Paying for International Environmental Public Goods

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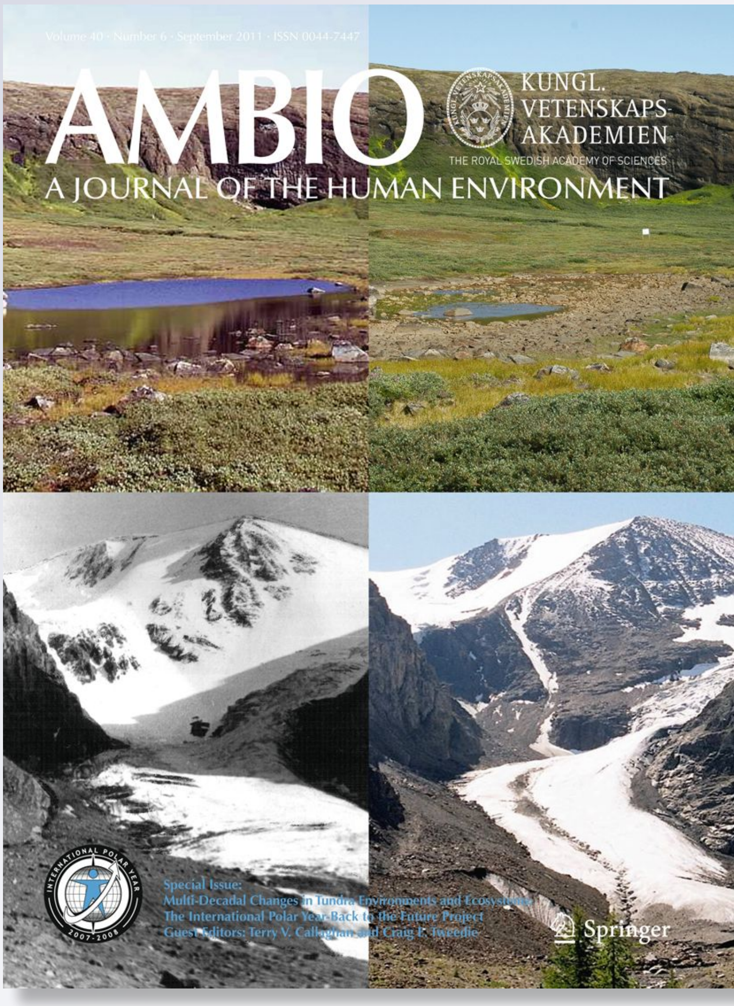

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REVIEW PAPER

Paying for International Environmental Public Goods

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Abstract Supply of international environmental public goods must meet certain conditions to be socially efficient, and several reasons explain why they are currently undersupplied. Diagnosis of the public goods failure associated with particular ecosystem services is critical to the development of the appropriate international response. There are two categories of international environmental public goods that are most likely to be undersupplied. One has an additive supply technology and the other has a weakest link supply technology. The degree to which the collective response should be targeted depends on the importance of supply from any one country. In principle, the solution for the undersupply lies in payments designed to compensate local providers for the additional costs they incur in meeting global demand. Targeted support may take the form of direct investment in supply (the Global Environment Facility model) or of payments for the benefits of supply (the Payments for Ecosystem Services model).

Keywords International environmental public goods · Ecosystem services · Payments for ecosystem services · Global environmental public

INTRODUCTION

How can we best secure the provision of international environmental public goods (IEPGs)—public goods offering benefits that span multiple national jurisdictions? It is well understood that markets undersupply public goods, and there is a wealth of evidence that many environmental public goods have been systematically undersupplied over a long period of time (Millennium Ecosystem Assessment 2005). If environmental public goods occur at the scale of the nation state or below, the failure of markets to supply public goods may be offset by the actions of local or national governments. There exist many national agencies with responsibilities for the provision of environmental public goods such as habitat for rare and endangered species, clean water, environmental health protection, and so on. There also exist many offset or mitigation systems for securing private provision of public goods at a national level (Madsen et al. 2010). At the international level, where there is no supranational authority to take responsibility, the failure of markets to deliver environmental public goods is more difficult to offset. Depending upon the magnitude and distribution of the payoffs to public good provision, individual countries will have a stronger or weaker incentive to commit resources to their provision. Doing more than that depends upon agreement between nation states (Kaul et al. 2003a; Barrett 2007).

