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How Can Latin America Help the World to Cope with Climate Change?

The Issue of Deforestation

Sebastián Galiani
Manuel Puente
Federico Weinschelbaum

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Abstract

Latin America has a comparative advantage in deforestation compared to other forms of climate change mitigation. Thus, to the extent that Latin America should engage in mitigation, the optimal climate change policy should manage these advantages by generating incentives in Latin America to deal with forestry. This paper describes the problem of deforestation and studies the market failures that arise in relation to forestry emission problems, analyzing them from a global public good perspective. The paper additionally describes other problems related to forestry emission issues and presents a non-exhaustive review of the solutions currently proposed to address this issue. The paper concludes with policy recommendations.

JEL classifications: D71, D79, F18, F53, F64, Q54
Keywords: Deforestation, Climate change, Mitigation, Public good, Market failure, Latin America

1. Introduction

In many ways the problem of human-induced climate change is unique: it is global, it will affect the planet for decades to centuries, and it is complex, imperfectly understood, and has the potential for serious consequences. Indeed, climate change (CC) presents one of the most complex and difficult coordination problems the world has ever faced. It is an intergenerational global public good problem that also has some intragenerational aspects. The problem is aggravated by uncertainty and by the fact that free rider problems often arise when sovereign states cannot be compelled to participate in institutional arrangements by organizations that aim at targeting the issue, nor can they be punished by force.

The hypothesis that the world's climate will change and that human activities can contribute to this change through emission or retention of greenhouse gas (GHG) is commonly accepted now by scientists and policymakers (see for example Drake, 2005; Stewart, 2010). However, there is much dispute on how strong the change will be or when it will happen. Furthermore, the problem is intensified by great impact heterogeneity across the globe, independently of each country's share of GHG emissions. First, some regions will face huge costs from CC, such as coastal areas affected by higher sea levels, and agricultural regions and especially warm regions such as Africa will see an increase in the frequency of floods and droughts. On the other hand, other regions might face relatively small costs or even a positive impact as unproductive land in cold regions becomes usable for cultivation as temperature rises. Second, CC presents a scenario where emitters of CO2 are distributed unevenly across regions. Developed countries contribute the largest share due to fossil fuel emissions, followed by deforestation in developing countries, principally from tropical zones in Africa, South and Central America and Asia. Nevertheless, GHG emissions from fast-growing countries are expected to rise as their demand for energy increases (World Bank, 2010). These countries might increase their share of GHG emissions unless they decide to use alternative low-emitting energy (i.e., sustainable development). Finally, human effort in adaptation is expected to vary greatly across countries, further exacerbating existing heterogeneity of impact. One of the main problems with environmental issues is great uncertainty about the real magnitude and distribution of costs. The need to address the issue is pressing, and further investigation is needed in order to be able to use resources more efficiently. There are basically two means of addressing the problem of CC. The first is to spend resources on mitigation; the second is to invest in adaptation to CC. The ideal ratio between resources spent on mitigation and on adaptation is not yet clear because the impact of policies is not yet fully understood. Another problem is that estimation of the costs of climate change is highly uncertain. However, this does not mean that governments should not do anything about CC until information becomes available, but rather that policies must adapt to new information as it appears.

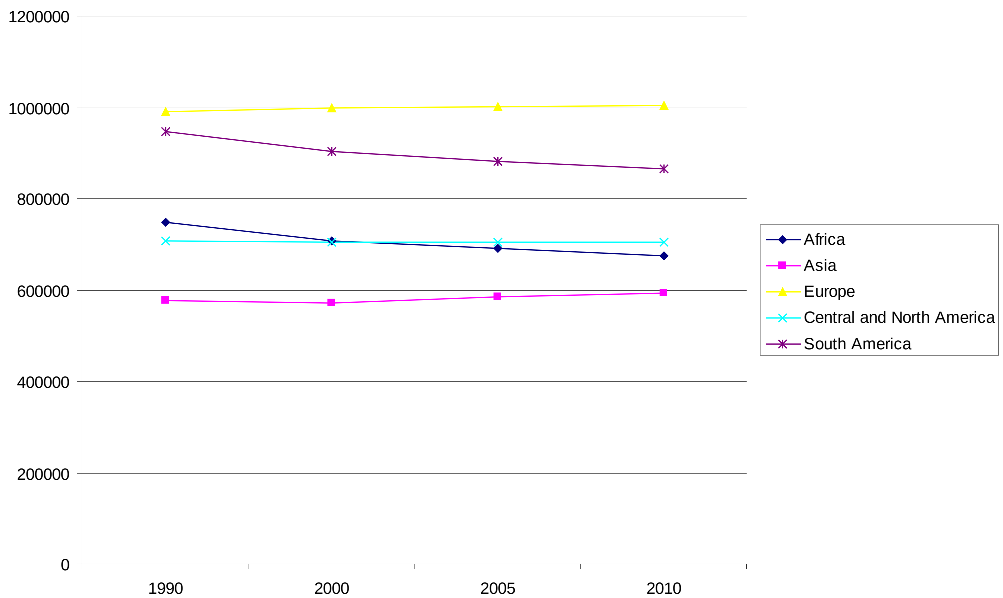
Latin America, like any other region, has to devote efforts to both mitigation and adaptation interventions. Moreover, the impact of one country's mitigation effort is distributed across the globe (see the explanation of global public goods below), while each country will enjoy most of the benefits from spending in adaptation. Then, if coordination problems are not solved and countries do not internalize mitigation externalities, we should expect an inefficiently high adaptation-mitigation ratio at the global level.

Deforestation accounts for approximately 25 to 30 percent of GHG emissions from human-related activities (Jiménez, 2007). In recent decades forests have increasingly received attention as important contributors to greenhouse gas (GHG) emissions as well as a possible instrument to alleviative climate change problems.

Deforestation is primarily confined to developing countries (Myers 1994), mainly in South America and Africa (FAO, 2011). In fact, while developed countries like the United States and the European Union have achieved a positive net rate of forestation (Sills and Pattanay, 2004; FAO, 2011), in the tropics an estimated forest area of the size of England is cleared every year (FAO, 2005), and by 2008 annual emissions from deforestation were comparable to the total CO2 annual CO2 emissions of the United States or China.

Tropical deforestation is estimated to have released 15-35 percent of annual fossil fuel carbon emissions during the 1990s (Houghton, 2003), or 10-25 percent of global human-induced emissions during that period (Houghton, 2003; Achard et al., 2002). These numbers become even more alarming if we account for the fact that, according to FAO (2011), deforestation rates might have been underestimated during the period. Annual rates of tropical deforestation from Brazil and Indonesia alone would equal four-fifths of the targeted emissions reductions from the Kyoto protocol in its First Commitment Period (see FAO, 2005). Although some regions present negative rates of deforestation, and global rates seem to be leveling (see Figure 1), it is widely agreed that forest management will be a major concern in future international policy agenda, and that climate stabilization in the medium term will not be possible without effective forestry policies. On the other hand, Latin American countries play only a small role in fossil-fuel related CC. Central and South America account for only 4 percent of total carbon dioxide emissions from energy consumption.

