Incorporating sustainable development concerns into climate change mitigation: A case study from Mexico

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Abstract
This paper is an examination of carbon dioxide emission mitigation scenarios within the forestry and energy sectors in Mexico. It is primarily intended to illustrate how, using a proper strategy, it is possible to identify development options that result in significant CO₂ emission reductions while simultaneously advancing national sustainable development priorities.¹

Introduction
The United Nations Framework Convention on Climate Change (UNFCCC) was agreed to in 1992 at the United Nations Conference on Environment and Development in Rio de Janeiro. The Kyoto Protocol to the Convention was developed and agreed to five years later at the third Conference of Parties (COP 3). Using 1990 emissions levels as a baseline, the Protocol instituted mandatory reductions of greenhouse gases (GHGs) for industrialized (Annex I) countries. It also established the possibility of trading ‘units’ of emissions reduction between Annex I and developing (non-Annex I) countries through the Clean Development Mechanism, which is expected to begin operating by the end of the year 2000.

Both the Convention and the Protocol state that the different actions and policies directed at the mitigation and/or reduction of the impacts of potential change in the Earth’s climate should be framed within the context of sustainable development. In order for Non-Annex I countries to participate in emissions reduction activities, the identification of mitigation options and future emissions reduction paths that simultaneously advance sustainable development priorities within the participating countries will be critical. Another crucial element will be the inclusion of mitigation options that not only involve both the forestry and energy sectors, but also encompass integrated scenarios that enable full examination of alternative emissions paths in each country.

¹ This article is based on Sheinbaum and Masera, “Mitigating Carbon Emissions while Advancing National Development Priorities: The Case of Mexico” in Climatic Change (November 2000 issue). Some of the text and graphics throughout this paper have been re-published here with the kind permission of Kluwer Academic Press. Please refer to this article for a more complete discussion of the approach, the model, scenarios, and results.
The case of climate change mitigation in Mexico is particularly pertinent for several reasons. First, Mexico is among the 20 countries with the highest levels of greenhouse gas emissions in the world. Second, Mexico has been a member of both the Organisation for Economic Co-Operation and Development (OECD) and the North American Free Trade Agreement (NAFTA) since 1994, and has therefore been subject to pressures to cap future GHG emissions or emissions growth. Third, Mexico is an oil exporting country and relies heavily on fossil fuels for its domestic energy needs. At the same time, however, Mexico is clearly a developing country in terms of its average income per capita, unavailability of basic services for a significant portion of its population, and its per capita emissions rate. In addition, the government does not have sufficient capital to make incremental investments in emissions mitigation options.

**The current situation**

About 96% of Mexico’s primary energy comes from fossil fuels. Carbon dioxide emissions related to energy use grew from 297 TgCO₂ in 1990 to 331 in 1994 (Sheinbaum and Rodríguez 1997). This has been compounded by severe deforestation and forest degradation, which has been estimated at a loss of 670,000 ha per year (Masera et al. 1997). Approximately 136 TgCO₂ are emitted each year as a result of land use changes, 185 TgCO₂ if forest regrowth on abandoned land is not taken into account. Total carbon dioxide emissions reached 434 TgCO₂ per year (118 TgC/yr) in 1990, 27% of which came from land use changes (Government of Mexico 1997) (see Figure 1).

There are currently several activities being conducted in Mexico that simultaneously address national development priorities while helping to reduce the GHG emissions. Within the energy sector these activities include improvements in energy efficiency in the industrial, transportation, commercial, and residential sectors; switching to less carbon intensive fuels; and the establishment of standards for new equipment. Forestry sector projects that focus on conservation and management of native forests as alternatives to deforestation, afforestation of degraded and deforested lands, and promoting agroforestry systems also have the potential to mitigate net GHG emissions. These measures are summarized in Table 1.

**Energy Sector**

Starting in 1989, several institutions were created in Mexico with the purpose of promoting energy efficiency. These include the Comisión Nacional para el Ahorro de Energía (CONAE — The National Commission for Energy Savings), Programa de Ahorro de Energía del Sector Eléctrico (PAESE — The Electricity Sector’s Energy Saving Program) and the Fideicomiso para el Ahorro de Energía Eléctrica (FIDE — The Trust for the Conservation of Energy), which is a revolving-loan trust fund to save electricity. These organizations have developed the following energy efficiency programs.
### Energy Efficiency Standard

There are several standards already in effect, including criteria for domestic refrigerators and coolers, room and central air conditioners, three phase electric motors, and non-residential lighting. According to CONAE, energy standards save 2000 GWh of electricity per year (CONAE 1996).

