Forest carbon sequestration programs: Reviewing and assessing Mexican efforts

by

Araceli Vargas Mena Amezcua

Master of Science
International Institute for Aerospace Survey and
Earth Sciences. The Netherlands

B. Sc. in Biology
National Autonomous University of Mexico

Submitted to the Department of Urban Studies and Planning
in partial fulfillment of the requirements for the degree of

Master of Science

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 2003

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
JUN 1 8 2003
LIBRARIES

© 2003 Araceli Vargas Mena Amezcua. All Rights Reserved

The author hereby grants to MIT permission to reproduce and to distribute publicly paper and electronic copies of this thesis document in whole or in part

Author_______________ _______________
Department of Urban Studies and Planning
May 24, 2003

Certified by_______________ _______________
Professor Lawrence Susskind
Department of Urban Studies and Planning
Thesis Supervisor

Accepted by_______________ _______________
Professor Langley Keyes
Chair, MCP Committee
Department of Urban Studies and Planning

ROTCH

Forest carbon sequestration programs: Reviewing and assessing Mexican efforts

by

Araceli Vargas Mena Amezcua

Submitted to the Department of Urban Studies and Planning
on May 24, 2003 in Partial Fulfillment of the Requirements for the Degree of
Master of Science

Abstract

This thesis examines current efforts to sequester carbon dioxide in the forests in Mexico. A brief review of the most relevant examples worldwide is also included in order to explain the international context and introduce some key concepts. The decision regarding the desirability of pursuing carbon sequestration projects does not change when international considerations are included, as the local and national benefits are sufficient in and of themselves. Different efforts carried out in Mexico are described, analyzing the advantages and disadvantages of carbon sequestration, as well as the social, institutional and political barriers to the success of such efforts.

Special emphasis is placed on identifying a set of indicators that can be used to monitor and evaluate sequestration projects in the short and long run. It would be desirable to have standardized mechanisms to evaluate the success and failure of such projects worldwide. These indicators should identify major obstacles to and opportunities for improving the implementation of carbon sequestration in developing countries.

Thesis Supervisor: Lawrence Susskind
Head, Environmental Policy Group

Thesis Reader: Luisa T. Molina
Executive Director, Integrated Program on Urban, Regional and Global Air Pollution

Acknowledgments

I would like to acknowledge the financial and logistic support I have received from the Instituto Nacional de Ecologia, SEMARNAT in Mexico, the MIT Chancellor's Office and the Integrated Program on Urban, Regional and Global Air Pollution at MIT.

I also want to thank Professor Lawrence Susskind and Dr. Luisa T. Molina, my thesis supervisor and reader, respectively, for their valuable comments on earlier drafts of this thesis.

I want to express my gratitude to everyone who in one way or another provided information for this research, especially Julia Martinez and Aquileo Guzman Perdomo from the Instituto Nacional de Ecologia and Fernando Ruiz from the Consejo Civil Mexicano para la Silvicultura Sustentable, A.C.

Finally, I want to thank my colleague Armando Yañez. He was co-author of a joint seminar paper on which thesis draws heavily. I very much appreciate his support and friendship during our studies in the Mexico-MIT-Harvard Masters Program in Environmental and Health Management.

Table of Contents

Introduction

As environmental deterioration becomes an increasing concern to the majority of the human population, the search for different tools to reverse the negative trends and improve environmental conditions while balancing economic and social concerns, becomes more and more a priority. One tool with enormous potential to contribute to a transition to more sustainable development is carbon sequestration projects (CSPs).

This thesis addresses the issue of carbon sequestration, particularly in the case of Mexico, focusing on the actual situation of CSPs and how they can be assessed.

Specifically, the thesis has three main objectives:

- To review the state of the art of carbon sequestration programs, including the institutional frameworks under which they must operate.
- To analyze the Mexican experience with carbon sequestration programs, addressing their current status as well as what has proven successful and what are still the biggest obstacles to effective implementation.
- To explore a set of indicators that can be used to assist in the assessment of carbon sequestration programs in Mexico and, most importantly, in the identification of trends, obstacles, bottlenecks and programmatic features that need adjustment.