Figure 1. Total Forest Area (per 1,000ha)



Source: Authors' compilation based on FAO (2011) data.

Taking these numbers into account, it is clear that Latin America has a comparative advantage in deforestation compared to other forms of CC mitigation. Thus, to the extent that Latin America should engage in mitigation, the optimal CC policy should manage these advantages by generating incentives in Latin America to deal with forestry; reducing GHG emissions from fossil fuels is primarily the task of developed countries.

In the following section we describe the problem of deforestation. In Section 3 we study the market failures that arise in relation to forestry emission problems, analyzing them from a global public good perspective. In Section 4 we describe other problems related to forestry emission issues and present a non-exhaustive review of the solutions currently proposed to address this issue. Finally, in Section 5 we conclude.

2. The Deforestation Problem

Forests influence climate change in several ways. First, they are a major sink of carbon (C), holding it in trees, biomass and underground soil. The amount of C held depends on the type of forest, tropical forests being the most important. Forests can have positive effects on climate change because of the absorption of carbon through photosynthesis, but they can also emit CO2 through respiration. Trees are net absorbers of C when they are growing but net producers when they reach their full growth. When forests are disturbed by human activity, their carbon is released in to the atmosphere. The amount of C released depends on the type of forest and the use given to the land once disturbed. For example, selective logging (i.e., logging only the trees with the greatest diameter) will have a much smaller impact than slash-and-burn activities. Second, forests can also absorb carbon when they are growing (due to forest regeneration after disturbance, reforestation of previously forested areas, or afforestation of land that have been given other uses for some time), in this way reducing the potential damage from other emission sources. Forests have the potential to absorb one tenth of world's carbon emissions in the first half of this century in their biomass, soil and products. Third, forests are very sensitive to climate change and have the potential to reinforce contamination problems. An increase in the intensity and frequency of diseases and fires due to extreme events could have a large negative impact on climate change. For example, the 1997-1998 *El Niño* episode provoked severe droughts in the Amazon and Indonesia, resulting in the loss of about 13 times the area burned during the average rainfall year and twice as much the annual deforestation (De Fries et al., 2005; Santilli et al., 2005; de Mendonça et al., 2004). Finally, the loss of forests has other tangible and non-tangible consequences, like the increase in floods and contamination of potable water in the surroundings, loss of biodiversity and animal habitat, and damage to tourist zones.

Many possible causes of deforestation have been discussed in the literature, which has not yet provided a general framework that can be applied to all cases. It seems likely that there are a variety of causes correlated with different characteristics of the soil, institutions and culture. However, this does not mean that a general solution cannot be found at a global level. As we will see, coordination from most nations is needed to solve public good problems but, as we discuss in this section, differences across cases require micro-implementation of the solution to be carefully thought out, accounting for the specificities of each case.

Toman (1994) explains the deforestation problem as an intergenerational one: higher rates of deforestation imply higher growth and lower natural assets for future generations, but consequently higher capital assets. Following the author, this line of reasoning raises the question of which forest to log, and how much logging should be done.

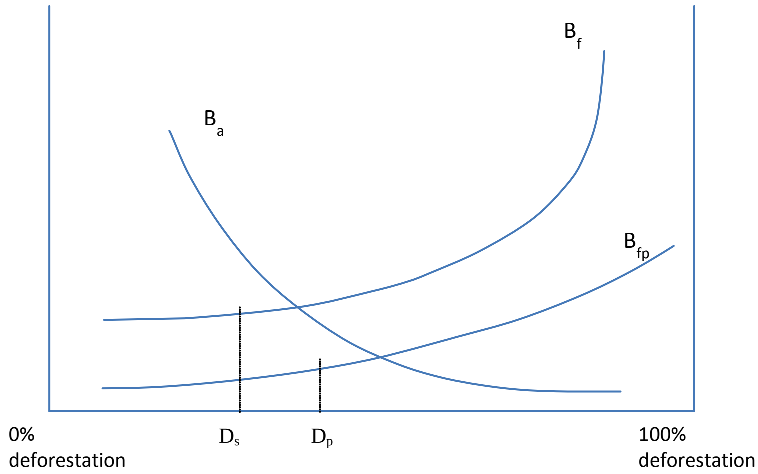
Even though a zero or negative deforestation rate might be undesirable from a welfare point of view for Latin America, at this moment agents involved in forestry (such as governments, private companies and farmers) do not have incentives to incorporate global externalities of their actions into their decisions, leading to higher rates of deforestation than the socially optimal.

Dann van Soest (1998) proposes a stratification of forests according to their benefits and their cost of opportunity. He states that it is efficient to deforest the parcels that are in the lower end of the "priorities of substitution" list, until the marginal benefits and costs of changing the last piece of forest to other land use are equal. According to Dann van Soest, some facts have to be taken into consideration when making this list. First, there should not be too much logging, because there is a point of no return ("the more you log the slower the regeneration time"). Second, forests with higher biodiversity should be higher on the list, as they have higher CO2 retention and fauna take longer to regenerate. Third, there has to be a distinction between primary and secondary forests. The former are forests that have not been disturbed by human activity, and thus retain the maximum amount of C, while the latter have already lost some of their biomass, and are regenerating and accumulating carbon in their soil, biomass and products.

The most common market failure in the topics studied here are externalities and public goods. Alternative land uses generate tangible economic benefits, such as timber, agricultural goods or organic fuel, which can be appropriated by the actors in charge of forestry decisions. On the other hand, most benefits from forests are locally or globally enjoyable (potable water to the region, global warming). Figure 2 illustrates this issue. First, we suppose that the opportunity cost of forests (e.g., the benefits of having more land for agriculture) is decreasing with the forest stock.[1] We assume that marginal benefits from forests (both private and social) are increasing with the level of deforestation. As we can see from Figure 2, if we do not take into account social benefits from forests, we will have an overexploitation of this resource (D_s<D_p).

[1] One justification could be general equilibrium effect: the higher the offer of forestry related goods, the lower the price. Another is decreasing marginal returns to alternative land uses.