Many IEPGs are strictly global. Examples include the conservation of the genetic diversity on which all future evolution depends, the mitigation of climate change, the control of emerging infectious diseases, and the management of sea areas beyond national jurisdiction. Many more are regional, such as the control of acid rain, the management of multi-country river basins, and the protection of international watersheds (Touza and Perrings 2011). Like all public goods, IEPGs exhibit both consumption indivisibilities and non-excludability. Non-excludability means that once the good is provided, none can be excluded from enjoying the benefits it confers. Indivisible consumption occurs when one country's enjoyment of the benefits does not diminish the amount available for others. Public goods are said to be 'pure' when they are both non-exclusive and non-rival (indivisible) in consumption. They are said to be impure if they are either partially excludable or partially rival—the most common form of which are local public goods, particularly the local common pool resources analyzed by Ostrom (1990). In most cases, it is not possible for any single state to provide such goods on its own. International public good supply depends on either international coordination or international cooperation (Anand 2004).

This article focuses on IEPGs whose benefits extend to people in multiple countries. Such IEPGs frequently also deliver benefits across multiple generations (Kaul et al. 1999), but we do not address this aspect of the problem. In practice, the beneficiaries of international public goods include national populations and their representatives, nation states, transnational corporations and non-governmental organizations, as well as a newly emerging set of institutions. Globalization has altered the way that members of civil society organize themselves across national boundaries. The information revolution has also stimulated new forms of social participation. New networks, frequently built around environmental websites, enable the exchange of ideas and implementation techniques. These new relationships and interactions have created a 'global environmental public', interested in asserting new rights and responsibilities to the resources of the planet. Its concerns span both the ethical responsibilities of individuals, organizations, countries and corporations, and the alternative forms of governance of the biosphere.

Following the Millennium Ecosystem Assessment, we suppose that the benefits people obtain from biosphere depend on a set of ecosystem services comprising:

- Provisioning services: products people obtain from ecosystems, such as food, fuel, fiber, fresh water, and genetic resources.
- Cultural services: nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences.
- Regulating services: benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, regulation of floods and droughts, regulation of human diseases, and water purification.
- Supporting services: those that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation.

These services affect human wellbeing in many ways: through their role in the production of consumption goods, their support of human health and security, or the satisfaction of peoples' cultural and spiritual needs. A number of these services have the characteristics of IEPGs, the most important of which involve the regulating and supporting services. Figure 1 indicates the relation between categories of ecosystem services and components of wellbeing identified by the Millennium Ecosystem Assessment. Of these, only the provisioning services consistently generate benefits that are both divisible (rival) and exclusive. The other services yield benefits that are generally indivisible and non-exclusive. We focus on the group of ecosystem services that are both public and international. These are services that: (i) cover more than one group of countries; (ii) benefit not only a broad spectrum of countries but also a broad spectrum of the global population; (iii) meet the needs of both present and future generations (Kaul et al. 1999; Anand 2004). International public goods generated in any one county must therefore generate spillover effects beyond a nation's boundary (Morrissey et al. 2002).

IEPGs can further be classified according to their 'technology of supply' (Sandler 2004). The standard treatment of public goods focuses on demand (Hirshleifer 1983). However, understanding the technology of supply of IEPGs is critical to the development of appropriate incentives. Three common examples of public good supply technologies are 'additive', 'best shot', and 'weakest link' technologies. As the name implies, in the additive case, the socially available amount Y of a public good is nothing but the 'simple sum' of the separate amounts, y^i, produced by each of m participating countries, the $i = 1,\ldots, m$. In the case of simple sum public goods, such as carbon sequestration, each unit of carbon sequestered has the same value no matter where it occurs. In the case of weighted sum public goods, such as habitat protection, the contribution of each hectare protected depends on its characteristics (Sandler 2004). For 'best shot' public goods, the benefit to all countries is determined by the most effective provider. For example, the Centers for Disease Control and Prevention are funded by the U.S.A., but provide information on infectious diseases to all countries. For 'weakest link' public goods, the benefits to all countries are limited to the benefits offered by the least effective provider. The best example of this is the control of infectious diseases. So for HIV and tuberculosis, the level of protection available to all countries is only as good as the control of the disease exercised in the poorest, most densely populated, and least well-coordinated country (Perrings et al. 2002).

