations. The participation from the private sector is also crucial. This project could generate commercial interest from various cross national corporations. Pharmaceutical corporations

have commercial interests in indigenous people's knowledge, as explained above. Medical and biological researchers are gathering today genome information about the different groups' immune system vulnerability or their resistance to various illnesses such as diabetes, for genetic therapies. Firms in the Information and Communication Technology area have natural affinities and commercial interests in the type of activities envisioned in this project. There could be natural commercial spin-offs of this project that will also require management. This could also be a role for international organizations.

The benefits of the project include honoring indigenous rights, training, and creating employment opportunities. In the process of recording and organizing global indigenous heritage and knowledge, we will also record the 'sources' of this knowledge. The various groups who are sources, and therefore own rights, could share the benefits created by their knowledge that lead to commercial gain by others. This could be an important part of the project that will ensure that some of the commercial benefits from the knowledge returns to its legitimate sources. It could bring considerable resources to indigenous reservations and groups, benefits that may be preferable in some ways to 'casinos' or other commercial ventures within Indian reservations. In terms of training, the use of information and communication technology will require minimal but valuable training of indigenous people, mostly of youngsters, who are in an ideal situation to gather the knowledge from the elders themselves while acquiring valuable tools in today's labor markets. With respect to employment creation, the project and various commercial spin-offs from it, will create employment for people in reservations and other indigenous groups and settlements worldwide. Employment will be created for gathering organizing and recording knowledge, as well as for the spin-offs that were described above, involving possibly the pharmaceutical industry, the medical and biological industries, and information technology and communications industries.

There are several ways to generate an appropriate flow of revenues to allow communities to benefit from the conservation of the knowledge assets at stake, and to create and allocate appropriately property rights on the asset across nations and within nations. One way is to create a public/ private corporation that owns the assets of a Digital Data Base that is developed to record, and prevent, permanent loss of verbally transmitted traditional or indigenous knowledge, together with records of the sources (or initial authors) of the knowledge itself. It is worth repeating for clarity that the rationale is to avoid permanent loss of traditional or indigenous knowledge that is currently threatened by the segmentation of traditional communities and the encroachment of industrial societies in their territory, as well as by the migration of its populations, and that traditional knowledge is verbally transmitted and therefore particularly vulnerable and at risk of permanent loss.

One way to deal with the initial allocation of property rights is for the Data Base to record original source and thus ensure licensing revenues according to international agreement. This issue has been the subject of heated debate in the Convention of Biological Diversity. However the purpose here is not to limit the use of the world's knowledge as is usually feared – for example through patents --but rather through the use of new systems of property rights proposed elsewhere by the author (see Chichilnisky and Heal 1995, 1998 and 2000, 2010a,b) that allow universal use and moderate income sharing by small license fees. The author has proposed replacing patents (which are a form of monopoly, for a limited period of time) by so called "compulsory licenses", so the knowledge cannot be removed from public use and yet its creators can be moderately compensated to encourage production and sustainable recording and use.

The knowledge itself is owned by the originating sources but is licensed for global use. The Public/Private Corporation sells knowledge services to private sector. Medicinal knowledge alone represents over \$100 billion in annual sales for pharmaceutical companies, and therefore the Data base would own the license rights on a very valuable asset. The data base development would encourage digital training and job creation for indigenous youngsters, mentored by communities' elders, thus helping heal the fragmentation of the communities. With the appropriate corporate structure – as discussed earlier for the case of watershed and forest corporations, the corporation that develops the Data Base could sell bonds and equity, placing its shares in global capital markets, and an IPO can create

liquidity to kick start the operations making the entire enterprise self funded and profitable, while encouraging sustainable use and redistributing gains towards low income groups and communities across the world. An Executive Committee of Elders can be created, drawn from the various indigenous peoples' groups who participate, who will act as the Board of Directors of the Project, together with the project Director and representatives of the main sources of funding. Major corporations in the Information and Communications area who may wish to participate and fund the project, as well as leading representatives from the pharmaceutical and the medical and biological industries. The funding for the entire project will be large, involving tens of millions of dollars distributed over several phases, as it will involve people in several nations and will require sustained effort for about 10 years to produce results.