Figure 2. Benefits of Alternative Land Uses According to Deforestation Level



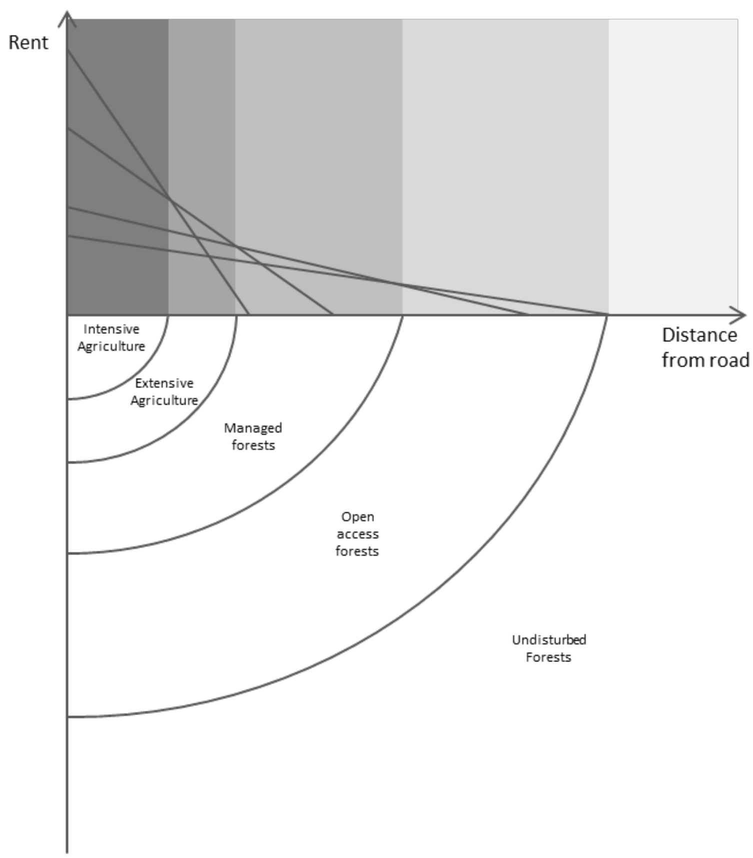
According to the literature on externalities, incentives have to be given to these actors to ensure the proper deforestation levels (D_s): positive incentives (e.g., transfers) or negative incentives (e.g., taxation or prohibition of alternative land uses) have to be used.

When wanting to model the microeconomic causes of deforestation, theorists usually use some sort of Von Thünen model. The idea proposed by Von Thünen (1826) is that some characteristics of the land, like distance to the city, will influence the rent expected from different land uses. Then, agents that seek to maximize profits will choose the type of cultivation that yields the highest benefits. Adaptations of this model for deforestation attempt to explain different land uses, like agriculture, forestry or logging, depending on macroeconomic (e.g., price of agricultural products), institutional (e.g., taxation of logging products) and technological variables, as well as some characteristics that are inherent to the particular piece of land and time (e.g., distance to a road).

Though it is tempting to use partial equilibrium models, there is a high risk of arriving at the wrong conclusions. For example, if a new technology that increases marginal agricultural production per square meter of land is introduced and the price of commodities is assumed fixed, we should expect an increase in deforestation. But a higher supply of agricultural products and a lower supply of forestry products will probably lower the benefits of the first option while raising those of the second one through price changes, mitigating or even reversing the first order effect.

Angelsen (2007) uses this analysis with a general equilibrium approach to explore the effect on deforestation rate of changes in agriculture-related technology, land tenure regimes, and community forest management. In his model land owners have to choose among five different (mutually exclusive) land uses for each hectare: intensive agriculture, extensive agriculture, managed forests, open access forests, and virgin forests. The application of the Von Thünen model with five alternative land uses gives the pattern shown in Figure 3 (Von Thünen's concentric circles), also found by Rudel (2005) in South Asia: as one moves from the center to the periphery the marginal rents decrease, generating intensive agriculture practices near the center (roads or cities), extensive agriculture, sustainable managed forests and finally *de facto* open and virgin forests as we move away from the center.

Figure 3. Von Thünen Model's Concentric Circles



Note: Each line represents rent of different land uses as a function of distance to the nearest road.
Source: Angelsen (2007).

In his model, Angelsen (2007) argues that the Von Thünen model helps to explain forest coverage in a static sense, but it does not provide an explanation of how land use varies when the rent of an alternative changes. In his paper, the transition to the new long-term equilibrium can be explained with two stages using the forest transition theory, which describes a cycle with high initial rates of deforestation, followed by low or even negative ones. As an example, suppose a new technology raises the productivity of land used for cultivation. In the first stage, agents react according to the Von Thünen model, using more land for cultivation as it becomes more profitable (implying higher deforestation rates). This can be seen in Figure 3 as shift to the right of limits between intensive and extensive agriculture and between extensive agriculture and forest management. In the second stage, this pattern is reversed, as in the new general equilibrium crop prices are lower and returns to forest higher. This illustration warns us of using partial equilibrium models, as we could be overlooking important general equilibrium effects.

Another part of the literature has tried to find the causes of deforestation empirically through case analysis. This is equivalent to try estimate the variables affecting the divisions between concentric circles in Figure 3. In the following paragraphs we present some studies as examples of this methodology.

Most of the research distinguishes between primary and secondary causes (Kaimowitz and Angelsen, 1998; Geist and Lambin, 2001; Contreras Hermosilla, 2000; Scrieciu, 2001). The primary causes, also called proximate or direct causes, are the most obvious ones. These are agricultural expansion, wood extraction and infrastructure extension. These causes are driven by underlying factors that are more difficult to identify. Giest and Lambin (2001) analyze 152 cases of tropical deforestation published in 40 scientific journals of different orientations, covering the time period from 1880 to 1996. They only use cases of deforestation and forest degradation (they do not work with other forest-related issues, like reforestation) and cases where data were available for two time periods. Thirty-six percent of the cases happened in Asia, 51 percent in Latin America, and 13 percent in Africa. They classify the cases according to the underlying causes of deforestation, using five broad categories: demographic, economic, technological, policy/institutional, and cultural or socio-political forces. The paper concludes "tropical deforestation is driven by identifiable regional variations of synergetic cause/driver combinations in which economic factors, institutions, national policies and remote influences are prominent." The expansion of cropped land and pasture is found to be the leading proximate cause of tropical deforestation (a result usually found across the literature, e.g., FAO, 2011), although in most cases it operates in conjunction with other proximate causes. Agriculture expansion operates in a synergetic way (cause connection) with the other proximate factors to create what the authors call the infrastructure-agriculture and the logging-agriculture tandem.

Poverty and population pressure are frequently proposed as the primary cause of deforestation. Large numbers of poor peasants increase population pressure and generate an expansion of cultivation towards forest lands (Myers, 1993; Rudel and Roper, 1997). This view sometimes gives rise to the pessimistic assessment that "demand for agricultural commodities and timber will continue to rise as the world population grows and becomes wealthier" (Eliasch, 2008. However, the link between national income and level of deforestation is not so clear. First, income could be positively associated with deforestation, raising the demand for agricultural and timber products and providing the opportunity to purchase new logging and farming technologies. But higher income might also permit investment in technologies of intensive agriculture and non-forest sectors such as industrial and service sectors (Sills and Pattanay, 2004; Foster and Rosenzweig, 2003). In many countries a pattern consistent with both alternatives has been found: at first, environmental damage increases together with income, and later income continues rising and environmental damage decreases or even becomes negative (e.g., the United States and many countries of the European now have positive net rates of forestation). This pattern is called the "environmental Kuznets curve" after Grossman and Krueger (1991).