Social composition functions

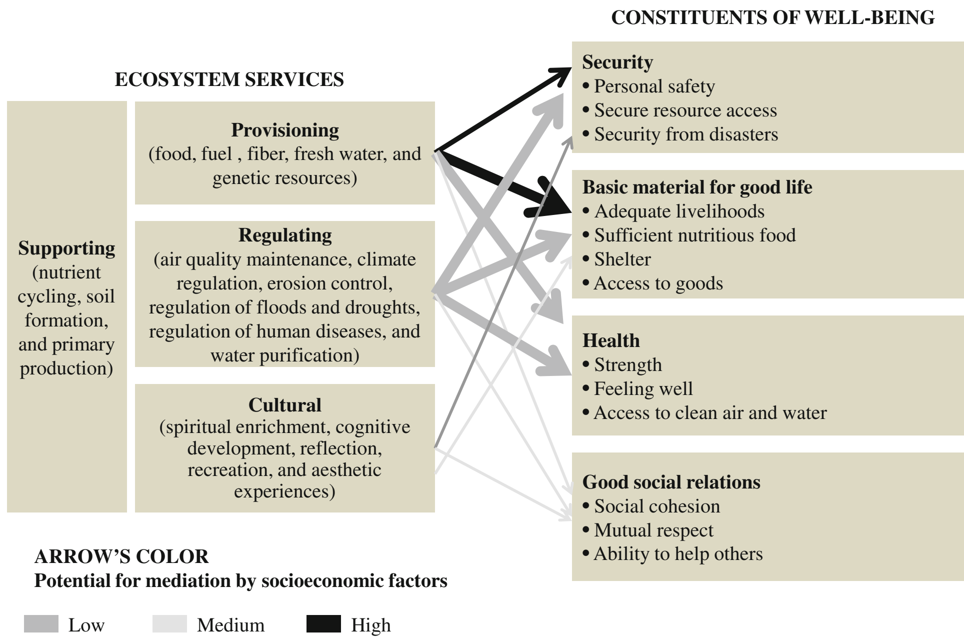
$$Y = \sum_i y^i \quad \text{Summation}$$

$$Y = \min_i y^i Y = \min_i y^i \quad \text{Weakest-link}$$

$$Y = \max_i y^i \quad \text{Best-shot}$$

Of all the Millennium Ecosystem Assessment ecosystem services, the regulating services are most often supplied as IEPGs. Examples include disease control, which is frequently supplied as a weakest or weaker link public

Fig. 1 Linkages between ecosystem services and human well-being (*arrow's width* intensity of linkages between ecosystem services and human well-being) (adapted from Millennium Ecosystem Assessment, 2003)



good, climate regulation through, e.g., carbon sequestration, which is supplied as an additive pure public good, or watershed protection which is generally an additive but impure public good (Holzinger 2001; Dombrowsky 2007; Touza and Perrings 2011). Many international public goods are also jointly produced with local public goods. Biodiversity in tropical forests, for example, yields a set of private benefits in the form of timber and other products including medicinal plants, hunting, fishing, recreation, and tourism. At the same time, tropical forests are a source of carbon sequestration, genetic information, hydrological and microclimatic regulation—commonly described as co-benefits (Perrings and Gadgil 2003).

