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Multiplier and Distributive Effects of Large-Scale REDD+ Policies in Mexico

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International Financing for REDD
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This is a report of the project "International Financing for REDD," undertaken by WWF US Policy Program between July 2009 and June 2010, as part of WWF FC NI Program "Engaging Civil Society in REDD Programs.

The focus of the "International Financing for REDD" project was: (a) To further UNFCCC parties' understanding of the role and sequencing of public, private and market funding for REDD; and, (b) To discuss institutional and funding arrangements for REDD at international and national level

The project worked by (a) engaging in the international REDD discussion in the run-up to COP15; (b) producing or participating in the production of technical reviews, reports and proposals; (c) advising WWF network on these issues; and (d) collaborating with WWF country offices in the review of country level arrangements for REDD.

This report, discussing the macroeconomic impacts of alternative REDD policies in Mexico, was jointly commissioned by this project and by WWF Mexico. To speed up its distribution we are releasing it as a technical discussion paper that does not necessarily represent WWF official position on the matter.

Please direct queries regarding the project to its director Pablo Gutman at Pablo.gutman@wwfus.org and questions regarding WWF Mexico work on climate change to WWF Mexico climate change director Vanessa Perez-Cirera at vperez@wwfmex.org

EXECUTIVE SUMMARY

The concept of Reducing Emissions from Deforestation and Degradation (REDD) has advanced rapidly within international negotiations and also on the Mexican policy agenda. The expectations for this mechanism of achieving substantial reductions of greenhouse gas emissions, and for REDD+, which goes beyond deforestation and forest degradation and expands the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks, are high.

REDD+ offers a unique opportunity to address the dire consequences of ongoing forest loss and forest degradation while benefiting the planet's climate, biodiversity and people. As such, apart from the environmental benefits of such policies, another crucial question is the economic benefit. To contribute to this discussion, WWF Mexico, with your support conducted this study "Multiplier and distributive effects of large-scale REDD+ policies in Mexico", which analyzes the costs and benefits of forest policies on a sectoral basis and integrates them into a dynamic computable general equilibrium of the entire Mexican economy.

The study analyzes the economic effect of sector-specific policies and their inter-relationship with other sectors and shows the benefits that the REDD and REDD+ policies may have for future economic development in Mexico.

At present, in Mexico, few people neglect the importance of forest conservation for biodiversity protection and community wellbeing; in Mexico 30,000 communities (around 12 million people) own, manage or are dependent on forest for their survival. However, given the small contribution of the forest sector to the economy as whole, federal budget allocations to the environmental sector are still low compared to other development and/or climate mitigation priorities. And environmental officers are constantly in need of justifying the economic impacts of environmental policies, in this case REDD.

What this study aims to emphasize are that there are multiplier and distributive effects linked to REDD+ related policies. Moreover it aims it identifying the REDD related policies which optimize their mitigation, social development and conservation potential. It should be noted that the complete range of environmental externalities (environmental services) of standing forests can be added to the mix.

In summary, REDD+ policies have a positive effect on the economy in the short, medium and long runs. Welfare levels tend to increase relatively uniformly under REDD, gain approximately an additional 50% under REDD+, and are marginally lower under Commercial Plantations. Forestry output grows under REDD, gains a third more under REDD+, and is lower than REDD for Commercial Plantations. Employment remains constant under the three cases. Finally sequestration is positive in REDD, escalates by a third to a half more under REDD+ being the most appropriate policy to increase sequestration, foster aggregate and sectoral growth both in the medium and long term, and increase welfare levels in a relatively progressive way.

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Multiplier and distributive effects of large-scale REDD+ policies in Mexico

María Eugenia Ibarrarán and Roy Boyd

1. Introduction

The purpose of this study is to simulate several carbon mitigation policies in the forestry sector on the aggregate Mexican economy. It gives the sense of the relative magnitude of the relative impacts of different policies and the expected sign of those effects. This is valuable for WWF Mexico and CONAFOR because it allows a broad analysis on the expected results from different combination of policies in the Mexican forestry sector, being a useful input both for domestic policy-making and for international negotiations within COP 16.

In order to estimate the impact of diverse forest policies, we take the economic costs and benefits on a sectoral basis and integrate them into a dynamic Computable General Equilibrium (CGE) model of the Mexican economy. This, in turn, allows us to assess the effect of these sectoral carbon sequestration strategies on overall and sectoral economic growth, the distribution of income, the level of economic welfare, government revenues, the balance of trade, the size of investment and capital in Mexico over the next 25 years, and the effect on carbon sequestration that results from these particular policies.

Results show that REDD+ is the most appropriate policy to increase carbon sequestration, foster aggregate and sectoral growth both in the medium and long term, and increase welfare levels in a relatively progressive way, even under a lower than optimum mitigation case, i.e. 50% effectiveness. REDD also has positive results but not as high as those of REDD+, and Commercial Plantations ranks below REDD, but is still an improvement form the no-policy case.

Background

Investment in the forestry sector is bound to have explicit effects on the Mexican economy through a multiplier effect. That is, any money poured into the country will have an effect on economic activity, reflected through sectoral and aggregate changes, showing the *economic* effects of investment. Additionally, depending on the sectors that are affected and the composition of the consumers' basket, particular groups of individuals may be affected through different welfare levels. Moreover, economic activity will have an effect on employment (that may change both domestic and international migration). These two facts, i.e. welfare and employment levels, can shed some light on the *social* implications of investment. Finally, policies particular to the forestry sector will have an impact on greenhouse gas emissions and therefore on the *environment*. Thus, investment of international resources in the forestry sector at a large scale may have overall effects in the economy. The aim of this study is to estimate the trends, i.e. positive or negative, and relative magnitudes of these effects, what economic sectors and income groups are affected most.

The Mexican economy, like any modern industrial economy, is comprised of a number of interrelated sectors. Although each sector is, in some respects, unique, it requires inputs from other sectors of the economy and produces outputs which are largely passed on to other sectors. Domestic output is linked to other economies through international trade, and all sectors are subject to government taxes and transfers. Labor and capital are employed by industry and the outputs of industries are used by other industries, workers and firm owners. Hence, any changes to a particular sector in the economy spill over to other sectors, affect final consumers, impact economic growth, and have international repercussion. The effects of climate change will work throughout the economy as well.

The structure of this analysis is as follows. In section II below we describe the dynamic CGE model employed in our modeling exercises, as well as the drawbacks of these types of models. Following this in section III we briefly summarize the forestry policies outlined in REDD, REDD+, and under a commercial plantations scheme. In section IV we examine the results of the simulations, outline the interactions between the sectors of the Mexican economy, and give the implications in terms of emissions, income distribution, and long term economic growth. Finally, in section V we summarize our findings and give the policy implications of this study.

2. The Dynamic Computable General Equilibrium Model

We turn to the issue of modeling the general equilibrium effects of climate change mitigation and adaptation policies in land use and bio-fuels as suggested by MEDEC[1]. Policies affecting this interrelated sector are not conducive to an analysis within a simplified framework. As noted in the introduction, introducing such policies in one or more sectors can have important repercussions throughout the economy. Such problems are appropriately dealt with using general equilibrium analysis. In this type of framework all the sectors in the economy are seen as one linked system where a change in any part affects prices and output economy-wide. Mathematically, an interlinked economy can be described by a large system of simultaneous equations. More precisely in an economy with *N* markets, we require *N-1* equations to solve for all of the prices and outputs in the system.

Table 1. Producing sectors and Consumption goods

PRODUCING SECTORS	CONSUMPTION GOODS
Agriculture	Food
Livestock	Household and other goods
Fisheries	Consumption services
Forestry	Energy
Manufacturing	Autos
Chemicals and Plastics	Gasoline
Mining	Public Transport
Oil and gas	Water
Transport	Housing
Electricity	
Services	
Refining	

In this paper we look at a national model that has 13 producing sectors and 14 production goods (namely, each sector produces one good, except for oil and gas that are two goods produced by one production sector,

1 México: Estrategias de Disminución de Emisiones de Carbono

i.e. natural gas and oil are produced jointly)[2]. The primary sector is disaggregated into agriculture, livestock, fisheries, and forestry (see table 1). This was done so that we can now explicitly deal and quantify the interaction of sector-specific policies with other sectors when carbon mitigation policies are initiated. It is particularly important we do this given the simulations we run in terms of land use change and bio-fuels, for example. The model also has four household (income) categories (listed in Table 2) and nine consumption goods (in Table 1). There is also a foreign sector and a government sector in this model. This model uses the latest information from the Input-Output matrix produced by INEGI that has 2003 as the base year.

Table 2. Household categories based on income

Category	Income Group
Agent 1	Bottom 2 deciles: 1-2
Agent 2	Deciles 3-5
Agent 3	Deciles 6-8
Agent 4	Top 2 deciles: 9-10

The economic variables determined by the model are investment, capital accumulation, production by each sector, household consumption by sector, imports and exports, relative prices, wages and interest rates, government budget expenditures and revenues, and total wage income. The level of depreciation and the initial return to capital are taken as exogenous, as is the rate of labor force growth.

Production[3]

In each time period producers maximize profits in a competitive environment. Profit maximization, based on the described production technology, yields output supply and factor demands for each production sector and factor market in the model. Output and input prices are treated as variables. Taxes are also included with producers facing tax exclusive prices and consumers (and input consuming firms) facing the tax inclusive prices.

As a word of caution, the goods produced in the model's production sectors are not the same final goods consumed by consumers. Agricultural products, for example, must be combined with transportation services, manufacturing, and chemicals before they can be consumed by individuals as food. Hence, in our model we use a matrix to map from the vector of production goods to the vector of consumption goods. We do this through the use of nested functions to the production side of the economy as well as to the production of final consumption goods and services. This allows for different degrees of substitution for the inputs considered, particularly between labor, capital, energy, as well as non-energy inputs. Technologies are represented by production functions which exhibit constant elasticities of substitution. Technical progress is taken as exogenous to the model.