Other factors have been found to be correlated with the level of deforestation in some studies but not in others. For example, distance to roads is found to be positively correlated with decreasing forest area by Chomitz and Thomas (2003) in Brazil, but has no effect according to Xiangzheng et al. (2008) in China.

Xiangzheng et al. (2008) use satellite remote sensing images of forest coverage in Jiangxi Province, China, to test whether the existence and the size of roads in 1995 affected the level of forest coverage in 2000 or the rate of deforestation between these years. Because distance measures that ignore topography can lead to wrong conclusions, they calculate the proximity to roads that penetrate the watershed in which each pixel lies. After controlling for additional covariates, they found that roads had no impact on the level of forest area and deforestation in this province.

Prices of agricultural products are typically positively correlated with deforestation, as well as wages (which constitute a part of the opportunity cost of land-use change). Another factor that could affect forestry is foreign debt. Countries with large foreign debt could be pushed to overexploit their natural resources to be able to meet their payment responsibilities. Finally, access to better technologies is sometimes associated with more deforestation (Vosti, Witcover and Carpentier, 2002), but, as discussed above, this could be just a short-run effect.

A final issue concerning the causes of deforestation is related to the efficient level of forest coverage. Environmental damage decisions have typically been associated with market failures, so interventions in these markets are necessary to guarantee an optimal level of exploitation.

Understanding the drivers of deforestation in a particular case is important in order to design an efficient policy that provides actors incentives to willingly adopt it. In other words, the policy should include compensation of at least the opportunity cost of continuing with business-as-usual. It is important to emphasize that this last point is true for individual actors such as farmers as well as for sovereign states, especially in poor countries where the lack of strong institutions, monitoring technologies or credible punishments makes it difficult to believe that the key actors will change their behavior due to a government mandate.

3. Forestry as Global Public Goods

In this section we review the general theory and lessons from the study of global public goods (GPGs) and their applicability to climate change in general and forestry in particular.

Public goods are typically used in economic literature as one of the cases of market failures. This means that the market on its own cannot generate efficient outcomes. Samuelson (1954) defined public goods according to two features: non-rivalry in consumption and non-excludability. The former means that no one can be excluded from their benefits or avoid their negative effects. The latter means that use by one person does not affect availability for the use of others. These characteristics imply that the good must be supplied at near-zero price, and *Samuelson's condition* must be met in order to assure efficient provision, which stipulates that the sum of the individual's marginal willingness to pay must be equal to marginal cost

(Samuelson, 1954).[2] The problem with this condition is that the market on its own will not generate the efficient outcome: at zero price, there are no incentives for producers to supply the goods. Provision-decisions must then be made by a non-market mechanism. A second issue is how the production of this good will be financed, as the characteristics of these goods drive individuals' incentives to under-reveal their preferences and result in the free-rider problem arises.

Sankar (2008) classifies public goods according to their geographical range and spillover area into "local (benefits affecting a small locality), national (pertaining to a nation), regional (relating to groups of nations) and global pertaining to the entire world)." According to the UNDP, a GPG has to meet two criteria. First, it must be a public good as defined above (i.e., characterized by non-rivalry in consumption and non-excludability). Second, its benefits have to be global in terms of countries, people and generations. This makes humanity as a whole the beneficiary of GPGs.[3] Environmental issues are a typical example of GPGs, and a highly problematic one. For local and transnational public goods, like national security, public supply and its financing through taxes are usually the best alternative. This is so because national governments have the means to provide the efficient level of the good and enforce payment through the tax system. In contrast, solving coordination problems is more difficult at a global level, as there is no international organization with a similar enforcing power.[4]

Another distinction usually made is between *technologies of public supply aggregation* (first introduced by Hirshleifer, 1983; for a full explanation of each category see Arce and Sandler, 2000). The distinction between different categories is particularly important for policymakers, as they imply different strategies taken by stakeholders. *Best-shot public goods* are cases where the total production of the public good depends on the maximum provision made by a country. An example is spending on the discovery of a vaccine, and the efficient solution is implementing transfer to one agent, who should be the only producer. *Weaker-link technology* refers to cases where the total production of the public good depends on the weakest effort made by one contributor, as with eradication of a contagious disease. These goods may present a

[2] To compute the aggregate demand of public goods, you need to sum vertically the amount that each individual is willing to pay, in contrast to the horizontally sum (of individual demands) needed to compute the aggregate demand of a private good.
[3] See Binger (2003) for other definitions
[4] The other important global public good is the knowledge. The traditional solution to this case is the patent system. In the Appendix we describe the patent system and compare the case of knowledge with environmental issues.

coordination problem, as each country has incentives to invest only if it believes that the other countries will invest too, although the stakeholders that derive highest benefits from the public good's delivery might have to transfer resources to other countries if their benefits are not strong enough. Finally, environment protection through forest management presents a *summation technology*, which implies that the total supply of the pubic good is the sum of individual contributions. This category is usually refer to as the one that presents the hardest problems to solve, as free riding will be a harder issue to solve, ending in a *prisoner's dilemma* as "an assurance that some countries will reduce their GHG emissions may not inspire other countries to join them" (Barrett, 2007).

Although the standard solution from public goods literature is applicable to the case of environmental change and forest management (i.e., the creation of an organization that decides the quota to be paid by each country and forces it to comply), the theory also agrees that such a solution would be difficult to implement. Kaul (2001) argues that in order to solve this problem, we need to think about this good as having three dimensions. He states that conventional textbooks recognize GPG's associated market failures, but not their political market failures. This failure comes from the fact that in international arenas national governments behave like individual actors seeking their own selfish interest and attempt to free-ride on other nations. He then proposes characterizing public goods with three criteria, which have to be combined in a proper way in order to successfully deliver the good. These criteria are the *publicness of decision-making* (how participatory decision-making process is); the *publicness of the distribution of benefits* (how equally distributed are benefits) and the *publicness of consumption* (the degree of nonexclusiveness of consumption). Together they form the "triangle of publicness" (Kaul, 2001).