An important feature of IEPG is that their spatial extent depends partly on the natural hydrological and atmospheric flows, and partly on the social linkages between countries—the flow of goods, people, and information. The global reach of carbon sequestration is a property of the general circulation system, but the global reach of disease regulation is a property of the global trade and air transportation systems. In fact, the closer integration of the world economic system has rapidly increased the number of environmental public goods that are global in reach (Kaul et al. 2003b):

- New technologies increasingly enhance human mobility as well as the movement of goods, services, and information around the world (e.g., case of transmission of human diseases and air pollution as international environmental public bads).
- Economic and political openness have provided further impetuses to cross borders and transnational activities (e.g., case of transmission of human diseases and air pollution as international environmental public bads).
- Systematic risks have increased (e.g., case of climate change as an international environmental public bad).
- International regimes are becoming more influential, often formulated by small groups of powerful nations yet often claiming universal applicability (e.g., case of bio-prospecting contracts to find cure for cancer and other human diseases).

The central problem addressed in this article is how to secure environmental public goods that (a) are provided at particular locations but offer benefits over a wider area, and (b) generate local benefits that are below the local cost of supply. These are the IEPGs that are most likely to be undersupplied. This article is organized in four sections. The following section reviews the fundamental problem with IEPGs—the incentive that each country has to free ride on the efforts of others. A third section then considers the options for addressing the problem. This reviews the applicability of currently popular instruments, such as payments for ecosystem services, in terms of the characteristics of the public good concerned. A final section draws out the implications for national and international environmental policy.

WHY ARE INTERNATIONAL ENVIRONMENTAL PUBLIC GOODS UNDERPROVIDED?

International environmental public goods generate benefits that spill over national borders, so that the benefits (or costs) of those goods extend beyond the country of origin. If the marginal local benefits of public good provision are less than the marginal local costs, there will be no incentive to provide the public good at all. If the marginal local benefits of public good provision exceed the marginal local costs of provision, but benefits also accrue to other countries, there will be an incentive to produce the public good, but unless the country is a 'best-shot provider' it will not be at a level that would satisfy international demand (Ferroni and Mody 2002; Kanbur 2003, 2004). We first of all review the problem and then consider the options for addressing it. We have elsewhere considered the cases where the national incentive to produce IEPGs is sufficient to meet global demand (Touza and Perrings 2011). In this article, we address the case where independent local action is not sufficient to secure efficient global supply.

Consider the conservation of endangered species. Can we rely on the national action to produce the efficient amount of an IEPG such as the protection of iconic species? The key to understanding this lies in the difference between a pure public good and a private good. For a private good, everyone pays the same price, but is free to consume as much or as little as they want. Consumers adjust the quantity they consume given the market price. For a pure public good everyone consumes the same amount of the "good" but is willing to pay a different price for it. Consumers adjust the amount they are willing to pay for the public good given the quantity supplied (Batina and Ihori 2005). In general, private provision of public goods will be below the socially optimal level. Efficiency requires that marginal benefit equals marginal cost. In the case of conservation of endangered species (or any other public good), the relevant measure of marginal benefits is social marginal benefit—the sum of all countries marginal benefits. We illustrate the problem in Fig. 2, in which local and global benefit curves for species conservation in a particular country, i, are presented. Global benefits are represented by the vertical sum of the benefit curves of country i, and all other countries.