### Demand-side Management Programs

**Residential lighting:** In the residential sector, the primary state-owned national utility, Comisión Federal de Electricidad (CFE — The Federal Electricity Commission), implemented 12 projects between 1989 and 1996 to promote the use of compact fluorescent lamps (CFLs) in Mexican households. By September 1996 these projects were responsible for the adoption of about 1.2 million CFLs in Mexican homes, resulting in energy savings of 160 GWh per year (Friedman et al. 1993 and 1995).

**Incentives:** The incentive program, which started in early 1998, is intended to achieve energy savings of 3,250 MWh in the year 2000 by promoting the intro-
duction of efficient technologies for residential lighting, commercial lighting, industrial motors and compressors, and municipal pumping (FIDE 1996).

**Roof insulation:** Since 1991 CFE has been promoting domestic roof insulation in northern Mexico by providing financing to homes using more than one MWh per month of electricity during the summer. Over 75,000 homes in northern Mexico, mostly in Mexicali, have been insulated to reduce cooling loads, with reported electric savings of up to 35% (DeBuen 1993).

**Daylight savings:** Summer daylight savings time was implemented in 1996. Evaluations of its success claim a national savings of 0.7% of national electric consumption (1.3 billion KWh TWh) and reduction of peak load by 500 MW (FIDE 1997).

**Industry**

Specific work in the industrial sector has included promoting the use of new, high-efficiency burners; improving current systems; and encouraging fuel switching. Additional activities include the instrumentation and control of boilers and burners and the promotion of energy management systems. Work in the public sector includes strengthening the relationship with Petroleos Mexicanos (PEMEX), the national oil company, as well as studies of recovery in rigs and platforms and the use of turbo compressors at terminal stations. Energy savings related to these programs are estimated to be around 480 GWh/yr (CONAE 1995; FIDE 1995a).

**Buildings**

Efficiency demonstration projects have been carried out in office buildings, educational facilities, commercial malls, department stores, restaurants, hotels, supermarkets, hospitals, and other establishments. The resulting energy savings have varied between 20 and 37%, with a maximum payback of three years on investments, and a total energy savings of 24 GWh per year (FIDE 1995b).

**Cogeneration**

As of 1994, Mexico had installed industrial cogeneration facilities with a combined capacity of nearly 3 GW, mostly in PEMEX refineries and petrochemical facilities. More recently, the Regulatory Energy Commission authorized close to 20 permits for cogeneration, which represents an installed capacity of around 600 MW. However, most of this installed cogeneration capacity has been used exclusively for on-site demand due to barriers related to electricity costs that have to be paid by the electric utilities (Sheinbaum et al. 1997-1998).

**Renewable energy**

**Rural electrification:** In 1994 a rural photovoltaic electrification program enabled 35,000 small household systems to be installed for communities that did not have access to the electricity grid (Mexican Secretary of Energy 1997).

**Solar thermal systems:** Water heating solar systems are being applied in a variety of capacities, both at the household level and in the commercial sector, including at one of the principal hospitals in Mexico City.

**Wind power generation:** The main wind power generation system in Mexico is in the southeast region of the country (La Venta to Oaxaca). It is connected to the national and interconnected grid system. It has a power capacity of 1575 kW (equivalent to 15,750 bulbs of 100 watts) and a capacity of nearly 40%. There are plans to expand wind projects to reach a power capacity of 56 MW by the year 2005 (CFE 1997).
Fuel switching
Most of the expansion in the electric power sector through the year 2005 will take place by adding natural gas fired (combined cycle) power plants (9500 MW from 1996 to 2005) instead of the traditional thermal (fuel-oil fired) power plants. In addition, the majority of the industries in the regions with the highest local pollution indexes, especially those in the larger cities, have switched from fuel oil to natural gas.