More precisely, the problems that impede the creation of well-functioning international environmental organizations include political willingness of sovereign states, enforcement of agreements, leakage, monitoring problems, and credibility of commitment. As states are sovereign, no organization can force them to comply with (or sign) international agreements or to be submitted to a monitoring process. From the supply side, difficulties in the creation of such organizations come from free rider as well as leakage and technical problems. The free rider problem states that if one country does not sign a treaty, it may still enjoy benefits from policies implemented by the treaty. Then, it may have incentives to stay outside the organization, enjoying the benefits without paying any cost. Furthermore, it may be possible for this country to experience additional benefits not associated with CC issues. For example, if a country incurs a cost of reducing its GHG emissions by imposing a tax on forestry products, an increase in the price of such products may be beneficial for a neighbor country that has not signed the treaty, as the value of its natural resources rises. This argument was widely used to explain the partial failure of the Kyoto Protocol and as a justification of why nations (like the United States) did not sign it. Applying policies to reduce GHG emissions would affect growth and competitiveness relative to other countries that did not apply such policies. For example, this argument was used by Environment Minister Peter Kent to justify Canada's exit from the treaty at the UNFCC meeting in South Africa in December 2011:

"*We must be fair if we are to be effective. That is why for Canada, the Kyoto Protocol is not where the solution lies – it is an agreement that covers fewer than 30 per cent of global emissions.* […] *At home, Canada is already making great progress toward our ambitious target of reducing greenhouse gas emissions by 17 per cent over 2005 levels by 2020. This is a target that is aligned with the United States, our closest neighbor and most important trading partner.*" (a translation of the speech can be found on Environment Canada's internet homepage: www.ec.gc.ca)

Additionally, there are critics of the creation of an international carbon market. These include forest management professionals who assert that this market will generate incentives for developed countries not to reduce their emissions, while still being able to buy cheap carbon credits from poorer nations. On the other hand, big companies and elites in countries with poor institutions could expropriate forest areas in order to sell their services, seriously affecting the lives and customs of indigenous peoples who may not share in such sales' benefits.

Another related problem comes when institutional weakness leads to higher costs of enforcing property rights. In this case, forests become *de facto* public goods and suffer from the "tragedy of the commons" problem (Hardin, 1968). In Figure 3, this could be seen as a widening of the external concentric circles.

Solving GPG problems implies the closure of three gaps (see Binger, 2003). The first is the *jurisdictional gap*, which arises because national boundaries differ from global boundaries, thus requiring intergovernmental cooperation. In the case analyzed in this work, the effect of higher GHG emissions by one country will affect the entire globe. Moreover, the closure of this gap is especially complicated because the potential for mitigation is unequally distributed across countries and the impact of CC will differ across regions. While poor countries are often the ones most affected by CC, they often assert that they deserve less blame and less responsibility for CC because of their relatively low GHG emissions. Second, we have the *participation gap*. This refers to the fact that an inter-governmental organization is needed in order to coordinate effort. This organization must include as many actors as it can, and assign relative bargaining power to each member according to its importance in the issue (in terms of costs, benefits and how much the member contributed in the past). In most existing international organizations, bargaining power is distributed unequally among rich and poor countries. This division may be illogical for this case if we take into account that developing countries have a great potential for CC mitigation through forest management programs. Finally, there is the *incentive gap*. This problem comes from the fact that sovereign countries cannot be compelled to follow agreements. Any solution must therefore include a structure of political and financial incentives so that every country finds it profitable to apply the policies agreed upon. In particular, a system of payments and compensations must be implemented whereby rich countries (winners) pay poor countries (losers) in exchange for absorbing GHGs or reducing their emissions.

Several solutions to externality problems in forestry issues have been proposed at regional, country and worldwide levels. Although some of these solutions are decentralized in nature, additionality and free rider problems generally indicate the need for coordinated global solutions. Following most of the literature, we will concentrate on positive incentive solutions. As we have seen, according to the GPG perspective we can interpret these problems as a situation in which a principal (the world) gives some sort of payment or compensation to an agent (tropical countries or local communities) to align their incentives relating to the manipulation of a particular good (forests). The implementation of this solution the creation of an international organization that would include as many countries as possible by providing adequate participation incentives

4. Additional Forestry Problems

In addition to being a GPG, forestry-related GHG emissions present other problematic characteristics, which generate five main concerns: leakage, additionality, verifiability, permanence, and double counting.

Leakage in GHG emissions refers to cases where the reduction of emissions in one place leads to an increase in another place. If this is the case, the real reduction in emissions will be smaller than otherwise, and the country that paid the cost will not be able to claim those reductions. First, the impact on climate change of the reduction from the first country will be reduced by the reaction in the second country. Second, as the marginal impact of reducing emissions from GHG emissions for the first country diminishes, countries will be less willing to accept ambitious carbon-reduction objectives. While leakage is a major criticism of decentralized projects, it is also a significant problem with more general proposals such as the Kyoto Protocol. As explained by Santilli et al. (2005), in the latter case, "forests sinks, and activities that increase carbon stocks in the 37 developed countries ("Annex I countries") are credited, but developing country forest destruction is not debited (..). An Annex I country could in principle cease timber harvests altogether at home and replace them with tropical imports and still receive credit under (...) the Kyoto Protocol." This problem could be minimized if more countries are included in the program. There are several measures to consider for mitigating this effect. First, since not all countries have the same potential to produce or absorb GHGs, the presence of some countries is more important than others. Therefore, it is important that countries like Brazil and Indonesia, which have extensive forests, or like the United States and the European Union, which are large producers of GHGs, become members of the agreement. Second, leakage will be more intense in some countries than in others. For example, programs that reduce deforestation in a country such as Bolivia will be more prone to leak to an adjacent country (e.g., Brazil) than to a far-away one. For this reason we should think more in terms of regions than of separate countries and thus give higher incentives to countries that have neighbors in the treaty, as their opportunity cost of forest management will be higher. Using this argument, it is more efficient to negotiate contracts as a region rather than as separate nations. At the same time, developing countries might find it beneficial to negotiate as a whole in order to avoid leakage problems. Third, the more impact the program has, the higher the benefits of not participating will be. Authorities should take this into account and give proper incentives for participation, as sovereign countries cannot be forced to compromise or comply.