VI. The Global Spectrum

This mechanism was first proposed in Chichilnisky 1996 a,b, and 2010 a,b.

There is in principle enough "bandwidth" available for a global spectrum assignment, or assignment of the global airways, that provides a unique wavelength to each of 10 billion people in the planet. Such a system would improve communications across the world and organize them so as to play the role of a "traffic light system" that avoids accidents and produces enormous efficiency values simply by organizing traffic in highly transited global telecommunication roads. The basis of this example is a type of property right that is not usually invoked -- the use of the global spectrum that is owned by each nation within its territory.

The financial mechanism I have in mind could create great efficiencies in global communication systems, while compensating nations for the use of their own property: the electronic wavelengths that go through their territory. The financial mechanism would create Private-Public corporation(s) to exploit the services of the global spectrum. Owned as appropriate by local communities, with bonds and shares sold in global capital markets, this IPES would be self funded and sustainable, and furthermore, as already explained above, it would recognize the valuable property of all nations small and large, thus helping overcome the global divide. Developing nations in the Asian Pacific region are the largest expansion markets for wireless services in the world today thus this is likely to become hugely profitable IPES. The rest of the structures discussed here apply to this example and do not merit repetition.

VII. Ecological Prices are Needed for Green GDP

One widely discussed issue has been the reform of national systems of economic to include natural capital, as a way to measure sustainable economic development. For example, it has been proposed to subtract from a nation's Gross Domestic Product the value of natural resources that have been extracted and exported in a given year -- also called 'depreciation of natural resource stocks.' This suggestion appeared early on in Chichilnisky (1977a, 1977b) Herrera, Scolnick and Chichilnisky (1976) and Chichilnisky and Heal (1986, 1991) and has again emerged last year at the G20 meetings (reference).

GDP measures the value of goods and services that a nation produces, using market prices. This takes us back directly to the problem of externalities, the missing markets prices to provide a measure of value of biodiversity and ecosystem services. Under current conditions, it is difficult to agree on what measures to use for measuring GDP, since those markets do not exist. Therefore, rather than suggesting the introduction of new accounting measures for GDP, which requires market prices that do not yet exist and therefore has met with limited success, this article proposes instead the creation of actual markets or

market mechanisms that recognize the new scarcities of natural resources. The new markets create new market prices and thus can be used to change our notion of economic value in the GDP. These are prices for environmental commodities such as a clean atmosphere, clean water, clean air, and biodiversity composition, on which human survival depends. Some of these markets have already been created--for example the carbon market of the Kyoto Protocol--which was designed and drafted into the Protocol by the author at the UNFCCC COP in 1997 and voted for by 160 nations. They are having the desired effect of: re-valuing natural assets such as the gas content of the atmosphere and help recognize, for the first time, the scarcity of the atmosphere as a sink to absorb burning fossil fuels to produce energy. This changes dramatically the market value of renewable energy v. fossil fuel energy all over the world and of all goods and services, which are produced using energy (see e.g. Chichilnisky and Sheeran 2009; Chichilnisky 1996a, 2010a; and Chichilnisky and Heal 1994, 1998, 2000) and thus the ultimate measure of GDP.