[2] Data restrictions prevent us from constructing a regional model. Furthermore, a regional model is largely impractical given that the capital in any given region is owned by individuals and corporations throughout the country. Lack of regionalization is not a major drawback however.

[3] For a formal mathematical description of the model, see Ibarrarán and Boyd (2006), pp. 114-126.

Consumption and income distribution

On the demand side, the model reflects the behavior of domestic consumers and foreigners (who can also invest through their savings), as well as that of the government. Domestic consumers are assigned to four groups (agents) according to income and a demand equation is specified for each group, which has a different consumption bundle depending on its income. All four groups are endowed with labor. Since only the wealthy actually have (formal) savings in Mexico, we assume here (in accordance with the latest data from INEGI) that only the top two groups (agents 3 and 4) own capital.[4] The gross income of each group rises by the rate of population growth plus the rate of technological change which is taken as capital augmenting. These resources are rented out to firms in order to finance the purchase of domestic or foreign goods and services, save, or pay taxes to the government. The membership of each group is fixed and although group income increases (or decreases) with GDP, individuals do not "migrate" as such, from group to group.[5]

Government

The government agent is modeled with an expenditure function similar to the household expenditure functions (i.e. based on a CES utility function). Revenues derived from all taxes and tariffs are spent according to an expenditure function. Within this expenditure function the government spends its revenues on goods and services from the various private production sectors discussed above. Consistent with the treatment of Ballard et al (1984) and others, we posit an elasticity of substitution between inputs to the government's utility function. This allows for price responsiveness in the provision of government purchased goods. The government also spends its revenues on labor. Together these arguments represent the government purchases and payment of government employees necessary for it to carry on its work. The government also separately redistributes income through exogenously set subsidies and transfer payments, and all revenues are spent.

Taxes in the model are expressed *ad valorem* and include personal income taxes, labor taxes, capital taxes, property taxes, revenue taxes (such as payments from oil and gas activities), value added taxes, sales taxes, and import tariffs. The taxes on final goods such as gasoline differ from other consumer goods because of special taxes levied on them by the government. By the same token final goods such as electricity differ in treatment due to existing government subsidies. When applicable, taxation is based on marginal tax rates. Subsidies, on the other hand, are essentially treated as negative taxes and in these cases the government transfers funds back to a sector in proportion to that sector's output. Thus, if these subsidies are abolished, the government has more revenue.

Trade

International trade within the model is handled by means of a foreign agent. Output in each of the producing sectors is exported to the foreign agent in exchange for foreign-produced imports. Under this setup

[4] Household saving here have a certain degree of endogeneity. The level of savings for each income group (i.e. Agents 3 and 4) are set at the levels which actually occurred in the base year of the dataset (i.e. 2003). After that time, however, they are allowed to vary in response to changes in the relative prices of consumption and savings.

[5] Such migration, though a concept to explore, is computationally beyond the scope of this model. Furthermore, our chief concern with income distribution is how different income groups with varying consumption bundles and income streams are differentially impacted by the effects of carbon mitigation policies.

the aggregate level of imports is set and grows at the steady state level, but the level of individual imports may change in response to changes in relative prices. Exports are exogenous as well and are assumed to follow a constant growth path. They are, however, responsive to changing prices, and can change as individual sectors are shocked. Transfer payments, on the other hand, are endogenous and act so as to clear the model. The exchange rate is determined then by the interaction of capital made available for external uses, goods supplied for export, and the exogenous level of imports.[6] Price-dependent import supply schedules are derived from elasticity estimates found in the literature[7]. In specifying the level of substitutability between goods we replace the classic Heckscher-Ohlin assumptions and rely instead on the Armington (1969) assumptions which allow for imperfect substitutability between foreign and domestically produced goods. One feature of this setup which is particularly important to our present analysis is that it incorporates flexible trade prices and thereby allows for the adaptation to severe droughts via adjustments in the balance of trade.

In this model we assume that Mexico has no market power in the world petroleum market. Hence we treat the international price of oil as given and Mexican oil producers as price takers in the market. Consequently, when the Mexican government institutes investment policies to increase aggregate oil output, the domestic price drops as output increases and more is exported as the international price increases relative to the domestic price[8]. On the other hand, oil depletion represents a curbing investment, but imports of oil increase to keep the economy running.

Labor Growth and Capital Formation

Growth within our dynamic CGE model is brought about by the changes over time in both the labor force and the capital stock. In keeping with the theoretical underpinning of the Ramsey model (1928), we take the changes in the population as exogenous and constant over the time period considered. In the absence of any perturbation, Ramsey predicts that the economy will grow at the labor supply growth rate in the steady state.

In the model we assume that there is only one type of raw capital good, which goes into the various sectors. In addition, to add realism we assume that the capital that goes into a sector, works like putty and clay. More specifically, we assume that capital which is new can be readily combined with other inputs to produce outputs. Over time, this capital becomes locked into an older technology (i.e. clay) and has a harder time combining with other inputs. In the growth literature this is also known as “vintage capital”. This is plausible as illustrated by sectors such as electricity production, which has been subject to a great deal of technological change over the years. The capital growth rate is modeled in accordance with neo-classical capital theory assumptions. More specifically, the growth of capital is modeled as investment net of economic depreciation. Such depreciation could, of course, vary as both capital and its productivity are affected by climate change.

[6] As a side note to this, closure in our model is determined by the equality of domestic and foreign leakages and domestic and foreign injections. More formally we have (S + M) = (I + X) where S is domestic savings, M is imports (current account), X is exports (current account), and I is the total amount of investment made available from foreign and domestic agents. The government budget is assumed to be balanced.

[7] See, for example, Serra-Puche (1984), Romero (1994) and Fernandez (1997), and Wylie (1995).

[8] Domestic and international price of oil may differ due to quality and transportation costs.

Drawbacks

Even though CGE models are quite powerful tools in that they can show the main relationships among different sectors, they also have several drawbacks. Here we mention a few.

First, the exact numbers that result from CGE models should be taken with as indicative. That is, even though the models are able to produce exact numbers, those should be interpreted as positive or negative trends, depending on their sign, and as relative magnitudes, i.e. if sector A is growing more or less than sector B, for example. This is more useful that stating that growth will change by an exact amount. Part of this is because there is uncertainty in almost all parameters used in the model, so they could be a little higher or lower, and doing sensitivity analyses for all possible combinations is truly impossible.

Second, CGE models have been criticized for being only simulation and not estimation models. This again is due to the vast amount of possible scenarios that could take place. However, presenting several simulations may compensate for the fact that no direct estimations are made, narrowing down the results given they are robust to different assumptions. In any case econometric estimation of crucial parameters is incorporated into the model and the scenarios.

Another criticism is that economic models have little to say regarding the environment. This is true in that these models look into the workings of the economy, and do not use physical units to quantify the environmental impacts. However, CGE models may calculate emissions through fuel use and hectares of land under different uses (MIT's EPPA model and BOYD-M used here work that way). Obviously this is only a proxy and quite inexact if compared to physical models. However, other models are not capable of reflecting the workings of the economy in such details. Based on this it is fair to say that CGE models complement physical models, and that their results, again, should be seen as showing trends in emissions and not an exact estimation.

Moreover, there is concern that this tool is not capable of reflecting changes in a small sector such as forestry. Results shown in section IV invalidate this critique since variations can be seen once the REDD, REDD+ and commercial plantation policies are included in the simulations.

Finally, this particular CGE model does not have a spatial resolution. This is true because it is built based on national accounts that are not regional. However, results may hint at the impacts on different regions depending on the site (and its particular characteristics) where investment takes place.

3. Mitigation Policies

We analyze at this point the set of mitigation policies proposed by REDD, REDD+, and commercial plantations and their implications in terms of carbon sequestration in the forestry sector.

Mexico has developed the National Strategy for Climate Change as well as the Special Program on Climate Change (PECC, due to its initials in Spanish). These are the two main official documents that state the goals of emissions reduction within the different sectors. The forestry sector has set some mitigation goals that are reflected in PECC.

On the other hand, the United Nations has defined REDD as 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+” goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

We have aggregated many of the policies listed under PECC into three sets of policies: one that would be the very minimum to address emissions reduction from deforestation and forest degradation (REDD); another that includes conservation, sustainable management and enhancement of carbon stocks (REDD+); and finally a policy involving only commercial plantations. Obviously this aggregation is rather subjective since the Mexican PECC was designed without having this REDD and REDD+ concepts in mind, and because there is ongoing debate internationally on the extent that REDD and REDD+ should cover.

REDD policies are meant to reduce emissions that result from deforestation and degradation by stopping these two types of ecosystem degradation. Thus, countries that are willing and may reduce carbon emissions from deforestation and forest degradation should be financially compensated for this (Parker et al 2009). To simulate REDD we consider a pilot program has been put in place by the Mexican government called “Pago por servicios ambientales”. This is a compensation to land owners that maintain their tree stocks, stopping deforestation and forest degradation, and thus protecting environmental services. These economic incentives to maintain forests throughout the country correspond to Goal 78 of PECC that implements the program of economic incentives, as it is listed in Table 3 below. REDD only considers the current area under this pilot program and not expansions (Goal 66) because these can be listed under conservation given the limited extent of degradation in these additional lands. However, this could be up for debate. Table 3 shows the goals that are included under different scenarios (i.e. REDD, REDD+, or Commercial Plantations), their mitigation potential and the share of mitigation that they represent with respect to the overall mitigation goal under PECC for the forestry sector for the 2008-2012 period.