Forest sector
Mexico has 49 million ha of native forests, half of which are temperate and half tropical (Masera et al. 1997). There are an additional 21 million ha classified as degraded forestlands. About 80% of total forestland is communally owned by rural communities. Approximately 95% of all timber harvesting in Mexico is conducted in native, mainly temperate, forests (SEMARNAP 1996). There are several programs in place to reduce deforestation and forest degradation in the country. The main forestry activities that will result in GHG emissions reductions are:

Promotion of sustainable forest management in native forests
By the end of the year 2000, the Mexican government plans to support the establishment of sustainable forest harvesting systems on more than 3 million ha of native tropical and temperate forests. Most of these forests are collectively owned by rural communities and are either unmanaged or have been managed using inadequate methods that have favored degradation and conversion to other land uses. Several incentives are in place that will help achieve the stated objectives, including a government program, el Programma para el Desarrollo Forestal (PRODEFOR—The Program for Forest Development), which allocates between US$9 million and US$13 million per year toward these initiatives (SEMARNAP 1996). Through PRODEFOR, forest owners, mostly rural communities and ejidos,3 receive subsidies that enable them to prepare integrated forest management plans for timber and non-timber forest products, to conduct forest inventories, and to improve the current management of timber and non-timber resources.

Commercial plantations
Approximately 25,000 ha will be established as commercial plantations by the end of 2000. Most of these plantations are sown with fast growth species that are intended to be used for cellulose production. A newly approved law places several constraints on the establishment of these plantations to insure that they will not cause major environmental or social problems (Alvarez-Icaza and Viveros 1996). Since 1997 a subsidy of US$30 million per year, as well as several fiscal incentives, have been provided to encourage the establishment of plantations (SEMARNAP 1996).

Agroforestry systems
Agroforestry systems combine the production of crops and trees in the same area for the purpose of obtaining both agricultural and forest products. As of 1997 there were 0.86 million ha dedicated to agroforestry systems in Mexico—about 0.8 million ha of this is producing shade coffee and 0.06 million ha is sown with cacao (Masera and Ordonez 1997). There is a large area of fallow lands, the exact size of which is currently unknown, that are also managed as agroforestry systems. Agroforestry systems offer a promising economic alternative to conversion of forests to

3 Ejidos are a form of collective land ownership. In the case of forestlands, members of the ejido are allowed to use the land but not to sell it.
pasture and agriculture, especially for tropical deciduous and tropical evergreen forests. There are currently several large governmental programs planned for implementation in different tropical regions of Mexico. Specifically, in the humid tropics, the program Desarrollo Sustentable del Tropico Humedo (Sustainable Development of the Humid Tropics) plans to reduce the extent of slash and burn agriculture by intensifying corn production, establishing soil conservation practices, and promoting different types of agroforestry systems.

*Restoration plantations (afforestation)*

Afforestation involves planting trees in both deforested and degraded lands. The objective is to enable the regeneration of vegetation in order to recover degraded areas, protect water basins, and reduce soil erosion. The afforested area has increased substantially over the last few years, but the national results of these programs are still modest (0.2 million ha). The government reforested 200,000 ha every year from 1995 to 2000, for a total of 1 million ha in the period (semarnap 1996). However this area should be adjusted by the trees’ survival rate, which is currently 34%, leaving a net of 0.46 million ha by the end of 2000.

*Other programs*

Mexico has currently 111 Natural Protected Areas (NPAs), covering 11.9 million ha of tropical, temperate, and semi-arid forests. Financial resources are not sufficient to adequately protect all of these areas, so the government has decided to give priority to the 10 NPAs deemed most important. Two programs directed at slowing the rate of conversion of forest to other land uses are the Unidad de Manejo de Vida Silvestre (UMAS – Wildlife Management Units) and the Programa para la Defensa de la Frontera de la Selva (PDFS – The Program for the Defense of the Forest Frontier). The former provides incentives to individuals and organizations for the management of fauna and vegetation for conservation purposes. It is currently being applied to 7 million ha of semi-arid, temperate, and tropical forests (Government of Mexico 1999). It is a voluntary agreement between landowners and government. The PDFS provides incentives to owners of land with marginal crop and pasture productivity to reconvert them to forests. The program currently covers 20,000 ha per year. A recently approved program, Programa Nacional de Leña (PNL – The National Fuelwood Management Program), will devote funds to encouraging the sustainable use of fuelwood in the countryside, which currently accounts for 78% of total wood demand in Mexico (Government of Mexico 1999).