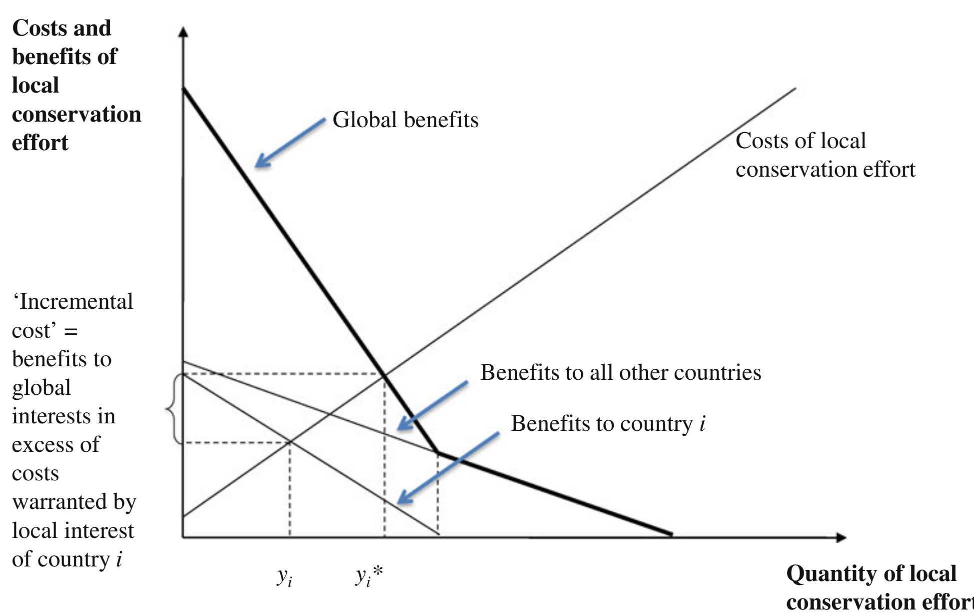
The level of conservation in country i that maximizes local net benefits is indicated by y^i, while the level of conservation that maximizes global benefits is indicated by y^{i*}. y^i is given by the intersection of local supply and local benefit curves, and y^{i*} by the intersection of local supply and the vertical sum of local benefits for all countries. Since the marginal cost of provision at y^{i*} is greater than country i would be willing to accept on its own, socially optimal provision of the public good depends on the existence of a mechanism to cover the 'incremental' cost of socially optimal provision to country i.

Biodiversity conservation, like many other IEPGs, is an impure global public good. If there are many potential providers, each generates local benefits from its conservation effort, but also benefits from the conservation actions of others. Following, Perrings and Gadgil (2003), we characterize the problem for the individual country as follows. V^i denotes welfare of the ith country, assumed to depend on consumption of a vector of market goods, x^i, and global biodiversity conservation, denoted $C = C(y^1, y^2,\ldots,y^m)$, then the problem it faces is of the general form:

$$\mathrm{Max}_{x^i y^i} V^i\left(x^i, y^i, C\left(y^1, \ldots, y^m\right)\right)$$

In other words, it derives a direct benefit from its own conservation efforts, y^i, but also benefits from the global conservation effort to which it has contributed, C. If the cost of conservation effort in terms of the cost of market

Fig. 2 Efficient provision of conservation effort



goods is $p(y^i)$, and if the income available to country i is I^i, this will be subject to the constraint that

$$I^i = x^i + p(y^i)y^i$$

In the absence of cooperation, and noting that $V^i_{y^i} = \partial V^i/\partial y^i, V^i_{x^i} = \partial V^i/\partial x^i$ and $C_{y^i} = \partial C/\partial y^i$, wellbeing of the ith country will be maximized where the local level of conservation satisfies:

$$\frac{V^i_{Y^i}}{V^i_{x^i}} = p_{y^i} - \frac{V^i_c}{V^i_{x^i}} C_{y^i}$$

If global wellbeing is the sum of the welfare of all countries, $V = \sum_{j=1} V^j$, then global wellbeing will be maximized where

$$\frac{V^i_{Y^i}}{V^i_{x^i}} = p_{y^i} - \sum_{j=1} \frac{V^j_c}{V^i_{x^i}} C_{y^i}$$

The extra terms in the summation term on the right hand side capture the conservation benefits that the ith country confers on all other countries. These benefits will be neglected by the ith country unless there is a mechanism to convert them into a direct incentive.

The failure of markets to signal the global benefit of such public goods accordingly results in under-investment in their local provision. The benefits of protection, management and establishment of forests provide a good example. Apart from the loss of the valuable environmental services (e.g., protection of genetic resources, air quality maintenance, climate regulation and regulation of human diseases), forest degradation frequently translates into a loss of timber and non-timber forest products important to local livelihoods (Landell-Mills & Porras 2002).