REDD+ on the other hand, expands the goals of REDD from only reducing emissions from deforestation and forest degradation to include conservation and increasing carbon stocks through reforestation. Additionally it has a broader scope in that it helps fight rural poverty and protect biodiversity and basic environmental services (Parker et al 2009). Additionally to Goals 78 (REDD) it adds goal 64 (increase the area under sustainable forest management by 2.95 million hectares), goal 65 (increase the areas for wildlife conservation by 2.5 million hectares of terrestrial ecosystems), goal 66 (increase the area covered under the economic incentives’ scheme -Pago por servicios ambientales- by 2.175 million hectares), goal 67 (include 750 million hectares of forests to national protected areas, for conservation and a sustainable use), and goal 43 (install 600 thousand efficient fuel-wood stoves, that at the end conserves resources). The mitigation potential of these goals can be seen in Table 3.

Finally, commercial plantations are another way to go. This implies introducing 170 thousand hectares of commercial plantations, be they to produce fuel or inputs to different industries, and corresponds to Goal 73 of PECC. This scenario is not built on REDD or on REDD+ because of the interference it has with the natural ecosystems. However, commercial plantations could take place jointly with either REDD or REDD+.

The policies to build the scenarios are shown in Table 3. This shows the goals as indicated by PECC and the mitigation potential in 2008-2010, period where PECC is binding.

Table 3. Mitigation potential for different forestry policies under PECC

Goal	Concept	Scenario	Mitigation $MtCo_2e$ 2008-2012	Share of Forestry Goal
M 78	Economic Incentives Program	REDD	8.97	23.75%
M 64	Increase area under sustainable forest management	REDD+	11.88	31.45%
M 65	Increase areas for wildlife conservation	REDD+	4.19	11.09%
M 66	Increase further area under "Payment for environmental services"	REDD+	6.27	16.60%
M 67	Include forests under conservation/ sustainable use regimes	REDD+	3.36	8.90%
M 43	Install efficient fuel-wood stoves	REDD+	1.62	4.29%
M 73	Install commercial plantations	COMMERCIAL PLANTATIONS	1.48	3.92%
Total mitigation for forestry sector			37.7	100.0%

Source: Own calculations based on information from Comisión Intersecretarial de Cambio Climático 2009

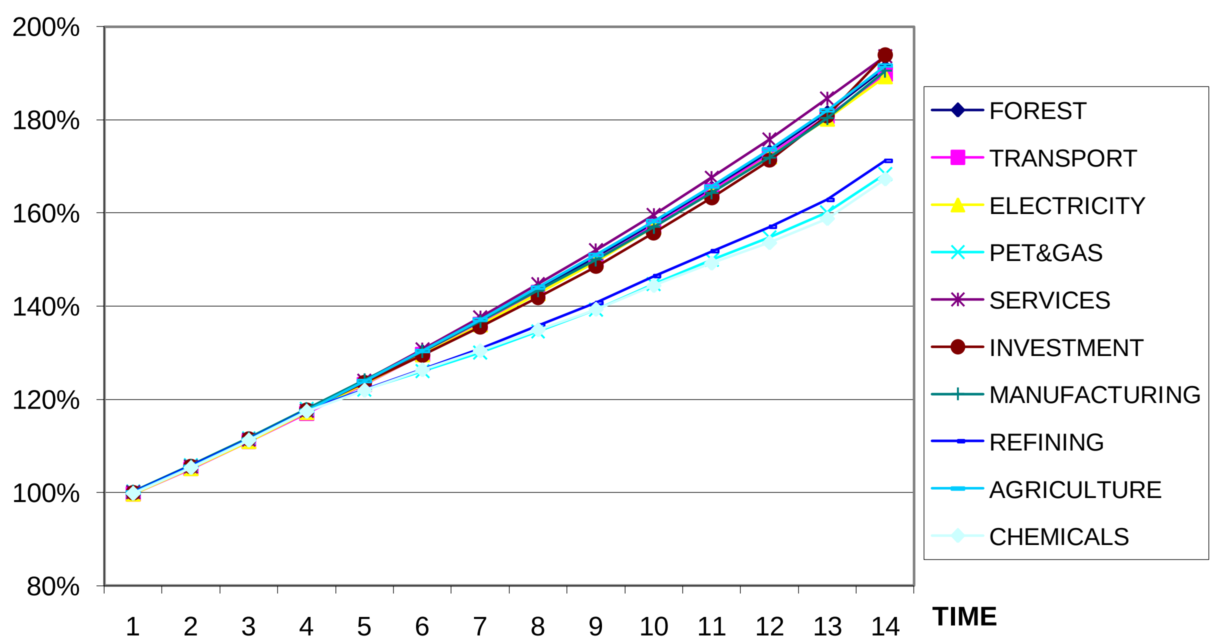
4. Model results

We now discuss the results of the simulations. In each scenario, the data for the simulation was taken from PECC for the years 2008 to 2030, scaling them to fit our dynamic CGE model, inserting them in the appropriate CGE production sectors, running our model with these new numbers, and comparing the results with those in the business as usual simulation plus drought, which is a good proxy of the economy under climate change (this scenario will be described below). The aggregate results for each scenario are given in the Appendix along with the results of the sectors of greatest interest, the production and on the consumption side and on foreign trade. The results are listed for 2012, 2020 and 2030 (i.e. the terminal year of the model that can be taken as the mid-term impacts if the PECC policies remain in place[9]). They are shown as percent deviations from the relevant scenario, indicated in each case.

Background Scenarios

The building block for the different scenarios used in the next sections is the Benchmark case that makes sure the model runs and behaves appropriately. However, this scenario assumes perfect competition in all markets and that all sectors grow at the same rate. A second scenario is run, i.e. the Business as Usual (BAU), shown in Figure 1, that represents some stylized facts of the Mexican economy, such as exhaustion of natural resources (particularly oil), market power in the oil and electricity markets, and minimum wages in the labor market, that at the end results in unemployment. Both the Benchmark case and the BAU scenarios are crucial to fully capture how the Mexican economy works in equilibrium and under imperfect competition, but they are not directly relevant for the discussion of the forestry policies. Thus, the Benchmark and the BAU scenarios are presented in the Appendix, under section A.1, together with the comparison of their results.

Figure 1. Business as usual



Climate Change: the True Benchmark

The Climate Change scenario has the characteristics of BAU[10], but includes drought to simulate climate change. Thus, the level of oil produced is allowed to rise according to the overall rate of economic growth until the year 2008, but from that time onward the amount of oil production is held constant. This is done because the depletion of existing stocks of petroleum will make it impossible for extraction to rise with the

[9] Policies that have been enacted under PECC for the 2008-2012 period are expected to remain in place thereafter, growing at a constant rate.

[10] Refer to Appendix A.1 for description.

rest of the economy without massive investment of PEMEX (i.e. the national oil company of Mexico) in drilling and oil exploration activities. Furthermore, by capping oil production our model simulations correspond exactly to PEMEX's current long run planning goals (see Secretaría de Energía, 2000). Holding extraction at 2008 levels then, is much more realistic than assuming that oil extraction expands as fast as general economic growth. However, in order for the Mexican economy to keep growing as expected, we allow for imports of oil to grow so that economic activity continues its pace. We also consider that PEMEX and CFE are government run monopolies with the power to raise prices. These assumptions, in turn, give us a much more reliable benchmark on which we can add the effects of climate change to the counter-factual scenario.

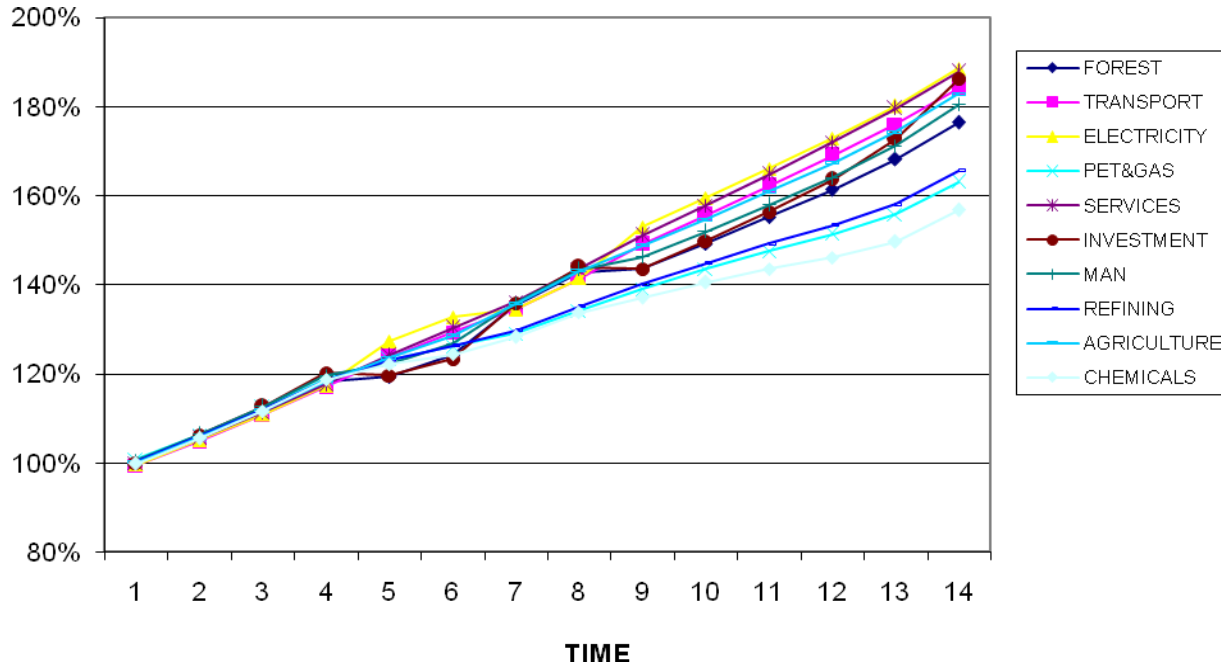
To model climate change, we simulate the effects of a major drought on the agricultural, forestry, and power sectors. The drought is the same one simulated in Boyd and Ibarrarán ((2009*) Journal of Environment and Development Economics).* The drought occurs from 2010 to 2015 and then returns with the same severity in the period from 2019 to 2030. The severity of the drought, in turn is based on the work of Liverman and O'Brian (1991) and Rosenberg et al (1993) (i.e. the MINK study). By doing this we are able to look jointly then at developments related to natural resources, electrical power, labor markets, and climate change.