*Building future carbon emission and sequestration scenarios*

There are several crucial steps that will be necessary in order to effectively link mitigation strategies with sustainable development priorities at the country level. The authors conducted a study of the options within the energy and forestry sectors that would address both the global responsibility of GHG emissions reductions and the national priority of sustainable development. A 15-year time period from 1995 to 2010 was used for this study. The study was funded by the U.S. Agency for International Development (USAID). Portions of the original text, paraphrased or verbatim, may appear in this document.
vantages: a) there is little control over the actual computational procedures; b) the users depend on the package programmers for any modifications; c) the form in which the data must be entered may not coincide with that in which information is available, so that a certain amount of exogenous data-processing must be completed before the package can be used; and d) most packages impose major constraints on the planning process (Reddy 1995).

For these reasons, the first step in this analysis was to develop and adapt existing tools to Mexico’s particular priorities. Specifically, the authors chose to create an integrated analysis of energy and forestry options, and developed a bottom-up accounting simulation model for Mexico that simulates energy consumption by end uses. The model has three basic submodels, which enabled the authors to conduct estimates for both the base year and projected scenarios. The submodels included: a) an end-use-based simulation of the Mexican energy system and its associated GHG emissions; b) a simulation of forest sector options, based on the demand for forest products and other services from the forest sector, accounting for both emissions and carbon sequestration; and c) a financial module comprised of an estimation of CO₂ mitigation costs and an incremental cost curve.¹

Identification of Mexico’s future sustainable development priorities

Through the end-use analysis of energy needs and a demand-based analysis of forest products, the authors identified a set of key activities that address national development priorities while simultaneously helping to reduce the current rate of GHG emissions growth. Within the energy sector, these activities include increases in energy efficiency in the industrial, transportation, commercial, and residential sectors; switching to less carbon intensive fuels; and the establishment of standards for new equipment. Within the forest sector, the authors recommendations included the adequate conservation and management of native forests, the support of afforestation of degraded and deforested lands, and the promotion of agroforestry systems.

Building reference scenarios and mitigation scenarios

The study examined two scenarios for the year 2010: a reference scenario and a mitigation scenario. In the energy sector, the reference scenario was based on an assumption of intensity frozen at 1994 levels. In the forest sector, the assumption was a constant rate of deforestation based on a percentage of the remaining forest area. The economic and population growth rates that were used to determine the demand for energy and forestry products were based on official projections.

The mitigation scenario focused on specific rates of penetration of mitigation technologies by sector. Only a limited set of options were analyzed; thus, the results presented should not be viewed as the total or maximum potential carbon mitigation for Mexico. This is particularly true for the energy sector, where data availability restrictions hindered a truly in-depth analysis of the transportation sector.

Transformation of sustainable development priorities into greenhouse gas emissions mitigation

The final step of the analysis was to demonstrate the implications of the scenarios in terms of GHG emissions and sequestration, and the associated costs. For this purpose, the authors used appropriate emission factors and methods to transform the identified targets in each scenario. For example, the number of compact fluo-

¹ See Sheinbaum and Masera 2000 for a complete description of the model.
rescent bulbs to be installed or the area to be restored through reforestation would be expressed in terms of GHG emissions and sequestration figures.

The costs calculated in the model included the investment, operation, and maintenance costs needed to achieve the energy and forest services for targeted years. The model combined the different options in order to determine the least cost “path” of the carbon mitigation scenarios.

**Results**

**Baseline scenario**

Without any mitigation activities, the total Mexican CO₂ emissions would reach 879 Tg per annum by 2010. Energy emissions can be expected to grow 149% in the 15-year timeframe used for this analysis (see Figures 2 and 3). A net loss of 10.4 million ha of forests, 20% of the existing area, is predicted by the baseline scenario. Because the net deforestation rate is proportionate to the remaining forested area, the area deforested annually would decline in the future. As a result, annual carbon emissions from deforestation will decline 33% between 1995 and 2010.