Markets require well define user or property rights to function. Accordingly, this article proposes global systems of tradable rights on the use of global environmental assets such as biodiversity and the ecosystem services it produces, which seem necessary at this stage of human evolution. It proposes markets that encompass and extend the Kyoto Protocol, and focuses on the challenging issue of how to extend a system like the carbon market to manage other sharply different global commons, such as biodiversity and the ecosystem services that it produces, as developed above. It outlines transmission mechanisms through which the proposed solutions can generate appropriate flow of revenues to allow developing nations to benefit from biodiversity conservation, proper management of ecosystem services and clean technologies, and the process by which global property rights could be allocated within and across nations, including how initial endowments can be decided. This builds on prior published work by the author (Chichilnisky 1996a, 1977a, 2010b; Chichilnisky and Heal 1994, 1998, 2000; Chichilnisky and Sheeran 2009), starting from the beginning of the 1990's and during the Kyoto Protocol negotiations in 1996 and 1997, including the proposal leading to the creation of the global carbon market of the Kyoto Protocol (Chichilnisky and Heal 1995, 2000; Chichilnisky and Sheeran 2009), and of an International Bank for Environmental Settlements (IBES) to regulate this (Chichilnisky, 1977 and 1996a,b). The article discusses specific mechanisms to guarantee the adequate level of funding and the appropriate selection of R&D projects, as well as the governance conditions for adequate performance, based on the first publications that discussed and proposed the creation of biodiversity markets, Chichilnisky (1993a,b and 1996b), Chichilnisky and Heal (2000).

VIII. Summary and Priority Actions

We proposed specific global financial mechanisms to forestall the rapid and irreversible loss of species ecosystems and indigenous knowledge that is taking place on land and seas, and take advantage of the global nature of the airwaves to benefit humankind, and more generally to help organize the global commons in a period of rapid globalization. The proposals represent merely a first step in what could be a process involving many years of scientific and diplomatic work, but they are of crucial importance because through the sea change we are precipitating in the metabolism of the planet, the survival of our own species could be at stake. This article proposed global systems of tradable property rights on the use of global environmental assets that seem necessary at this stage of human evolution, markets mechanisms that encompass and extend the Kyoto Protocol, its emission caps, carbon market and Clean Development Mechanism. We focused on the challenging issue of how to extend a system like the carbon market to manage other sharply different global commons -- such as biodiversity.

To fix ideas, the article focused on a few prominent examples, (1) watersheds (2) forest biodiversity, (3) indigenous knowledge and (4) the global airwaves. They are all non-rival goods and represent different aspects of the same global nature of the evolution of our species and the challenges it creates. As we

discussed in the article, and all share the same foundational properties that a new global mechanisms must satisfy: (i) to be self funded, (ii) promote sustainability, and (3) be fair and efficient and geared towards decreasing the global divide between rich and poor nations, and rich and poor communities the world over. These are challenging principles, but the Kyoto Protocol satisfies all three and the article showed how they can be achieved in the examples chosen here.

We outlined transmission mechanisms through which the proposed solutions would generate appropriate flow of revenues to allow developing nations to benefit from biodiversity conservation and clean technologies, and the process by which global property rights could be allocated within and across nations, including how initial endowments can be decided. It showed how the creation of new global property rights can generate revenues to fund R&D efforts to the benefit of all, in particular, of developing nations. The rationale for these proposals in this chapter is based on prior published work by the author starting from 1993, during the Kyoto Protocol negotiations in 1996 and 1997 and include the author's proposal leading to the creation of the global carbon market of the Kyoto Protocol.

The article discussed specific mechanisms to guarantee the adequate level of funding and the appropriate selection of R&D projects, as well as the governance conditions for adequate performance. By means of a few practical examples the chapter explained the global and the local nature of the environmental assets under consideration, such as watersheds and forests; indigenous knowledge and the global spectrum (Chichilnisky 1996a,b, 2010a,b). The examples are diverse but they all share the same principles of how to organize the local and global commons. Once these examples are presented, the article suggested specific ways in which substantial revenues can be obtained for the benefit of all and examples of the mechanisms to guarantee (i) adequate levels of funding, (ii) selection of projects that are self funded, (iii) encourage sustainability and (iv) redistribute income and welfare in fair and efficient ways locally, regionally and globally.

The proposals presented here are ambitious. But a sea change is taking place in the world economy and it requires a corresponding change in institutions from the Bretton Woods orientation that prevailed in the world economy since WWII. We need to create new institutions with principles that are harmonious with the planetary resources, and can be consistent with the survival of our species. The proposals in this chapter addresses this challenge.

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