Climate change imposes costs on the Mexican economy. Looking first at the aggregate results we see that a severe drought results in the decrease in GDP, investment, and the value of the aggregate capital stock as production in the primary sectors declines (shown in Appendix A.2). It also results in the decrease in welfare for all agents. By and large the agents are affected more or less equally. It should be noted however that the largest proportional losses are suffered by the poorest agents due to the higher importance of agricultural products in their total budget. Figure 2 shows the impact of climate change on growth of different sectors (in percentage changes). In particular, climate change disrupts growth in forests and agriculture. Refining, Petroleum and Chemicals are distorted because of resource constraints from the BAU scenario that are carried on to the climate change scenario. In any case, growth of these sectors is lower than that of the rest of the economy.

Glancing now at the individual production sectors in Appendix A.2, we see that, as expected, the largest effects by far are on the agricultural, livestock and forestry sectors. Indeed, the production in all sectors tends to go down reflecting their linkages to agriculture. The one notable exception to this is in the petroleum sector were production actual rises moderately. This is due to the fact that petroleum is a large export item, and as more agricultural imports are required (to deal with the effects of drought), more oil is exported to acquire foreign exchange. Finally, turning to the consumption sectors we find that by 2030 consumption in all sectors has declined with the largest declines in food products.

This scenario is crucial since all other simulations will be built on this one. Thus, the next three scenarios will take the stylized facts of the Mexican economy and climate change as a given. REDD, REDD+, and commercial plantations will be built on top of this.

Figure 2. The impact of climate change on selected sectors



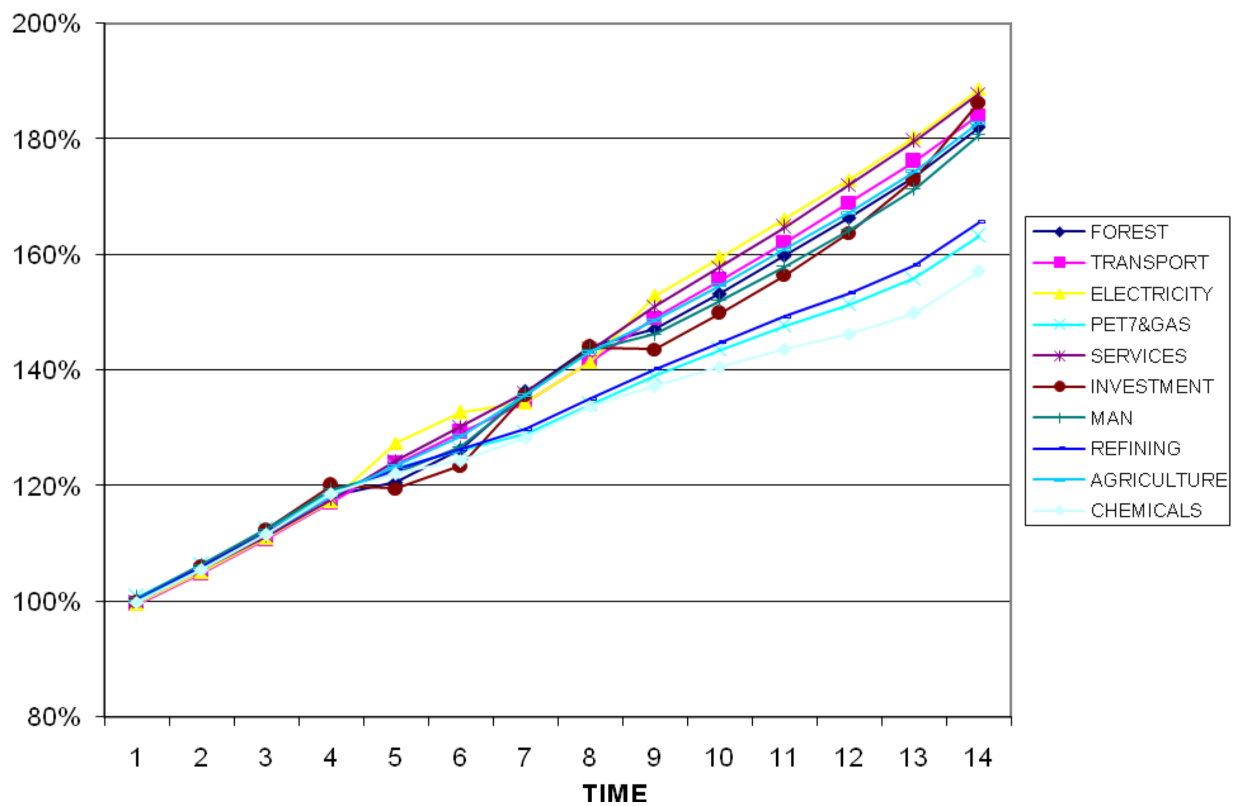
From Business as Usual with climate change to REDD

Here we simulate the impact of investment in protecting the forestry sector through the pilot program that has been put in place by the Mexican government called "Pago por servicios ambientales", that is a compensation to forest owners that currently maintain their tree stocks, stopping deforestation and forest degradation, and thus protecting environmental services. These economic incentives to maintain forests throughout the country correspond to Goal 78 of PECC. More specifically, looking at detailed engineering data supplied by PECC, we calculate the dynamic general equilibrium effects of avoided emissions that result in turn from avoided deforestation and forest degradation. This scenario then entails a host of secondary general equilibrium effects throughout the Mexican economy.

The set of numbers in Appendix A.3 gives us the changes that occur (both in the economy wide indices and sector by sector) as we go from the Business as Usual plus Climate Change scenario to the REDD scenario. In this scenario, shown in Figure 3, as mentioned above, we reduce the levels of deforestation which has gone on in Mexico and hence provide an improvement in forest cover relative to that which would have occurred if no such action had been taken and land would have continued to be taken out of forest use and put into other uses.

Turning first to the aggregate numbers and indices we see that there is a general improvement in economic welfare for all income groups. The numbers are, admittedly, small, but they are positive. Likewise the level of the capital stock rises a bit. The GDP and government numbers initially go down a small amount but they are all positive by 2030 as is the level of investment. The reasons for this are a bit complex but nonetheless fairly straightforward. Initially, preserving the forest prevents the land from being used for other (primarily agricultural) purposes which (initially) have greater economic value than forestry uses. Eventually, however, the positive externalities provided by more forest cover (e.g. more protection from harmful erosion, etc.) outweigh these losses. These positive externalities are completely separate from the more substantial carbon sequestration gains (to be discussed later) and suggest that there is a benefit from such preservation from strictly economic terms even without taking climate change, aesthetic beauty and other factors into consideration.

Figure 3. The economy under REDD

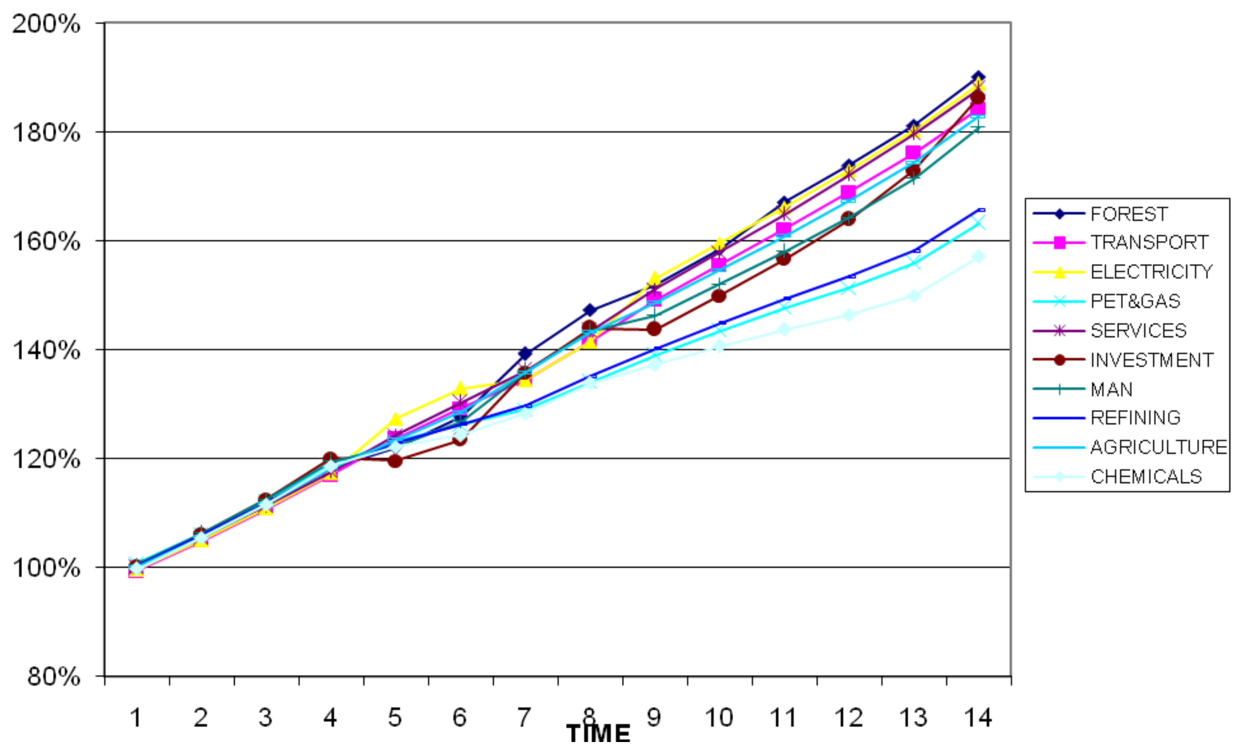


Looking now at the sectoral changes we see that, as expected, the biggest gains are in forestry since this sector is the one which is directly benefited. As noted before, there are initially small agricultural losses but these are turned around by the end of the period studied. Interestingly just about all other production sectors are benefited albeit by small amounts suggesting the positive externalities provided by more forest cover. Just about all consumption sectors rise relative to business as usual, and, as noted before, this has a positive impact on consumers of all income groups. Finally, the international trade sector is relatively unaffected except in forestry.