**Mitigation scenario**

**Energy sector**

For the purposes of this study, the mitigation options related to energy use included combined cycle plants, efficient industrial electric motors, efficient industrial boilers, industrial cogeneration, efficient commercial and residential lighting systems, efficient potable water pumping, inter-modal substitution of passenger transportation methods in the Mexico City Metropolitan Area (MCMA), and wind power generation. The assumptions used for the mitigation scenario analysis were as follows:

6 For a detailed description of the methodology, see Sheinbaum and Masera 2000.

Combined cycle plants: The assumption was that rising demands for electricity could be satisfied by installing systems based on natural gas combined cycle plants, rather than fuel oil thermoelectric plants. By the year 2010, it is projected that the required installed capacity will have reached 51,464 MW, 43% of which could be produced by combined cycle plants.

Efficient industrial motors: It was assumed that all the motors sold from 1999 to 2010 would be high efficiency units. Substitution was considered for motors between 5 and 125 horsepower (hp), with energy savings of 15% per motor. This substitution would create a cumulative energy savings of 754 GWh by the year 2010 (Rodriguez 1997).
Industrial cogeneration: The models used the assumption that all new industrial plants would implement cogeneration in their processing. Energy needs were calculated assuming that the exhaust heat of a gas turbine would satisfy the thermal necessities of industrial processes. Under these conditions, the cogeneration system would supply more than enough power for the industrial process, with the cogeneration potential for new plants reaching 8664.3 MW by the year 2010 (Sheinbaum 1997).

Industrial boilers: According to Selmec (1994), 10,000 boilers with capacities of between 10 and 2000 hp are currently installed in the Mexican industrial sector. The mitigation scenarios assumed fuel switching (from diesel and fuel oil to natural gas), insulation, and burner substitution for 20% of all industrial boilers by 2010 (Aguillon 1997).

Efficient lighting in commercial sector: It was assumed that 5 million efficient lighting systems would be installed by 2010 due to the expected increases in electricity prices and decreases in the costs of efficient lighting technology (Sheinbaum and Vazquez 1997).

Compact fluorescent lamps (CFLs) in the Residential Sector: FIDE’s incentive program estimates that 9.6 million lamps (out of a stock of more than 150 million lamps) will be replaced by CFLs by the year 2010. The mitigation scenario used the assumption that for each lamp considered within the incentive program, another one would be installed, resulting in energy savings of 500 GWh by the year 2010 (Sheinbaum and Vazquez 1997).

Efficient water pumping: It is estimated that corrective and maintenance measures could save approximately 35% of the national water pumping electricity consumption (Carmona 1997). This assumption was applied in the mitigation models.

Inter-modal transportation substitution in the MCMA: Replacement of small gasoline-powered buses with large diesel buses and increased use of electric mass metro and light train lines are considered the most viable emissions mitigation technology options for the MCMA. The mitigation scenario assumed the substitution of 60,000 microbuses with 30,000 diesel buses, as well as increased service from the metro and light electric trains (Dartois 1997).

Large scale wind electricity generation: Based on different studies of the potential for wind power generation in Mexico, the model used the assumption that 5000 MW of large wind power plants would be installed in the country by the year 2010, which equals about 14% of the total installed capacity in 2000. Using a capacity factor of 0.3, the generation capacity of these plants would be 1314 GWh (Caldera 1997).

Forest sector
The analysis covered three forestry mitigation strategies in detail: management of native forests, afforestation for forest restoration, and agroforestry systems.

Management of native forests: Sustainable management of native forests is one of the best options available to Mexico for avoiding carbon dioxide emissions from forest degradation and deforestation. At the same time, this scenario also offers important development benefits, such as local employment opportunities, increased wood and non-wood forest product outputs, and soil and biodiversity conservation. Currently, about 95% of all timber harvesting in Mexico occurs in native forests, which are mostly communally owned by 10 million people grouped in several thousand communities and ejidos. This means that encouraging sus-
tainable management of native forests will be particularly beneficial socially as well as environmentally.

In the mitigation scenario, the area of native forest under management was estimated at 4.4 million ha. This was determined using the expected rates of deforestation, offset by the area to be converted to improved management systems. Based on projected population and economic growth, the mitigation scenario also factored in the demand for wood products up through 2010. Long-term unit carbon sequestration ranges between 618 t of CO\textsubscript{2}/ha for temperate forest and 763 t of CO\textsubscript{2}/ha for tropical forest.