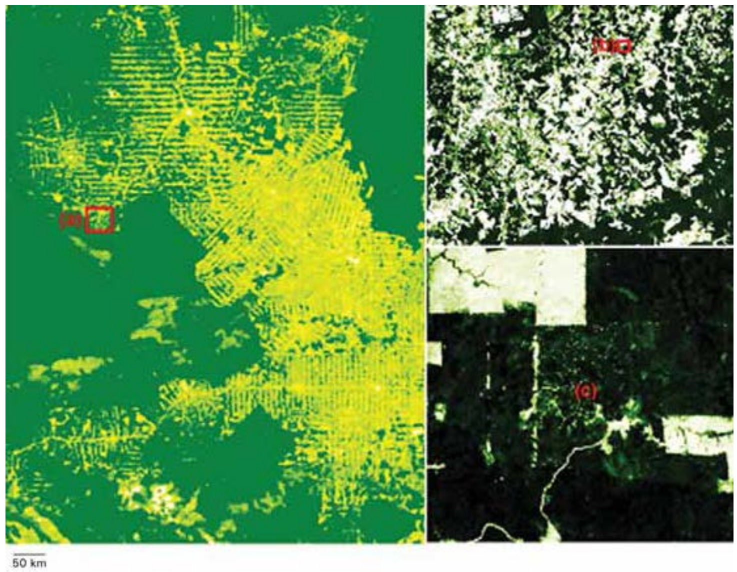
Furthermore, estimating how strong leakage is in order to quantify the real impact of a policy is extremely difficult, especially if the countries in which leakage is more probable are not included in the treaty or do not have the technical capacity or political willingness to submit to a monitoring process. Since leakage is more likely to occur among neighboring countries with similar characteristics, an obvious policy recommendation is to include in the treaty as many countries as possible and encourage regional cooperation.

The possibility of leakage imposes the necessity of treating forestry as a dynamic problem. It is not only important that countries with currently high important levels of deforestation agree to reduce it, but also that countries with high potential levels of deforestation refrain from engaging in it.

A second concern is that proposed solutions must be considered successful only if they result in a change in the behavior of its participants, reducing GHG emissions that otherwise would still be in the atmosphere. In the literature it is common to say that solutions have to be additional rather than business as usual.

Furthermore, the gains called for in positive incentive programs must be verifiable. While this is a necessary condition if we want to avoid typical principal-agent problems, verification raises the further question of monitoring costs. As deforestation occurs mainly in developing countries, monitoring is a major concern because of corruption and capability problems. One of the alternatives is the use of satellite remote sensing images of forest covering at different moments in time to evaluate whether deforestation has occurred (see Figure 4). The historic database permits account for the level of deforestation in tropical countries since the 1990s (DeFries, 2005). With this method, a computer program classifies each pixel of the picture into forest or not-forest area. Then, calculating the difference on the number of forest-pixels in two different moments in time, the rate of deforestation can be found. One of the main problems with this method is that if the size of the forest clearing is too small due to selective logging the change in tree cover is not recognized (Houghton, 2005). The inverse can also be said if we are trying to evaluate reforestation or afforestation projects. A second problem is that tropical countries do not have the capabilities to monitor deforestation in this way (with some exceptions like Brazil and India), and thus their governments will not be able to use this method to enforce agreements (DeFries, 2005).

Figure 4. Example of Satellite Monitoring[5]



Source: From DeFries et al. (2005).

The fourth problem is that the gains of a given project may not be permanent. For example, a country may commit to lowering its rates of deforestation for a certain period in exchange for economic payments but increase its deforestation rate once the contract period has ended, resulting in much lower net emission reductions. The same is true if, for example, newly planted forests are cut down after the contract has ended. Contracts must then take this into account and generate the necessary long-term incentives.

Finally, there is the problem of double counting. One example would be if two developed countries that have to meet their GHG quotas buy the same emission reductions from a developed country. To avoid the double accounting problem there has to be some kind of external registration of offsets (Gorte and Ramseur, 2008).

The solutions currently proposed involve NGOs, bilateral agreements between governments, and multinational agreements like those organized by the United Nations under the Reducing Emissions from Deforestation and Forest Degradation program (REDD+). Although

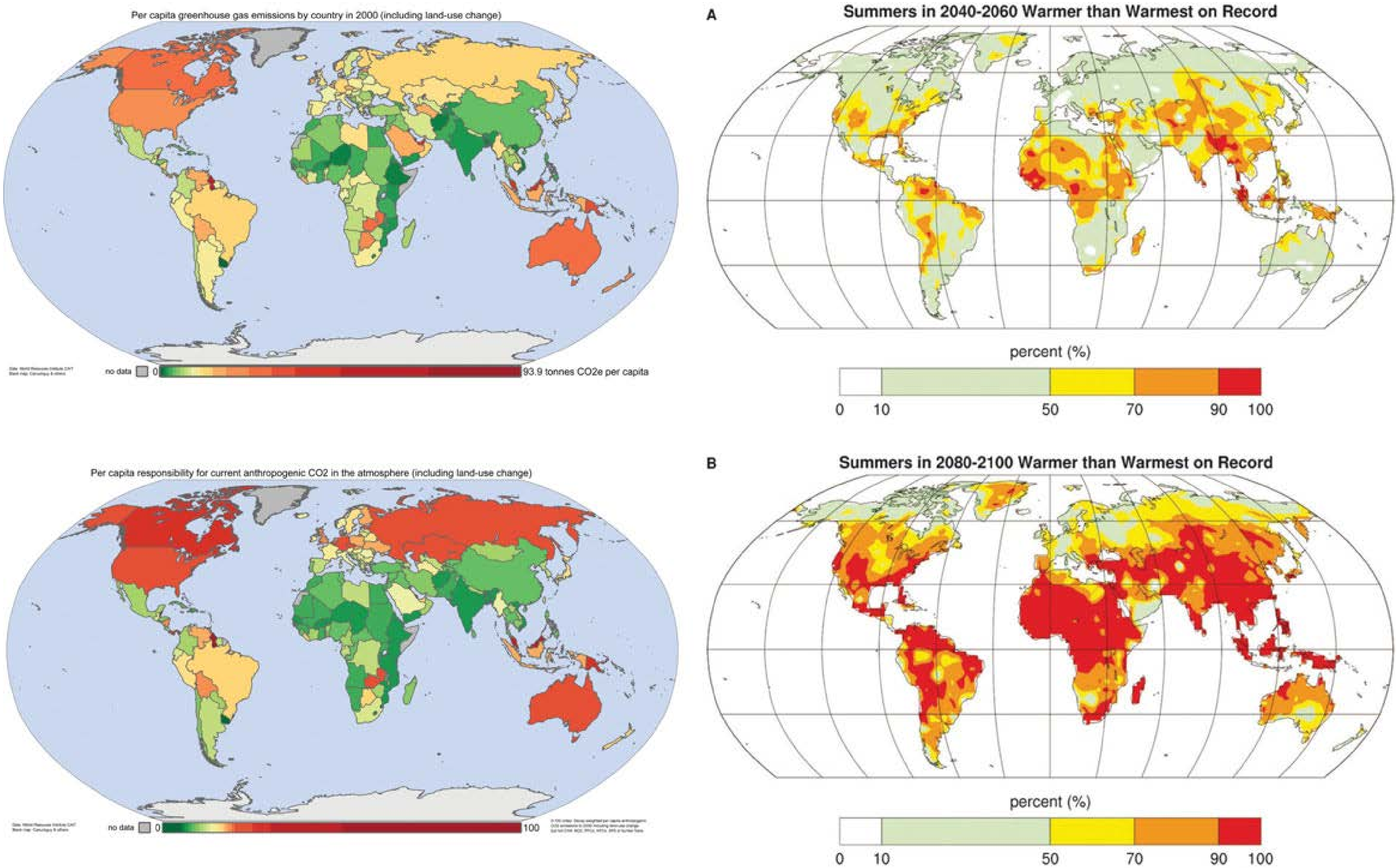
[5] Yellow dots are deforested area.

independent projects have proven successful in some cases, we believe that an effective solution to climate change will come from international treaties, like a post-Kyoto protocol.