REDD+

This scenario is much like the previous one in that the impacts of depletion and climate change are incorporated into the model. It differs, however, in one respect. Instead of just showing the impact of decreases in deforestation (i.e. REDD) it additionally shows the impact of afforestation and sustainable development (i.e. REDD+). Overall trends for the different sectors are shown in Figure 4. As such it represents an initiative to not only maintain but to increase the forestry sector and promote development and wildlife preservation. It also represents a larger investment in terms of the country (and/or) the international community. As before, we have divided the impacts into aggregate indices and individual sectoral results. Additionally, for purposes of clarity, we have contrasted the results of this scenario with those of the REDD scenario above.

Figure 4. The added impact of REDD+



With respect to the aggregate numbers (Appendix A.4) we see that the impacts here are, by and large, modest but positive. As would be expected, the investment level goes up in the medium term and all consumer groups show slightly higher welfare. The level of GDP, economic growth, and the level of the capital stock also rise a bit. It should be mentioned, however, that, in as much, as stands of timber in the forest are capital, the capital stock here rises by more than the number given since this number only includes buildings and machines. Finally, the government number goes down slightly. This is because in this model run we assume that the investment is internally funded. If, on the other, hand, there is international involvement, the expense for the Mexican government will go down.

Turning now to the sectoral figures we see that, again, there are, by and large, positive gains over the previous scenario. Consumption rises slightly in just about all sectors as consumers are better off and able to spend slightly more for goods and services. Production is also up slightly, with, by far, the largest gains occurring in the forestry sector. Interestingly, the levels in the agricultural and livestock sectors are largely unchanged suggesting that and increase in the forestry sector will not come at the expense of the other primary sectors. Finally, there are very few changes in the foreign trade sector except, of course, for forestry.

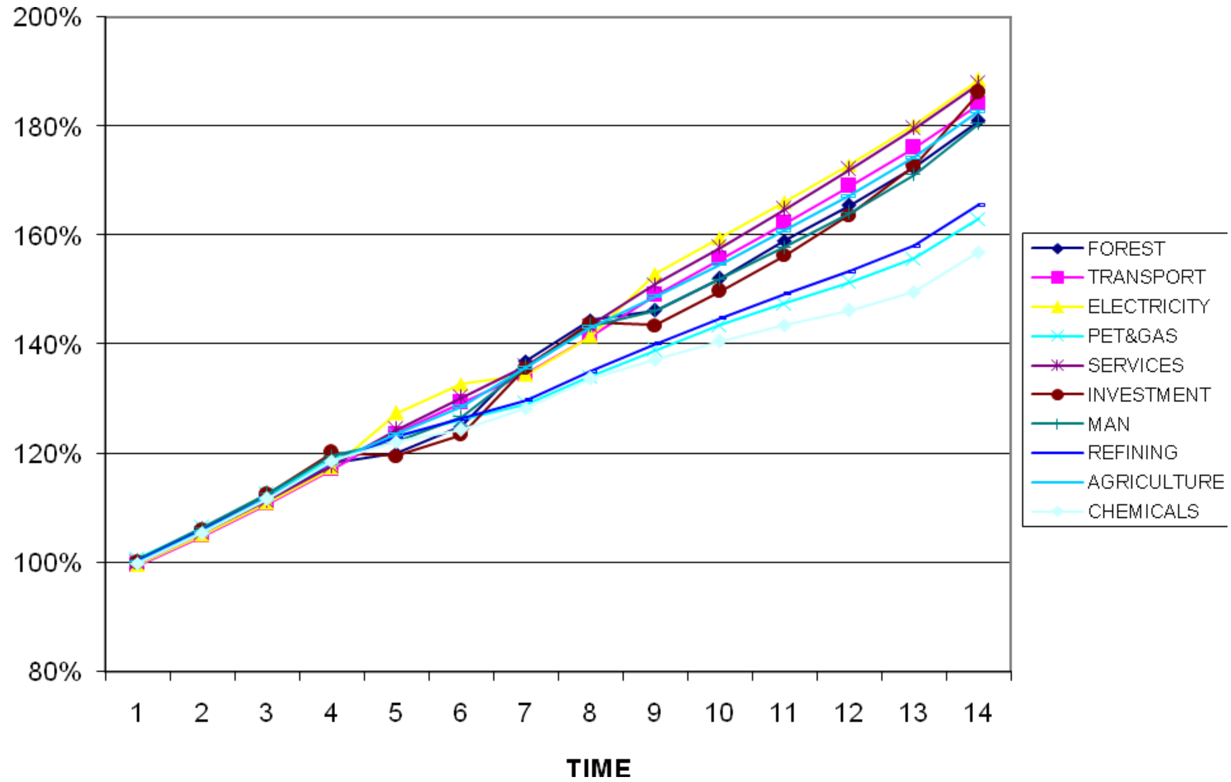
Commercial Plantations

In our final model simulation we examine the aggregate and sectoral impacts (over time) of investing funds in timber plantations for the purpose of carbon sequestration, following PECC. Sectoral output is shown in Figure 5. Although the climate change goal here is similar to that of the last two simulations (i.e. REDD and REDD+) this particular approach differs in other important respects. In the previous two simulations the purpose was to prevent the destruction of virgin forests and provide new natural forests for carbon and wildlife preservation. Here however, the trees to be grown would function as plantations and not as "natural" forests. This, of course, is not to say that the goals of these scenarios do not overlap or that they could be done in tandem. We only wish to emphasize that the goals as well as the methods here are distinct those of the last two model simulations.

Two other clarifications are relevant at this stage. First, commercial plantations as described under PECC are much smaller in terms of mitigation potential than REDD (M 78). Commercial plantation will mitigate 1.48 $MtCO_2e$ in the 2008-2012 period while mitigation potential for REDD is 8.97, and for REDD+ 27.32. Thus, the very marginal benefits of commercial plantations are due to the reduced size of this policy proposed by PECC. Additionally, commercial plantations have tradeoffs with agriculture since they compete for land, so planting trees broadly drives land away from agriculture, and may impose a negative effect on consumers, on agricultural output, and on GDP as well.

For purposes of clarity and ease of presentation, the numbers here are compared to the REDD simulation and the percentage changes are given with respect to that scenario. As in all previous examinations of our results we initially look at the aggregate numbers (Appendix A.5). Here we see that, in the case of plantations, investment, the level of the capital stock, GDP, Government, the rate of economic growth, and the level of all agents' welfare is less than in the REDD case. A quick glance at the last scenario also reveals that the aggregate numbers here (except for government) are not as large as in the case of REDD+. This is not to say that plantations do not have a positive impact on the economy, however. Our results here indicate economic gains, but they also indicate that the gains here are not as large as when we looked at the REDD and REDD+ scenarios. Furthermore, as we noted above, plantations and investment in natural forests are not mutually exclusive. When compared side by side though, the plantations do not have as large of an overall impact.

Figure 5. The impact of Commercial Plantations



The sectoral results that we see are, more or less, consistent with the aggregate results described above. Consumption in just about all sectors is smaller here than in the REDD case. Since aggregate consumption is lower, it then makes sense that this would be reflected in lower numbers for the individual consumption sectors. As far as production goes, the most important sector for our purposes is the forestry sector and here we see that the impact of plantations is less than that of REDD (and certainly less than that of REDD+. Production is also less in virtually all other sectors when compared to REDD. One major caveat, of course, is that these simulations may represent overestimates of one or more of these options. Effectiveness is not guaranteed just by making an investment (see the impact of 50% effectiveness in Appendix A.6). Nevertheless, if the effectiveness of all three options is roughly of the same magnitude, it would seem that the largest impact (in terms of economic and forest sector growth) comes from the REDD+ option and the smallest from the plantations option.

Unemployment under the different policy options

Unemployment is not significantly affected under any of the policies. Climate change increases unemployment form 4.9% under Business as Usual to 6.4% when climate change hits the Mexican economy. After that, any of the policies, be it REDD, REDD+ or Commercial Plantations face a 6.3% unemployment rate by 2030. This is because the forestry sector does not generate a lot of employment as would probably be the case of agriculture or other land use. These policies in the forestry sector, in the limit, keep unemployment relatively constant and at least hold workers in place and therefore may contribute to maintain migration constant.

Carbon sequestration, costs, and incidence

Based upon Masera et al (1997) and Ibarrarán and Boyd (2006), REDD could lead to 529.2 million tons of carbon sequestered that would not occur if deforestation were allowed to continue. Given all the uncertainties regarding carbon capture by forests, this is an upper estimate. In addition to this capture by REDD, REDD+ could lead to another 138.7 to 234 million tons of new sequestration, depending on whether this is strictly reforestation(the lower number) or an investment is made in managed forests (the upper number). Finally, commercial plantations would lead to 201.5 million tons of sequestration. The numbers for REDD+ are then over 3 times that of sequestration from plantations alone. Again, these results, reported for the terminal period, i.e. 2030, are very uncertain and they are only intended to illustrate the relative magnitude of sequestration under the different forest policies.