Currently, there are few measures of the underprovision of public goods. The United Nations Development Programme (UNDP) has opted instead for measures of "adequate" provision that differ from one public good to another. Such measures can, for example, correspond to the complete elimination of global public bads. More generally, they are measures of what is considered possible, given the current state of technology (e.g., to control—rather than eradicate—the problem of HIV/AIDS) and what is "fair" (e.g., what would emerge if all concerned stakeholders had an effective voice in the decision-making process) (ODS-UNC 2002). The criterion of adequacy is not meant to indicate optimality—the balancing of marginal costs with the sum of people's marginal willingness to pay for a particular public good (see Samuelson 1954; Cornes and Sandler 1996). Rather, it is meant to establish a relatively simple, yet reliable, yardstick for measuring the present provision of a certain good against a technical notion of adequacy.

In the case of the global public good 'communicable disease control', for example, it has been possible, given the biological characteristics of the infectious agent and available technologies, to completely eradicate certain diseases. In these cases, the criterion for adequate provision is defined as complete eradication, or zero incidences in the "wild." The determination of "adequate provision" is based solely on technical considerations, without reference to costs, benefits or existing preferences and willingness to pay. Therefore, there may be cases where adequate provision may not be economically feasible. It is important to assess the net benefits/costs of inaction against the net benefits/costs of corrective action to determine, at least approximately, whether meeting the technological requirements for adequate provision is economically desirable (UNDP 2002).

POLICY OPTION: PAYMENTS FOR ECOSYSTEM SERVICES

In principle, the solution to IEPG problems of this form lies in payments designed to compensate local providers for the additional costs they incur in meeting global demand. Indeed, that is the basis on which the Global Environment Facility (GEF) was founded. The GEF unites 182 member governments—in partnership with international institutions, nongovernmental organizations, and the private sector—to address global environmental issues. An independent financial organization, the GEF provides grants to developing countries and countries with economies in transition for projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants. These projects benefit the global environment, linking local, national, and global environmental challenges, and promoting sustainable livelihoods. The concept of incremental cost, which notionally determines the payments made by the GEF, is related to the difference between the cost a country would be prepared to bear in the provision of an environmental public good (the cost that would be warranted in terms of the national benefits generated by the public good) and the cost of meeting global demand for the same public good (Pearce 2003, 2005). It is a national payment for an environmental service that is an IEPG.

Systems of Payments for Ecosystem Services (PES) have become popular instruments for dealing with IEPGs, in part because they appear to satisfy the incremental cost principle (Ferraro and Simpson 2002; Goldstein et al. 2006; Wunder 2007; Ferraro and Kiss 2007; Pagiola 2008; Engel et al. 2008; Wunder et al. 2008). They are not, however, appropriate mechanisms in all cases. International PES schemes are appropriate where non-marketed ecosystem services are privately supplied in one country, but offer benefits that are public and accrue elsewhere.

To illustrate the potential pluses and minuses of PES, we consider a particular problem: the impact of local deforestation on the provision of a range of IEPGs including climate regulation (through carbon sequestration), protection of genetic diversity, and watershed protection in addition to timber and non-timber forest products. The Economics of Ecosystems and Biodiversity (TEEB) study is a major international initiative to draw attention to the global economic benefits of biodiversity, to highlight the growing costs of biodiversity loss and ecosystem degradation, and to draw together expertise from the fields of science, economics and policy to enable practical actions moving forward. The current assessment of TEEB on PES has used existing studies to estimate the mean value of both the macroclimatic regulation offered by terrestrial carbon sequestration, and the change in provisioning and cultural services offered by forest systems. Its findings are preliminary but telling. TEEB (TEEB 2009; Kumar 2010) suggests that the mean values of forest ecosystem services, in US$/ha/year, are dominated by regulatory functions: specifically regulation of climate ($1965), water flows ($1360), and soil erosion ($694). The mean value of all provisioning services combined—timber and non-timber forest products, food, genetic information, pharmaceuticals—is $1313. This is less than the value of water flow regulation alone. There are substantial off-site benefits to forest conservation that are not currently captured by forest landowners and are difficult to incorporate on PES schemes.