Climate Change is also related to differences in preferences and interests across countries and difficulties in accurately measuring and transferring part of the benefits from the “winners” to the “losers” of a particular policy (see Kok, Brons and Witmer, 2011). At the national level, such policies must be complemented by transfers to those that otherwise would lose, thus generating a Pareto improvement and participation incentives. Accordingly, the Framework Convention on Climate Change in the Kyoto Protocol places a heavier burden on developed nations under the principle of “common but differentiated responsibilities” (UNFCCC, 1997, Article 11), as the countries that developed first have contributed the most to CC. In addition, many developing countries like China and Brazil claim that the process of industrialization of rich countries was done with cheap energy, and that they should not have to implement costly environmental policies that might affect their development. In addition, some developing countries have the greatest potential for GHG reduction and absorption. Forest management is a typical example, with tropical forests being the most important ones.

Finally, the geographical distribution of the negative effects of CC will not match the distribution of responsibility (emissions) across the globe. As we can see in Figure 5, the distribution of costs from CC and GHG emissions does not match. Billete de Villemeur and Leroux (2011) analyze this topic and propose a global insurance scheme where responsibilities are distributed across countries according to their past and current emissions and the damage they are expected to face. It should be added that poorer countries might also suffer more as they will be able to spend less on adaptation technologies. Bretschger and Valente (2011) develop a theoretical model where CC affects capital stock and its rate of depreciation, concluding that “poor countries are likely to be hurt more, and they can even be trapped in equilibria that exhibit long-run unsustainability induced by climate change.” We should also take into account that adaptation policies must be pursued independently of the success of current and future mitigation technologies, as some climate change is already inevitable (see Stern, 2006).

Figure 5. GHG Emissions and Projected Summer Temperatures



Note: On the left, the upper plot shows per capita current and accumulated GHG emissions. On the right: the likelihood that future average summer temperatures exceed the highest temperature observed on record, for the periods 2040-2060 (upper plot) and 2080-2100 (lower plot).
Source: Billete de Villemeur and Leroux (2011).

Adding these facts to their greater valuation of climate stabilization, developed nations are usually viewed as the ones that should bear most of the cost of GHG emissions. As stated earlier, the problem is worsened by the fact that developing countries are the ones that have the greatest potential to absorb and mitigate GHGs through forestry-related policies at a low cost, as most of the proposed forest-related solutions to climate change are intended for tropical forests. Taking these two features into account (higher valuation of developed countries and higher potential of developing countries), a solution must include a system of payments and compensation from rich to poor countries, so that the latter have incentives to generate the efficient level of forest management.

At the beginning of the 1990s, growing concern about human-related climate change caused the majority of world's leaders to create the United Nation Framework Convention on Climate Change (UNFCCC) in 1992 and to commit to reduce GHG emissions in the Kyoto Protocol in 1997, which entered into force in 2005 and was ratified in 2008. In line with the agreed principle of "mutual but differentiated responsibilities," the 37 developed countries ("Annex I countries") participating in the protocol agreed to reduce their GHG emissions below 1990 levels in the first commitment period (2008-2012), while non-Annex I (developing countries) had no real obligations. Because the changes needed to comply with the emission caps could have strong negative economic implications for those countries if made in an abrupt manner, the protocol has flexibility mechanisms. Each of these mechanisms generates "carbon credits" that can then be used by Annex I countries to meet their carbon caps. One of these mechanisms is International Emissions Trading, which allows countries that could not meet their objectives to buy carbon credits from other countries that have caps higher than their actual emissions. The idea behind this mechanism is that emission reductions will be attained first in countries where it is cheaper to do so, thus increasing efficiency. The second mechanism is Joint Implementation (JI), which permits the creation of Emission Reduction Units (ERU) from projects in Annex I countries that produce emission reduction. Finally, the Clean Development Mechanism (CDM) is similar to the JI mechanism, except that projects are undertaken by developed countries in non-Annex I countries (Jiménez, 2007).

Michetti and Rosa (2011) study the possible effects of afforestation and reforestation-timber management in Europe under an independent European commitment to reduce CO2 emissions by 20 to 30 percent by 2020. To do so they use a model of global general equilibrium, simulating the global economy until 2020, taking into account investment, population growth, endogenous energy and food prices. They compare these cases with a baseline where neither policy is implemented, concluding that leakage effects are low in comparison with the benefits.

In 2008, United Nations created the Reducing Emissions from Deforestation and Forest Degradation (REDD) program, which allowed some forestry projects to be eligible under the CDM. In 2009, the Marrakech Accords added the REDD+ mechanism, which is based on a payment system for carbon stock through sustainable forest management. To limit leakage and non-permanence problems, this program is limited to afforestation and reforestation in developing countries, and does not recognize avoided deforestation as a possible alternative (Michetti and Rosa, 2011).

The REDD+ program was launched in 2008 in order to include forestry in the international environmental agenda, by helping governments, NGOs or private sectors to create and implement sustainable management of forests. REDD+ activities can be divided into three phases, the final one being the development of "results-based actions that should be fully measured, reported and verified" (UN-REDD, 2011). If the country finishes all phases, it earns a REDD+ certification, which could provide information that the amount of offsets that it claims are real and verifiable.

Many scholars hope for the inclusion of REDD+ in a post-Kyoto protocol as a way to offset emissions from developed countries. The idea would be that countries that cannot reach their emissions objectives could buy emission offsets from REDD+ programs in developing countries. Furthermore, this arrangement could encourage a more efficient use of resources. A developed country would buy this kind of emission offsets only if its price is lower than the cost of achieving its objectives though other kind of reductions. Thus, if we assume well-functioning carbon markets, prices will adjust until the marginal cost of forest management equals the marginal cost from other forms of mitigation.

Currently, UN-REDD has 44 partner countries, 16 of which receive support for National Programmes, NP (i.e., creation and implementation of REDD+ strategies at a national level). In Latin America and the Caribbean, the governments of Bolivia, Ecuador, Panama, and Paraguay are receiving support for NPs. These kinds of initiatives are of great value, as they help resolve the problems commonly associated with forest management explained above.