**Afforestation:** The scenario was based on the planting of trees in both deforested and degraded lands. The afforestation penetration estimation for this part of the scenario was based on governmental policies and goals for the year 2010, which were offset by relevant variables to determine that there would be 1.3 mil-

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**Table 2: Basic Assumptions for the Reference and Mitigation Scenarios**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Reference Scenario</th>
<th>Mitigation Scenario (Year 2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Medium GDP growth scenario (nearly 4%/yr); Reduction of population growth from 1.6% in 1995 to 1.1% in 2010</td>
<td>Combined cycle plants: The required installed capacity will reach 51,464 MW, of which 43% will be combined cycle plants. Efficient industrial motors: Cumulative energy savings of 754 GWh by the year 2010. Cogeneration: 8,664 MW for the year 2010. Industrial boilers: Fuel switching (from diesel and fuel oil to natural gas), insulation, and substitution of burners for 20% of all industrial boilers by 2010. Efficient Lighting in Commercial Sector: 5 million lighting systems will be installed by 2010. CFLs in the Residential Sector: 15 million CFLs will be installed by 2010 (double the incentive program estimate). Efficient Water Pumping: Corrective and maintenance measures used to save approximately 35% of the national water pumping electricity consumption. Transportation in the Metropolitan Area: The substitution of 60,000 gasoline microbuses by 30,000 diesel buses and increased service from the metro and electric light trains. Wind Electricity Generation: 5000 MW of large wind power plants.</td>
</tr>
<tr>
<td>Forestry</td>
<td>Net deforestation rate (deforestation minus afforestation) at 15% per year (based on early 1990s) from 1995 to 2010</td>
<td>Forest Management: 361 thousand ha per year of deforestation avoided by sustainable management of native forests. Afforestation: Additional 1.3 million ha designated as restoration plantations by 2010. Agroforestry: Additional 200,000 ha being used for agroforestry systems by 2010.</td>
</tr>
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Source: Adapted from Sheinbaum and Masera 2000.
lion ha of afforested land within the analysis period. In this case, the annual carbon balance for the period from 2000 to 2010 shows a steady increase from 2.8 to 12.1 TgCO$_2$.

**Agroforestry:** The model examined several different systems of combining trees and crops for the purpose of producing both agricultural and forest products. It used a conservative estimate of an additional 0.2 million ha under these systems by the year 2010. The rate of carbon sequestration varies greatly depending on the particular system, but usually ranges between 73 and 440 t of CO$_2$ per year in 2000, and up to 2.0 TgCO$_2$ per year by 2010.

Figure 4 illustrates the avoided CO$_2$ emissions for different energy and forestry options for the year 2010. The total mitigation potential for the options examined reaches 45 Tg of CO$_2$ in the energy sector and 262 Tg of CO$_2$ in the forest sector by 2010.

**Mitigation costs**

Within the energy sector, annual costs per unit range from US$45.90 per ton of CO$_2$ for residential lighting to US$106.40 for industrial motors. The average costs for forestry options range from US$3.50 per ton of CO$_2$ to US$5.40 depending on the option (see Figure 5). The mitigation options that resulted in higher costs than the baseline scenario are forest management in tropical areas, restoration plantations, agroforestry systems, increased use of the metro and light trains in the MCMA, and integration of efficient industrial motors. It should be noted that even cost-effective options, such as efficient lighting or, very specifically, the sustainable management of native temperate forests, usually require substantially higher investment costs than conventional technologies. Also, specifically in the case of forestry options, costs are extremely site-dependent; thus, the average values presented here may be much higher or lower for specific projects. However, the analysis showed that if mitigation scenario options were added one-by-one, they could be achieved at almost no additional net cost compared to the baseline scenario (Sheinbaum and Masera 2000).

**Discussion**

The analysis identified a mitigation potential of 393 Tg of CO$_2$ for Mexico by the year 2010. If this potential were realized, Mexico would reduce its total emissions by 7% from 1990 levels rather than increasing them by 69%, which is what the
The baseline scenario predicts that the per capita emissions rate would drop by 30% in the same period of time (from 6.2 to 4.3 tons of CO₂ per capita), instead of increasing by 26% (See Figure 3). Thus, by properly implementing a series of promising mitigation options in the energy and forest sectors, Mexico has the opportunity to significantly advance national development priorities for the period from 1995 to 2010, while keeping its per capita carbon emissions low and experiencing a very modest increase in total emissions. Therefore, in principle, there should be no contradiction between the national and global interests.