Governments around the world have frequently implemented forest protection policies in areas high in biodiversity, landscape beauty or critical for their watershed protection. However, as pressure mounts on governments to curtail spending and cut budget deficits, their ability to invest directly in the provision of public goods and services is compromised. Where public authorities have been unable to tackle the public good problem, they have searched for ways to involve non-governmental actors. Efforts to transfer responsibility for forest environmental services out of the public sector have relied on a combination of regulation and market-based approaches (Landell-Mills and Porras 2002). Experience has shown that well-designed market-based instruments can achieve environmental goals at less cost than conventional "command and control" approaches, while creating positive incentives for continual innovation and improvement (Stavins 2003). Examples of such instruments in the forestry sector include stumpage value-based forest revenue systems, financial and material incentives, long-term forestry concessions, trade liberalization, forest certification and the promotion of markets for non-timber forest products.

The costs and benefits associated with many human activities spill over jurisdictional boundaries, thereby generating externalities that are often reciprocal and quantitatively significant (Cornes 2008). Therefore, IEPGs supply depends on either international coordination or international cooperation. Among payment schemes to internalize the external benefits of maintaining intact forests, Reducing Emissions from Deforestation and Forest Degradation (REDD) is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. REDD is an example of international coordination in delivery of ecosystem services. Its integration into international market-based climate change policies poses a number of challenges both to institutional design and to implementation. At present, for example, there are few effective mechanisms for converting international payments to governments into incentives to on-the-ground forest communities (Myers 2008; Sikor et al. 2010). Indeed, creating an effective multilevel system of payments is seen as the core issue in building REDD considering that REDD goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forest and enhancement of forest carbon stocks (Anngelsen and Wertz-Kanounnikoff 2008). It is predicted that financial flows for greenhouse gas emission reductions from REDD could reach up to US$30 billion a year. This significant North–South flow of funds could reward a meaningful reduction of carbon emissions and could also support new, pro-poor development, help conserve biodiversity, and secure vital ecosystem services.

A second issue is the linkage between distinct ecosystem services. The REDD scheme targets one important ecosystem service: carbon sequestration. However, it has the potential to secure other services as well. These services potentially include both habitat provision for biodiversity conservation and watershed protection. Reaching international agreement on an instrument to reduce emissions from deforestation and forest degradation, while recognizing the co-benefits offered by conservation, and the sustainable management of forested watershed would both secure global carbon sequestration services, as well as help to maintain other valuable services provided by forests (TEEB 2009). There is growing recognition that REDD planning requires a broadened approach. A future REDD mechanism should incentivize emissions reduction from reduced deforestation, enhanced carbon sequestration and address a number of non-carbon services. Implementation of REDD also requires attention to the quality of forest governance, conservation priorities, local rights and tenure frameworks, and sub-national project potential (Phelps et al. 2010).

IMPLICATIONS FOR INTERNATIONAL ENVIRONMENTAL POLICY

Globalization is often associated with increased privateness—economic liberalization is associated with the growth of the number of goods and services allocated through markets, international market integration, and enhanced private cross-border economic activity such as trade, investment, transport, travel, migration and communication. However, globalization is also about increased publicness—about people's lives becoming more interdependent. Events in one place of the globe often have worldwide repercussions. Moreover, a growing volume of international policy principles, treaties, norms, laws, and standards is defining common rules for an ever-wider range of activities (Kaul et al. 2003b).

Public goods are recognized as having benefits that cannot easily be confined to a single "buyer" (or set of "buyers"). Yet once they are provided, many can enjoy them for free. A clean environment is an example. Without a mechanism for collective action, these goods will generally be underprovided. In fact, many crises dominating the international policy agenda today reflect the under-provision of global public goods. With globalization, externalities are increasingly borne by people in other countries. Indeed, issues that have traditionally been merely national are now global because of the greater interconnectedness of the planet.

Kaul et al. (2003b) suggest a rethinking of three notions underpinning the theory of public goods. First, properties of non-rivalry in consumption and non-excludability of current benefits do not automatically determine whether a good is public or private. Some goods may be either public or private. Nevertheless, it is important to distinguish between a good's having the potential of being public (that is, its having non-rival and non-excludable properties) and its being de facto public (non-exclusive and available for all to consume). Second, public goods do not necessarily have to be provided by the state. Many other actors can, and increasingly do, contribute to their provision. And third, a growing number of public goods are no longer national in scope, having assumed cross-border dimensions. Many have become global and require international cooperation to be adequately provided.