The thesis follows a simple two-part structure. The first part presents a general overview of the main concepts related to carbon sequestration including a presentation of the primary environmental concerns addressed by CSPs, the theoretical basis for these programs and the international framework within which they are operating.

The second part of the thesis focuses on the Mexican experience. It reflects on the opportunities, obstacles and limitations that define the current situation. It presents a review of the efforts underway in

Mexico and suggests a mechanism that can be used to evaluate the success of carbon sequestration programs in developing countries. Finally, there is a section with policy recommendations that grow out of my findings.

PART I. GENERAL OVERVIEW

1. Global Warming

1.1 Problem? What problem?

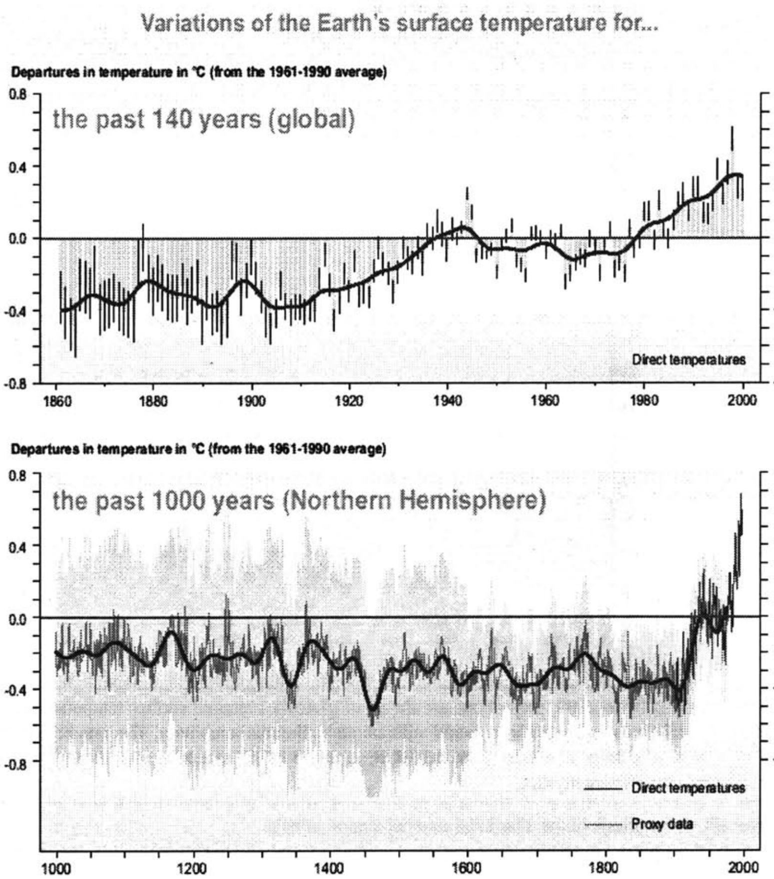
Even though public awareness for environmental issues has greatly improved in the last decade, there are still many aspects of environmental degradation that are not fully understood by the public at large and even some of the major risks are not regarded as important enough to do something about them. Experience has shown that there is a huge gap between scientific research and public understanding/action, especially when the specific environmental concern is not accompanied by a "shooting gun" or newsworthy environmental catastrophe or event to help open the eyes of the skeptics.

One such issue, that has put the scientific community on high alert and yet its true dangers are not fully perceived by civil society, is climate change. Evidence that global climate change is occurring is mounting everywhere, more and more science is at a consensus that the problem exists and it is only bound to get worse. Very severe droughts, floodings and other extreme weather events are some of the signs. However, people just don't seem to understand what this truly means.

Fortunately, the scientific evidence has been explained in detail by knowledgeable authors and institutions, most notably the IPCC, thus we will not present all the facts in detail but rather would refer the reader to such instances. Additionally, since apparently the mere presentation of the scientific evidence has not been enough to effectively communicate the risk at hand, we will try to sketch its magnitude through a few arguments that can shock anyone into realizing that climate change is occurring and the extent of its implications.