Forestry options, particularly sustainable management of native forests, show the largest carbon mitigation potential for Mexico in the short term. Forestry and energy projects specifically aimed at carbon mitigation are already operating successfully (Scolel Té 1997; Montoya et al. 1995; De Buen and Masera 1994) or are waiting only for approval of financial resources (Uzachi- ixeto 1998). It should be noted, however, that forestry options are ultimately limited by the amount of available area, and unless effective actions are taken in the energy sector, emissions will eventually continue growing at a rapid pace (see Figure 3). While resulting in a lower short-term carbon emissions reduction rate, there are several energy options, such as OILS, that would be extremely cost effective given Mexico’s strong dependence on relatively cheap oil resources. In this case, it will be necessary to employ a consistent and strategy, starting immediately, to insure that efficient technologies and renewable resources are integrated into policymaking over the next decade, and continue to be essential elements of development thereafter. At the same time, the large amount of carbon that could be potentially captured via forestry projects could provide Mexico with additional time for the development of a renewable energy path.

Conclusions

While it has been determined that Annex I countries are primarily accountable for the rising GHG emissions levels, Non-Annex I countries such as Mexico also have minor responsibilities both historically and in the present. The participation of these countries is very important to climate change mitigation. It is therefore critical that strategies be developed to support projects that will abate the future growth of GHG emissions in these countries while addressing their sustainable development priorities.

As demonstrated in this paper, Mexico is not a passive spectator in the climate change regime. Several actions have already been taken that, without explicitly addressing climate change, have a definite impact on emissions reductions. This paper also illustrates that future emissions paths can be identified in which there is no contradiction between sustainable development and climate change mitigation. The authors have shown that emissions of GHG gases can be cut by replacing conventional technologies with efficient ones, by introducing renewable energy technologies, and by implementing sustainable forest management, afforestation, and agroforestry systems. Many of these mitigation alternatives are “no regret” options for Mexico, not just because most of them are cost-effective, but because they simultaneously address sustainable development goals. Energy efficiency and increased use of renewable resources will lead to improved economic productivity, less investment to satisfy the increasing energy demand, and the possibility of raising the quality of life for those who do not currently have access to electricity. In the forest sector, in addition to carbon sequestration, the alternatives presented...
in this paper are likely to have tangible benefits at the local level, such as generation of income opportunities, conservation of biodiversity, and the preservation of soils and watersheds.

However, the mitigation potential identified will not be reached automatically. Strong and consistent efforts are needed at the local, national, and global levels. Locally, one of the main barriers to overcome is the increase in investment costs associated with carbon mitigation options. This is true for both energy and forestry options—even for those alternatives that will be cost-effective on a life-cycle scale, because they may require higher initial investment. This is true of options such as cogeneration and sustainable management of native temperate forests. As such, innovative schemes are needed to reduce up-front costs so users can afford to invest in GHG mitigation alternatives.

At the national level, energy and land-use policies should be established to address long-term concerns, as opposed to the six-year planning cycle that is currently employed by the government of Mexico. Internationally, industrialized countries need to significantly increase the transfer of funds and technology to the Non-Annex I countries. These funds, channeled through mechanisms such as the CDM, could play a critical role in removing the investment barriers associated with several energy and forestry mitigation options. Appropriately managed, new funds and better access to technology could also catalyze the “leap-frog” from obsolete technology to state of the art systems (Goldemberg 1998).

Specific actions that can help in the design of appropriate GHG mitigation options and scenarios in Non-Annex I countries include:

- Supporting the development of locally-adapted tools and methods that allow an integrated assessment of future mitigation scenarios in terms of the countries’ own defined sustainable development needs.
- Promoting an integrated approach to scenario building, where energy and forestry options can be examined and combined.
- Increasing and strengthening local capacity and institutions for the identification of mitigation options, project formulation, implementation, and monitoring (cooperation between developing countries is very important in this respect).
- Encouraging technology adaptation, and building on indigenous knowledge when possible and appropriate.
- Insuring and encouraging the effective participation of local communities, from the identification of options to the implementation of alternatives (e.g., Scolel Té Project, Mexico).

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