REDD programs are under implementation around the world. Indonesia, for instance, has signed an agreement with the EU to limit illegal deforestation. The agreement commits timber producers to meeting auditing criteria to certify that their products were not made from illegal logging (Dickson et al., 2009). Another case is a REDD agreement between Guyana and Norway that aims at developing a “low-carbon economy by promoting investment in low carbon economic activities and infrastructure” (Trevin and Nasi, 2009).

The omission of avoided deforestation in the first commitment period of the Kyoto protocol has been largely criticized, since the inclusion of related projects has the potential to raise reduction objectives and lower their costs (Moutinho and Schwartzman, 2005; Eliasch, 2008). On December 2007, the UNFCCC conference in Bali, Indonesia culminated in the adoption of the “Bali Road Map” in which deforestation was one of the major topics (Witoelar, 2007). According to the Bali meeting, avoided tropical deforestation will be included in any post-Kyoto (after 2012) accord (Gorte and Ramseur, 2008).

Some countries have announced their intention of reducing their emissions and becoming carbon neutral by themselves. Costa Rica is a leading example globally in such projects, with the intention of meeting its objectives by 2021. Other examples in the Americas are Mexico and the Dominican Republic.

Finally, smaller bilateral agreements between NGOs and local communities have been successful in decreasing forest-related emissions all around the world. In Payments for Environmental Services (PES) projects, NGOs compensate locals for their opportunity cost of deforestation by providing payments conditional on the level of conservation. PES programs are “voluntary, conditional agreements between at least one ‘seller’ and one ‘buyer’ over a well defined environmental service” (Wunder, 2008). Although these programs have the potential of working in remote areas, where government enforcement is difficult, they are prone to leakage problems and cannot be undertaken on a large scale.

5. Concluding Remarks

From a global perspective, when considering a global strategy to deal with climate change, Latin American and Caribbean countries should contribute to the mitigation strategy by improving their forest management policies. Forestry problems have been attracting growing attention in the past decades, and they are now the second largest source of carbon emissions. Furthermore, while these countries play only a small role in energy-related emission, while they have an enormous comparative advantage in helping mitigation through forest management.

As we have seen from the GPGs perspective, climate change issues present market failures, which impede optimal production of related goods. The solution for this problem would involve the creation of some sort of market for GHG emissions or institutions able to regulate them. The price of emissions would compensate countries or countries for the opportunity cost of avoided deforestation, reforestation or afforestation projects. Although this market has to be made mainly at an international level, new solutions should consider reducing crowding out of existing organizations like NGOs that address climate change. Some of these organizations have been successful in addressing climate change issues, and their inclusion should be taken into account.

The creation of a post-Kyoto international agreement is vital. This agreement must include as many countries as possible, though the inclusion of a subgroup of nations can still be Pareto-improving (but suboptimal—see clubs in the sense of Arce and Sandler, 2000). From the point of view of developed countries, the inclusion of more countries is important, as it can reduce the free-rider problem. From the developing countries side, this could alleviate leakage-related problems.

Finally, the relative importance of each country and its corresponding decision-making power must be agreed upon by participants. This determination will depend on many variables such as a country's past and current emissions, its potential to absorb GHGs, the intensity of the damage the country is expected to suffer and its potential for diminishing leakage effects. The necessary incentives to comply with the agreement must include credible punishments in case someone fails to meet his responsibilities. Finally, an interlinked net of payments from winners to losers must be created.

This leads us to another problem, which is the division of responsibilities among countries: developed ones are the biggest emitters of GHGs and have higher willingness to pay, while developing ones have the highest potential for mitigation. Consequently, one of the principal characteristics of this "market" is that developed countries will have to compensate developing ones for their loss. As we have seen in this paper, a solution involves transfers of resources from buyers (developed countries) to sellers (developing countries), conditional on real GHG reductions. The main difficulty of this solution is avoiding moral hazard issues. If sellers cannot assure that a real reduction in GHGs will occur because of lack of credibility, institutions or technology that guarantee commitment, then buyers will not be willing to pay for them.

Therefore, developing countries may find it in their best interest to invest in such institutions and technology if it guarantees better contracts in the future. In line with this argument, REDD+ programs aim at solving this problems. International organizations such as the Inter-American Development Bank (IDB) can have a role in this matter, fostering such projects around the region. This would provide better monitoring technologies and institution. In turn the possibility of offering real GHGs emission offsets would boost the attractiveness of projects by developed countries, compensating all or part of the costs.

We have structured most of our recommendations regarding the mitigation of the problem of CC. International organizations, particularly the IDB, can also help developing countries by financing adaptation measures; these include the implementation of new technologies and infrastructure that uses resources more efficiently and withstands more extreme weather, in a world with rising energy prices. Such measures can be part of a larger strategy of so-called sustainable development.

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Appendix: Forest Management and Patent Protection

The literature that studies the problems related with intellectual property rights protection has many similarities with the literature on environmental problems. Since the first problem has been studied for a longer time, it presents a large body of theoretical work. Researchers of environmental issues might find it profitable to study this literature in order to adapt and use it.

The United Nation's Millennium Declaration identifies both intellectual property and the environment as GPGs that the international community is focusing on.[6] Knowledge is usually quoted as an example of a GPG, as its production involves R&D-related costs, but once a technology is discovered it can be used at zero cost by anyone around the globe. Then, as with any other public good, these goods will be underprovided if left to market forces. The solution found by policymakers was the creation of patents that ensure to the developer of new ideas property rights over their use.

While this solution has been proven to work for developed countries, its implementation at an international level has proven more difficult. As industrialized countries have lower costs of production of new technologies, they would benefit from the enforcement of intellectual property rights by developing countries by selling these technologies to them. In contrast, non-industrialized countries have a high cost of producing these goods and thus can benefit from weak enforcement of patents, as they can copy new technologies at a low cost. This free-riding problem generates underproduction of these goods, as Samuelson's condition is not meet, and a Pareto-inefficient equilibrium arises.

A similar argument can be made in the case of forestry. Now, developing countries are the ones that have advantages in terms of production of "clean air," as they face lower marginal costs. Again, without intervention, the total production of clean air will be such that for every nation, its willingness to pay for an additional unit of the good equals its marginal cost, which implies an inefficient equilibrium.

In both cases the proposed solution would be the creation of an international agency[7] with enforcement power and the inclusion of as many countries as possible, and the implementation of cross-national payments in order to ensure necessary incentives for countries to be willing to participate. In the case of forest management, developed countries should transfer resources to

[6] See Kaul et al. (2001)
[7] See Chin (1988) for a better justification of in the case of intellectual property rights protection.

developing countries in exchange for environmental goods derived from avoided deforestation, reforestation and afforestation. In the case of intellectual property rights protection, industrialized nations should generate participation incentives that compensate non-industrialized nations for the loss they would incur when providing and enforcing patent protection. For both cases, the first challenge is to agree on the responsibilities of each actor, and the second one is the creation of a monitoring and payment system that ensures efficient production of these goods.