As mentioned in the outset of this paper, the forestry sector is relatively small within the Mexican economy, so aggregated emissions remain fairly constant even though carbon sequestration due to REDD, REDD+ and commercial plantations take place. Reductions in emissions are in the order of 0.1 to 0.2% in the best case, and very close to zero in most cases. Thus, overall emissions for Mexico remain relatively constant regardless these specific forestry policies because of their relative size with respect to the entire economy. These figures are shown in Appendix A.6.

In terms of mitigation costs, Johnson et al (2009) in the MEDEC study use the figure that REDD was $1.44 USD/t$CO_2$e sequestered. The cost of sequestration through REDD+ was build from numbers in their report and was $4.29. Finally, sequestration from commercial plantations was $7.17 per ton. Thus, the total cost of sequestration from REDD would be in the order of $760 million dollars. Additional sequestration from REDD+ would be in the range of $600 milion to $1 billion, that would be added to the cost of REDD. The cost sequestration through timber plantations would be $1.45 billion.Thus, REDD+ may be as expensive as commercial plantations but it has a higher carbon sequestration potential.

In this study, the costs of mitigation are paid by the Mexican economy in the form of investment. The macroeconomic effects of these policies are reflected as a minor reduction in overall and sectoral GDP in activities other than forestry for particular years. These results are relevant because they show a tradeoff between particular policies and economic growth, at least in some sectors, making clear that all policies have associated costs and there is no free lunch.

Even though the results of these policies are positive both in terms of GDP and welfare levels, the Mexican government needs resources from abroad, for roughly $760 million to $1.8 billion dollars to support the introduction of these policies. The United Nations has offered incentives for developing countries undertaking REDD policies. On the other hand, Mexico cannot distract resources from other priorities such as poverty alleviation and other development expenditure. Additionally, carbon sequestration is a global public good and the international community may be interested in having Mexico mitigate emissions at probably lower costs than other countries.

Sensitivity analysis

It is frequently asserted that the effectiveness of forestation, deforestation prevention, and other carbon sequestration activities can be highly risky investments and any given investment will not yield the level of deforestation anticipated or desired. Hence, as a sensitivity exercise we run several scenarios at less than 100% efficiency. More specifically, we run the REDD scenario, the REDD+ scenario, and the Commercial Plantations scenarios assuming that the same level of investment is made but that the level of forest growth and carbon sequestration is 50% of that which was anticipated. In this way we are able to give a range of results that will hopefully bracket any "real world" environmental and economic results that may result from future investment activities in Mexico's forestry sector. In so doing we attempt to give a realistic picture of what the eventual outcomes of such activities would be. The aggregate results from this exercise are given in section A.7 of the Appendix to this report. As can be seen there, although the growth in the forest sector is roughly half of what it was in the tables given in Appendix A.3 to A.5, the economic results to welfare and growth can widely vary since a lessoning of growth in a single sector will not have a linear affect across all sectors. Thus, even under a 50% effectiveness of the mitigation potential across all policies, REDD+ has the highest impact on growth of GDP and final capital stock, growth of the forestry sector, and higher and more progressive welfare impacts. REDD also has positive and relatively progressive welfare impacts, but those of Commercial Plantations are much smaller and marginally regressive.

5. Conclusions

Policies to reduce greenhouse gas emissions in the forestry sector also bring an increase in efficiency within the sector, social benefits, and sequestration of carbon. Now, due to the interrelations among sectors, both the economic and the environmental effects of the policies may be felt on the economy as a whole.

This study analyzes the effect of sector-specific policies and their inter-relation. The findings are interesting in that we can clearly see the impact on the particular sector addressed by the policies, the other sectors that, with intent or not, are affected, and the impact on aggregate variables and welfare of the different income groups. The economic impacts are measured in terms of aggregate variables and sectoral growth in the forestry sector. Social impacts are addressed through changes in the welfare levels of all agents and through employment. Finally, environmental impacts are clear through changes in carbon sequestration.

The forestry sector is small within the Mexican economy, so any policy aimed at it will only have modest effects on the overall economy. Once this has been said, REDD has a small negative effect on aggregate GDP in the short and medium run, but marginally positive in the long run. This negative, very small effect is enhanced in the short run by REDD+, but then it becomes positive REDD+ comes into play. Plantations have a lesser effect on overall growth than REDD, scenario to which it is compared. The same trends are observed with the final capital stock: it grows under REDD, more than duplicates under REDD+, and is lower than REDD under commercial plantations. Welfare levels tend to increase relatively uniformly under REDD, gain approximately an additional 50% under REDD+, and are marginally lower under Commercial Plantations. Thus, from a welfare standpoint these policies are beneficial to all consumer groups, regardless their income level. Forestry output grows under REDD, gains a third more under REDD+, and is lower than REDD for Commercial Plantations. Employment remains constant under the three cases: this may lead to no changes in migration, at least linked to these particular forest policies. Finally sequestration increases in REDD, escalates by a third to a half more under REDD+, and falls below a half of those of REDD under Commercial Plantations. Thus, overall, REDD+ is the most appropriate policy to increase sequestration, foster aggregate and sectoral growth both in the medium and long term, and increase welfare levels in a relatively progressive way, even under a lower than optimum mitigation case. It therefore brings economic, social and environmental benefits to the country that are relatively marginal because of the sheer size of the forestry sector and de policies proposed, but positive.

These costs of mitigation in this study are paid by the Mexican economy in the form of investment. The macroeconomic effects of these policies are reflected as a minor reduction in overall and sectoral GDP in activities other than forestry, for particular years. Even though the results of these policies are positive both in terms of GDP and welfare levels, the Mexican government needs to take advantage of the proposal of the United Nations that states that economic incentives should be provided to foster this type of forest-related policies. The required resources from abroad would be in the range of $760 million to $1.8 billion dollars. These resources may come through some mechanism, like the proposed Green Fund, from the international community.

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APPENDIX A.1 BENCHMARK AND STYLIZED FACTS IN THE MEXICAN ECONOMY

Scenario 0. The Reference Case

We first run the model as a reference case. Here each equation is calibrated so that the level of each variable matches the actual level observed in 2003 in hundreds of billions of 2003 pesos. In this case we assume that there is no change in policy or technology over the 2000-2030 time horizon beyond the 2.75% overall growth rate that has been historically seen. Furthermore, in the reference case we assume that the balance of trade, consumption, imports and exports, government revenue and expenditure, economy-wide savings, and the effective labor supply in hours worked all grow by this exogenously determined rate of growth. Finally, we assume that the production of oil and gas grows at the same steady rate as the rest of the economy in spite of decreasing reserves.

The function of the reference case is to see that our social accounting matrix (SAM) is balanced and to make sure that our dynamic CGE model is working correctly. It does not, however provide us with useful results for policy, since it does not explicitly account for the fact that oil is being depleted, the power and fossil fuels sectors have market power and that labor markets may not clear. Hence, in a subsequent run which we label scenario 1, we run the same model as in the benchmark case except that now we introduce some stylized facts that make the model more realistic.

Scenario 1. The "Business as Usual" Case

In scenario 1 the level of oil produced is allowed to rise according to the overall rate of economic growth until the year 2008, but from that time onward the amount of oil production is held constant. This is done because the depletion of existing stocks of petroleum will make it impossible for extraction to rise with the rest of the economy without massive investment of PEMEX (i.e. the national oil company of Mexico) in drilling and oil exploration activities. Furthermore, by capping oil production our model simulations correspond exactly to PEMEX's current long run planning goals (see Secretaría de Energía, 2000). Holding extraction at 2008 levels then, is much more realistic than assuming that oil extraction expands as fast as general economic growth. In order for the Mexican economy to keep growing as expected, we allow for imports of oil to grow so that economic activity continues its pace. We also assume that PEMEX and CFE are government run monopolies with the power to raise prices. These assumptions, in turn, give us a much more reliable benchmark with which to measure the impacts of climate change.

The results of this simulation exercise are given in the Table A.1, where the "business as usual" simulation results are compared to the benchmark case. Looking first at the aggregate natural resource use we see that, as expected, crude oil production declines substantially from its final total in the steady state reference case. Natural gas drops too. These declines are not restricted, however, to just oil and natural gas production. Because oil is the chief contributor to the generation of CO_2, the emissions of that gas decline precipitously. Thus, the natural process of depletion can limit to some extent the emissions of greenhouse gases and failure to include depletion could possibly result in an over estimate of emissions.

Since crude oil serves as a direct or indirect input into other economic sectors, we see that the decline in petroleum production leads to significant declines in the production of refinery products, manufacturing, and electricity. There is also a decline in the production in all of our model's transportation sectors. Energy is essential to agricultural production and as the price of energy goes up so do transportation costs. Transporters are forced to cut back on production and high cost producers are forced to leave the industry altogether. Even without climate change mitigation policies then, there are cost factors that are going to bring about pressure on Mexico' economic sectors and this has to be taken into account by policy makers attempting to ameliorate emission levels. Since oil plays such a vital role in the Mexican economy there is also a marked drop in GDP (see the GDP Chart), the final (i.e. 2030) level of investment, the economic welfare of all four agents, and the final value of the capital stock[11]. Because of the high proportion of energy consumed by Mexico's poor and middle income groups the decline in oil growth has a generally regressive impact on income distribution as the poorer agents experience proportionally greater losses than the richer agents. Depletion also has a significant impact on Mexico's foreign trade. Much of Mexico's foreign exchange is earned through its oil exports, and, as can be seen in the numbers given, the loss in oil production results in a significant curtailment of total exports and, consequently, huge deterioration in Mexico's balance of payments.

[11] This value along with the welfare and government expenditure numbers is discounted back to 2005 dollars for purposes of consistency.