For the most part, the theoretical and empirical literature in economics has focused on two polar models of public goods provision: the provision of pure public goods that benefit all agents, and the provision of local public goods that only benefit agents in one community (Bloch and Zenginobuz 2007). We are concerned with cases where the members of one community enjoy positive spillovers from the public goods provided by other communities. In the context of global climate regulation, the REDD scheme will compensate tropical nations that succeed in reducing carbon emissions from deforestation and forest degradation—source of nearly one fifth of global carbon emissions. Since forests offer a number of benefits aside from carbon, however, the scheme could potentially benefits to communities that would otherwise be unable to afford them (Stickler et al. 2009). If well designed and implemented, PES schemes such as REDD have the potential to secure provision of IEPGs that offer benefits at multiple scales, such as the protection of water supplies, local and regional climate regulation, and habitat provision for the protection of biodiversity. The effectiveness of PES schemes depends heavily on the conditionality of payments (Arriagada and Perrings 2009), but the principles for their effective design and implementation are well understood.

To summarize, the implications of this paper for international environmental policy are the following:

1. Diagnosis of the public goods failure associated with particular ecosystem services is critical to the development of the appropriate international response. There are a number of cases where the incentive structure is such that independent actions by nation states will be 'good enough' to secure the public interest (Touza and Perrings 2011). Where the technology of supply is 'best shot' or where the local benefits are high enough to lead to a level of supply that is close to the global optimum, then the independent actions of nation states will be adequate. However, where local benefits lead to a level of local supply that leaves global demand unsatisfied, then international coordination or cooperation in the delivery of ecosystem services will be required. We note that this largely depends on the nature and strength of off-site effects. Local actions that generate significant off-site benefits or costs are most likely to require international coordination or cooperation. Off-site effects can reflect both natural (through hydrological or atmospheric flows) and social (through trade and travel) transmission. Since social transmission of effects is rapidly evolving, understanding social transmission pathways is important to the diagnosis of the public goods failure.
2. There are two categories of IEPGs that are most likely to be undersupplied. The first involves an additive supply technology, a high opportunity cost of supply and transmission to a large number of other countries through the general circulation system. Examples include mitigation of climate change, and management of transboundary nutrient flows, currently addressed through the UN Framework Convention on Climate Change and the Convention on Long Range Transboundary Air Pollution. The second involves a weakest link supply technology, and transmission to a large

number of other countries through global trade, transport and travel. Examples include the management of infectious zoonotic diseases and the control of invasive pest species, currently addressed through the International Health Regulations, the Sanitary and Phytosanitary Agreement, and the Convention on Biological Diversity.

3. If there is a public good failure that demands international coordination or cooperation, it is then important to determine the degree to which the collective response should be targeted. In principle, action should be targeted to reflect the weight attaching to the supply from any one country. So, at one extreme, international contributions to an IEPG with an additive supply technology that is unweighted (a simple sum), such as carbon sequestration by forest plantations, should not be targeted at all. Whereas international contributions to a weakest link international environmental public good, such as infectious disease control, should be targeted at the weakest link. In practice, most ecosystem services are jointly produced (come as a bundle), and involve an intermediate position. Particular countries are more important for the provision of some services than others (e.g., high biodiversity countries contribute more to the global gene pool than others) so most international contributions to IEPGs should be targeted in some measure.
4. For IEPGs that are supplied in specific countries, support may take the form of direct investment in supply (the Global Environment Facility model) or of payments for the benefits of supply (the Payments for Ecosystem Services model). The fact that GEF is under-resourced, and is only weakly targeted, suggests that the second option may become the dominant mechanism for assuring local provision of IEPGs. We have elsewhere discussed the conditions that need to be satisfied for PES schemes to be effective (Arriagada and Perrings 2009). The most important of these is that payments for ecosystem services should be conditional on the supply of those services. Where PES schemes have both income transfer/poverty alleviation and public good supply objectives, conditionality may be lost altogether. It is important that the design of PES schemes fit the diagnosis of the public good problem, and the technology of public good supply.

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