First, the fact that nine out of the ten warmest years have occurred since 1990 is simply astonishing. Temperature has been formally measured for 146 years since 1856, thus this fact cannot be attributed on chance alone. If global temperature was a random occurrence the probability of having 9 of the 10 warmest years practically together would be almost zero! Something has to be going on! The trend of Earth's surface temperature can be seen in the following graphs.

Figure 1. Earth's surface temperature

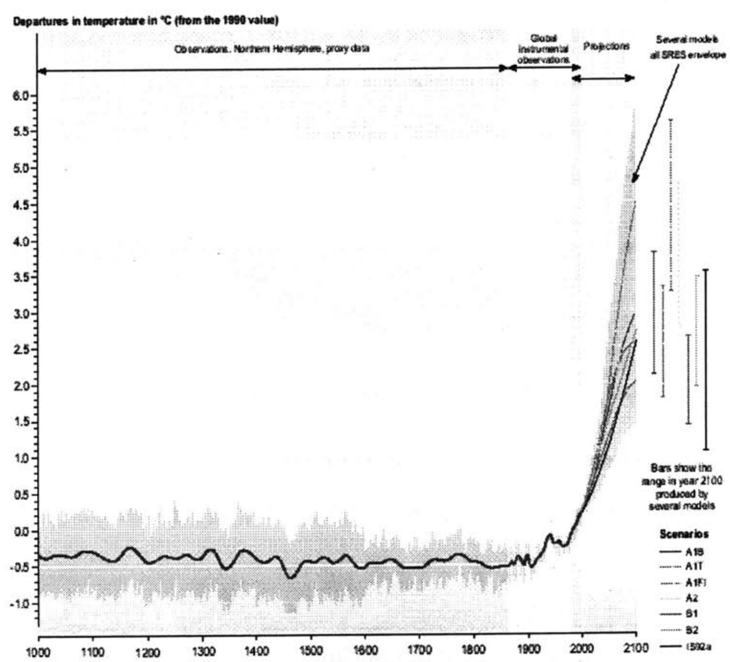


The Earth's surface temperature has increased by about 0.6°C over the record of direct temperature measurements (1860-2000, top panel) – a rise that is unprecedented, at least based on proxy temperature data for the Northern Hemisphere, over the last millennium (bottom panel).

Source: IPCC, Synthesis of the Third Assessment Report, 2001.

It is indeed remarkable that, in the last century, global temperature has already increased by about 0.6°C and all of IPCC forecasting scenarios (both optimistic and pessimistic) project that global temperature will keep on rising. By 2100 global average temperature could rise anywhere from around 1.5 to 6 degrees Celsius (figure 2)! This might not sound like much, yet the shivers come when you realize that prior to this rise, global average temperature remained relatively stable for about 10,000 years and the global average temperature at the time of the last Ice Age was only about 5°C colder. In some scenarios we are looking at a climate change even bigger than that of the Ice Age which was responsible for the lost of thousands of species!

Figure 2. Projections of the Earth's surface temperature to 2100



Over the period 2000 to 2100, projections are shown of globally averaged surface temperature or the six illustrative SRES scenarios and IS92a as estimated by a model with average climates sensitivity. The gray region "several models all SRES envelope" shows the range of results from the full range of 35 SRES scenarios in addition to those from a range of models with different climate sensitivities.

Source: IPCC, Synthesis of the Third Assessment Report, 2001.

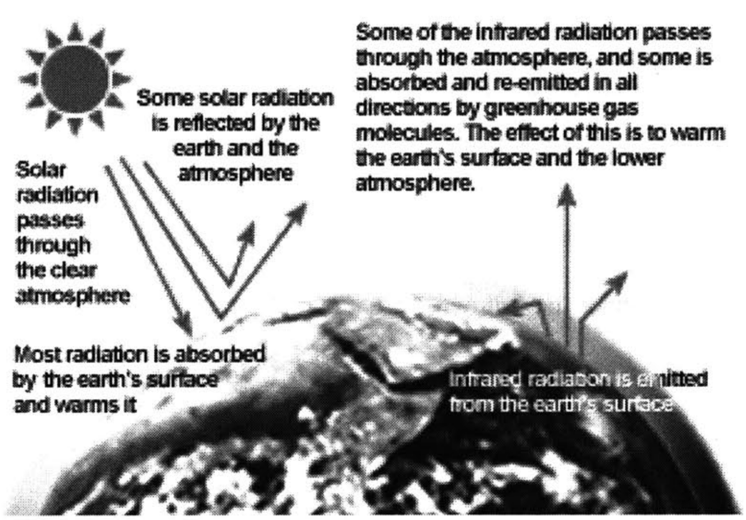
Additionally, just by looking at the trends it can be seen that the rising of temperature matches almost perfectly with the growth of human activity, particularly industrialization (this can also be seen in figure 4).