Table A.1 The Cost of Imperfections in the Mexican Economy

Macroeconomic Impacts due to imperfections in Mexican Economy
Business as usual vs Benchmark

Percentage changes

	2012	2020	2030
GDP	0.083%	-1.653%	-3.849%
Investment	-0.242%	-3.257%	-3.340%
Government	2.323%	1.594%	-1.016%
Balance of Payments	-0.242%	-3.257%	-3.340%
Final Capital Stock			-3.243%

Cumulative Welfare			
Agent 1			-2.011%
Agent 2			-1.934%
Agent 3			-1.809%
Agent 4			-1.876%

Production Goods	2012	2020	2030
Agriculture	0.000%	-1.659%	-4.513%
Livestock	-0.093%	-1.841%	-4.282%
Forestry	-0.442%	-1.792%	-4.658%
Fishery	-0.671%	-2.174%	-5.809%
Oil	-1.501%	-5.699%	-16.080%
Natural Gas	-1.475%	-9.286%	-16.090%
Mining	0.145%	-2.576%	-5.998%
Refining	-1.401%	-8.345%	-14.665%
Transport	-0.544%	-2.346%	-5.433%
Electricity	-0.449%	-2.505%	-5.679%
Chemicals	-1.601%	-9.240%	-16.569%
Services	0.090%	-0.934%	-3.456%
Manufacturing	0.155%	-2.289%	-5.000%

Consumer Goods	2012	2020	2030
Food	-0.813%	-6.697%	-4.132%
Household Goods	-0.985%	-2.357%	-5.338%
Services	-0.769%	-1.446%	-3.958%
Autos	-0.866%	-1.865%	-4.571%
Energy	-1.105%	-2.900%	-6.229%
Transport	-0.941%	-2.431%	-5.563%
Gasoline	-1.344%	-4.801%	-9.133%
Water	-0.782%	-1.389%	-3.865%
Housing	-0.728%	-1.344%	-8.833%

Imports	2012	2020	2030
Agriculture	-0.323%	-0.913%	-1.496%
Livestock	0.000%	-3.448%	-2.632%
Forestry	0.000%	0.000%	-3.030%
Fishery	-0.015%	0.158%	0.000%
Oil	2.648%	0.000%	15.231%
Natural Gas	2.591%	22.454%	39.052%
Mining	0.000%	-1.198%	-1.376%
Refining	1.716%	10.693%	17.879%
Transport	0.000%	0.000%	-0.413%
Electricity	0.000%	0.000%	0.000%
Chemicals	0.467%	1.747%	2.582%
Services	-0.271%	-1.095%	-1.759%
Manufacturing	-0.122%	-0.567%	-0.898%

Exports	2012	2020	2030
Agriculture	1.429%	0.691%	-1.940%
Livestock	1.923%	1.563%	-2.381%
Forestry	0.000%	0.000%	0.000%
Fishery	0.000%	0.000%	-4.348%
Oil	-1.345%	-9.370%	-16.136%
Natural Gas	-1.292%	-18.518%	-30.447%
Mining	2.273%	0.000%	-2.778%
Refining	0.000%	-9.692%	-17.845%
Transport	1.385%	0.000%	-3.165%
Electricity	10.000%	0.000%	-5.882%
Chemicals	0.777%	-1.881%	-5.755%
Services	1.486%	0.875%	-1.637%
Manufacturing	1.383%	0.342%	-2.478%

APPENDIX A.2 THE COST OF CLIMATE CHANGE

Table A.2 The Cost of Climate Change

Macroeconomic Impacts due to Climate Change
Climate change vs Business as Usual

	2012	2020	2030
GDP	-5.077%	-4.434%	-7.611%
Investment	-3.236%	-3.367%	-3.971%
Government	4.194%	1.692%	-3.479%
Balance of Payments	-19.079%	-17.915%	-21.810%
Final Capital Stock			-3.062%
Cumulative Welfare			
Agent 1			-1.801%
Agent 2			-1.681%
Agent 3			-1.516%
Agent 4			-1.511%

Production Goods	2012	2020	2030
Agriculture	-3.045%	-4.186%	-7.238%
Livestock	-16.116%	-16.954%	-19.033%
Forestry	-20.889%	-21.898%	-24.425%
Fishery	0.000%	-0.556%	-3.084%
Oil	1.000%	-0.843%	-3.124%
Natural Gas	0.998%	-0.175%	-3.111%
Mining	-0.724%	-1.923%	-5.238%
Refining	0.778%	-0.352%	-3.259%
Transport	0.467%	-0.490%	-2.943%
Electricity	-2.291%	-3.250%	-5.727%
Chemicals	0.048%	-1.678%	-6.467%
Services	0.342%	-0.600%	-3.012%
Manufacturing	-1.647%	-2.668%	-5.453%

Consumer Goods	2012	2020	2030
Food	-0.911%	-1.822%	-4.101%
Household Goods	-1.032%	-1.951%	-4.223%
Services	-0.011%	-0.929%	-3.229%
Autos	-0.838%	-1.781%	-4.065%
Energy	-2.863%	-3.733%	-6.005%
Transport	0.299%	-0.623%	-2.937%
Gasoline	0.261%	-0.703%	-3.072%
Water	-20.032%	-20.743%	-22.513%
Housing	0.210%	-0.724%	-3.007%

Imports	2012	2020	2030
Agriculture	1.618%	1.579%	1.619%
Livestock	17.391%	21.429%	18.919%
Forestry	20.000%	20.000%	21.875%
Fishery	-1.113%	3.747%	0.000%
Oil	-0.716%	0.000%	-0.861%
Natural Gas	-4.383%	-3.735%	-2.997%
Mining	-0.746%	-0.606%	-0.930%
Refining	-2.169%	-1.968%	-1.799%
Transport	-1.342%	-1.622%	-1.245%
Electricity	0.000%	0.000%	0.000%
Chemicals	-0.514%	-0.527%	-0.548%
Services	-1.088%	-1.107%	-1.194%
Manufacturing	0.122%	0.135%	0.145%

Exports	2012	2020	2030
Agriculture	-0.563%	-1.602%	-3.777%
Livestock	-15.094%	-16.923%	-17.073%
Forestry	-12.500%	-20.000%	-23.077%
Fishery	7.143%	5.882%	0.000%
Oil	1.590%	0.599%	-1.551%
Natural Gas	5.455%	3.782%	0.588%
Mining	2.222%	1.818%	-1.429%
Refining	2.732%	1.951%	-0.820%
Transport	2.049%	1.119%	-1.148%
Electricity	-9.091%	-7.692%	-6.250%
Chemicals	1.445%	0.399%	-1.908%
Services	2.018%	1.093%	-1.261%
Manufacturing	0.708%	-0.231%	-2.545%

APPENDIX A.3 REDD

Table A.3 The effects of REDD

Macroeconomic Impacts due to REDD
REDD vs. Business as usual with climate change

Percentage changes

	2012	2020	2030
GDP	-0.709%	-0.190%	0.363%
Investment	0.000%	0.070%	0.107%
Government	-2.676%	-1.195%	1.736%
Balance of Payments	0.000%	0.000%	0.000%
Final Capital Stock			0.077%

Cumulative Welfare			
Agent 1			0.035%
Agent 2			0.025%
Agent 3			0.030%
Agent 4			0.032%

Production Goods

	2012	2020	2030
Agriculture	-0.039%	-0.033%	0.053%
Livestock	-0.056%	0.000%	0.074%
Forestry	6.180%	14.019%	17.110%
Fishery	0.000%	0.000%	0.000%
Oil	-0.024%	-0.021%	0.071%
Natural Gas	0.000%	-0.262%	0.075%
Mining	0.000%	0.000%	0.201%
Refining	-0.034%	0.000%	0.075%
Transport	-0.010%	0.000%	0.060%
Electricity	0.000%	0.032%	0.078%
Chemicals	-0.032%	0.014%	0.163%
Services	-0.012%	-0.004%	0.057%
Manufacturing	-0.010%	0.042%	0.135%

Consumer Goods

	2012	2020	2030
Food	0.006%	0.014%	0.073%
Household Goods	0.046%	0.114%	0.191%
Services	0.006%	0.009%	0.071%
Autos	0.000%	0.060%	0.097%
Energy	0.072%	0.060%	0.145%
Transport	0.000%	0.000%	0.054%
Gasoline	-0.029%	0.024%	0.060%
Water	0.000%	0.000%	0.000%
Housing	0.000%	0.000%	0.069%

Imports

	2012	2020	2030
Agriculture	0.000%	0.130%	0.100%
Livestock	0.000%	0.000%	0.000%
Forestry	-4.167%	-10.000%	-12.821%
Fishery	0.023%	-4.629%	0.000%
Oil	0.008%	0.036%	0.044%
Natural Gas	0.082%	0.105%	0.103%
Mining	0.000%	0.000%	0.469%
Refining	0.000%	0.182%	0.000%
Transport	0.000%	0.000%	0.000%
Electricity	0.000%	0.000%	0.000%
Chemicals	0.000%	0.020%	0.030%
Services	0.000%	0.000%	0.086%
Manufacturing	0.006%	0.004%	0.007%

Exports

	2012	2020	2030
Agriculture	0.000%	0.000%	0.000%
Livestock	0.000%	0.000%	0.000%
Forestry	0.000%	12.500%	20.000%
Fishery	0.000%	0.000%	0.000%
Oil	-0.045%	0.000%	0.034%
Natural Gas	-0.116%	-0.108%	-0.215%
Mining	0.000%	0.000%	0.000%
Refining	0.000%	0.000%	0.000%
Transport	0.000%	0.000%	0.000%
Electricity	0.000%	0.000%	0.000%
Chemicals	-0.095%	0.000%	0.065%
Services	-0.039%	-0.032%	0.000%
Manufacturing	-0.032%	0.000%	0.064%

APPENDIX A.4 REDD+

Table A.4 Expanding REDD to REDD+

Expanding REDD to REDD+

REDD+ vs. REDD

Percentage changes

	2012	2020	2030
GDP	-0.003%	0.004%	0.021%
Investment	0.000%	0.070%	0.054%
Government	-0.025%	-0.020%	-0.004%
Balance of Payments	0.000%	0.005%	0.004%
Final Capital Stock			0.098%
Cumulative Welfare			
Agent 1			0.014%
Agent 2			0.019%
Agent 3			0.011%
Agent 4			0.012%

Production Goods	2012	2020	2030	Consumer Goods	2012	2020	2030
Agriculture	0.000%	0.000%	0.000%	Food	0.006%	0.009%	0.023%
Livestock	0.000%	0.000%	0.000%	Household Goods	0.009%	0.030%	0.061%
Forestry	1.058%	3.279%	4.545%	Services	0.006%	0.009%	0.019%
Fishery	0.000%	0.000%	0.000%	Autos	0.000%	0.000%	0.049%
Oil	-0.024%	0.000%	0.018%	Energy	0.000%	0.060%	0.097%
Natural Gas	0.000%	0.000%	0.000%	Transport	0.027%	0.000%	0.018%
Mining	0.000%	0.000%	0.000%	Gasoline	0.029%	-1.221%	0.020%
Refining	0.000%	0.000%	0.000%	Water	0.000%	0.000%	0.000%
Transport	0.000%	0.000%	0.013%	Housing	0.000%	0.000%	0.000%
Electricity	0.000%	0.000%	0.026%				
Chemicals	0.016%	0.029%	0.038%				
Services	-0.003%	0.000%	0.011%				
Manufacturing	0.004%	0.021%	0.021%				

Imports	2012	2020	2030	Exports	2012	2020	2030
Agriculture	0.000%	0.000%	0.000%	Agriculture	0.000%	0.000%	0.000%
Livestock	0.000%	0.000%	0.000%	Livestock	0.000%	0.000%	0.000%
Forestry	0.000%	-3.704%	-2.941%	Forestry	0.000%	0.000%	0.000%
Fishery	0.004%	0.014%	0.000%	Fishery	0.000%	0.000%	0.000%
Oil	0.000%	0.006%	0.013%	Oil	0.000%	0.000%	0.000%
Natural Gas	0.033%	0.044%	0.690%	Natural Gas	-0.031%	-0.039%	-0.001%
Mining	0.000%	0.000%	0.000%	Mining	0.000%	0.000%	0.000%
Refining	0.000%	0.000%	0.000%	Refining	0.000%	-0.478%	0.000%
Transport	0.000%	0.000%	0.000%	Transport	0.000%	0.000%	0.000%
Electricity	0.000%	0.000%	0.000%	Electricity	0.000%	0.000%	0.000%
Chemicals	0.000%	0.000%	0.000%	Chemicals	0.000%	0.000%	0.000%
Services	0.000%	0.000%	0.000%	Services	0.000%	-0.032%	0.026%
Manufacturing	0.000%	0.000%	0.000%	Manufacturing	-0.006%	0.000%	0.021%

APPENDIX A.5 COMMERCIAL PLANTATIONS

Table A.5 The Impact of Commercial Plantations

Introducing Commercial Plantations
Commercial Plantations vs. REDD

Percentage changes

	2012	2020	2030
GDP	-0.01%	-0.01%	-0.06%
Investment	0.00%	0.00%	-0.11%
Government	-0.01%	-0.01%	-0.05%
Balance of Payments	0.00%	0.00%	-0.09%
Final Capital Stock			-0.07%

Cumulative Welfare			
Agent 1			-0.03%
Agent 2			-0.02%
Agent 3			-0.02%
Agent 4			-0.03%

Production Goods

	2012	2020	2030
Agriculture	0.04%	0.00%	-0.05%
Livestock	0.06%	0.05%	-0.07%
Forestry	-5.29%	-10.66%	-12.34%
Fishery	0.00%	0.00%	0.00%
Oil	0.02%	0.02%	-0.07%
Natural Gas	0.00%	0.00%	-0.07%
Mining	0.00%	0.00%	-0.20%
Refining	0.03%	0.00%	-0.07%
Transport	0.01%	0.00%	-0.05%
Electricity	0.00%	-0.03%	-0.08%
Chemicals	0.03%	-0.01%	-0.15%
Services	0.01%	0.00%	-0.05%
Manufacturing	0.01%	-0.03%	-0.12%

Consumer Goods

	2012	2020	2030
Food	0.00%	-0.01%	-0.06%
Household Goods	-0.05%	-0.10%	-0.16%
Services	0.00%	-0.01%	-0.06%
Autos	0.00%	-0.03%	-0.07%
Energy	0.00%	-0.06%	-0.14%
Transport	0.03%	0.00%	-0.05%
Gasoline	0.03%	-0.02%	-0.06%
Water	0.00%	0.00%	0.00%
Housing	0.00%	0.00%	-0.07%

Imports

	2012	2020	2030
Agriculture	0.00%	-0.13%	-0.10%
Livestock	0.00%	0.00%	0.00%
Forestry	4.35%	7.41%	11.76%
Fishery	-0.02%	-0.04%	0.00%
Oil	0.00%	-0.03%	-0.03%
Natural Gas	-0.07%	-0.08%	-0.08%
Mining	0.00%	0.00%	-0.47%
Refining	0.00%	-0.18%	0.00%
Transport	0.00%	0.00%	0.00%
Electricity	0.00%	0.00%	0.00%
Chemicals	0.00%	0.00%	-0.01%
Services	0.00%	0.00%	-0.09%
Manufacturing	-0.01%	0.00%	-0.01%

Exports

	2012	2020	2030
Agriculture	0.00%	0.00%	0.00%
Livestock	0.00%	0.00%	0.00%
Forestry	0.00%	-11.11%	-16.67%
Fishery	0.00%	0.00%	0.00%
Oil	0.00%	0.00%	-0.03%
Natural Gas	0.09%	0.08%	0.21%
Mining	0.00%	0.00%	0.00%
Refining	0.00%	0.00%	0.00%
Transport	0.00%	0.00%	0.00%
Electricity	0.00%	0.00%	0.00%
Chemicals	0.10%	0.00%	-0.06%
Services	0.04%	0.03%	0.00%
Manufacturing	0.03%	0.00%	-0.06%

APPENDIX A.6 EMISSIONS UNDER DIFFERENT SCENARIOS

	REDD vs BAUCC	REDD+ vs REDD	COM. PLANT vs REDD
2020	-0.2%	0.0%	0.0%
2030	-0.1%	0.0%	-0.1%

APPENDIX A.7 SENSITIVITY ANALYSIS

50% effectiveness of REDD vs. BAU w/CC

Percentage changes	2012	2020	2030
GDP	0.004%	0.028%	0.042%
Investment	0.000%	0.070%	0.017%
Government	-0.006%	0.000%	0.000%
Final Capital Stock			0.049%
Forestry	4.494%	7.944%	11.027%
Cumulative Welfare			
Agent 1			0.021%
Agent 2			0.020%
Agent 3			0.018%
Agent 4			0.020%

50% effectiveness of REDD+ vs. BAU w/CC

Percentage changes	2012	2020	2030
GDP	0.003%	0.952%	0.075%
Investment	0.000%	4.459%	0.107%
Government	-0.019%	-0.015%	0.029%
Final Capital Stock			0.059%
Forestry	4.494%	9.813%	13.688%
Cumulative Welfare			
Agent 1			0.028%
Agent 2			0.027%
Agent 3			0.025%
Agent 4			0.026%

50% effectiveness of Plantations vs. BAU w/CC

Percentage changes	2012	2020	2030
GDP	0.003%	0.936%	0.063%
Investment	0.000%	4.390%	0.054%
Government	-0.019%	-0.015%	0.029%
Final Capital Stock			0.005%
Forestry	0.562%	0.935%	1.521%
Cumulative Welfare			
Agent 1			0.002%
Agent 2			0.003%
Agent 3			0.003%
Agent 4			0.003%

International Financing for REDD
A Project of WWF US Policy Program
List of Publications

All these publications can be downloaded from WWF Connect or copies can be obtained from Melissa Tupper Melissa.Tupper@wwfus.org or Pablo Gutman Pablo.Gutman@wwfus.org

- Report No. 1 P. Gutman; "The State of REDD+ Negotiations and Possible Outcomes at COP15. A September 2009 Update"
- Report No. 2 C. Loisel; "REDD+ Initiatives Outside the UNFCCC. An October 2009 Update"
- Report No. 3 A. Sen; "National Institutional Arrangements for REDD. Case Study Guyana" November 2009
- Report No. 4 T. Blanco Freja (cord.) "National institutional Arrangements for REDD. Case Study – Colombia" November 2009
- Report No. 5 M. Cigaran Tolmos (cord.) "Challenges, Opportunities and Critical Aspects Regarding the Possible Implementation of REDD+ in Peru" December 2009
- Report No. 6 P. Gutman "Funding for Developing Countries' REDD+ in the US Climate Change Legislation. A December 2009 Update"
- Report No. 7 F. Ardiansyah (cord.); National institutional Arrangements for REDD+ Case Study – Indonesia" December 2009
- Report No. 8 P. Gutman and D. Patterson; "Lessons from REDD+ Preparedness in Colombia, Guyana, Indonesia and Peru.
- Report No. 9 M. Ibarraran and R. Boy "Multiplier and distributive effects of large-scale REDD+ policies in Mexico" June 2010

Related publication by a partner institution, with the participation of this project staff

- C. Streck, L. Gomez-Echeverri, P. Gutman, C. Loisel and J. Werksman" REDD+ Institutional Options Assessment, Meridian Institute, 2009. Available at www.REDD-OAR.org