We, human beings, seem to effectively be the main cause of the problem. But what exactly is going on?

1.2 CO_2 and the causes of global warming

According to scientists global warming is a consequence of the accumulation of gases that create a "green house" effect thickening the natural canopy of gases in the atmosphere and causing more heat to become trapped. EPA offers a clear and simple explanation of this phenomenon (figure 3): "Energy from the sun drives the earth's weather and climate, and heats the earth's surface; in turn, the earth radiates energy back into space. Atmospheric greenhouse gases (water vapor, carbon dioxide, methane, nitrous oxide, and ozone) – which occur naturally in the atmosphere – trap some of the outgoing energy, retaining heat somewhat like the glass panels of a greenhouse. Without this natural "greenhouse effect," temperatures would be much lower than they are now, and life as known today would not be possible."

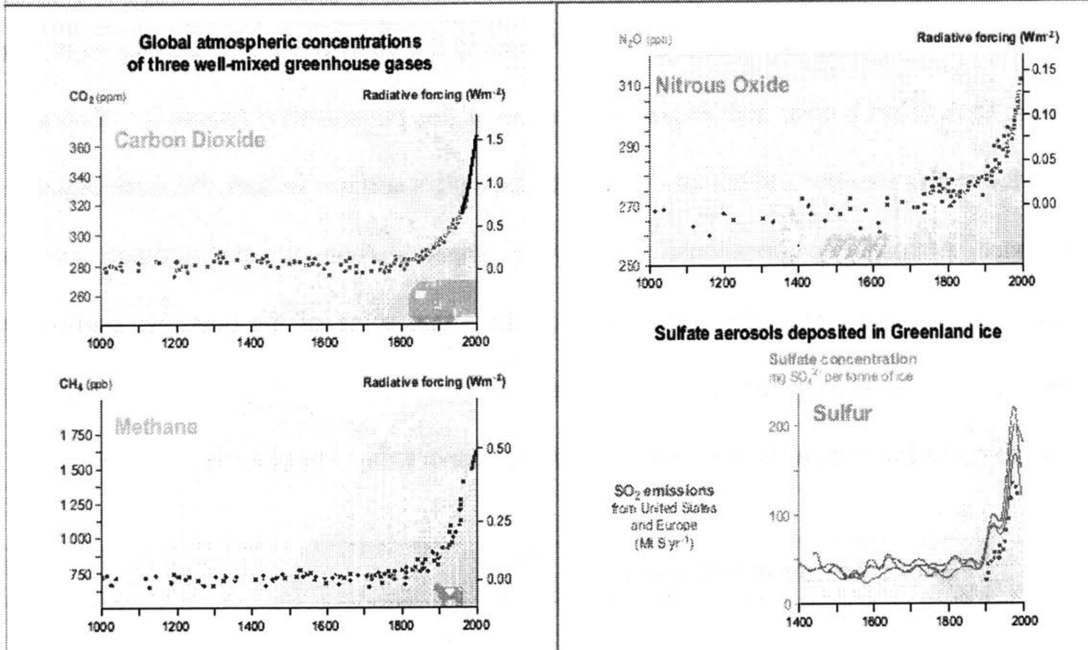
Figure 3. The greenhouse effect



Source: US Environmental Protection Agency, Website accesed March 2003.

Even though the greenhouse effect is a natural phenomenon, problems may arise when the atmospheric concentration of greenhouse gases increases. We mentioned before that these increases are substantially happening due to human activity thus they are enhancing the heat-trapping capability of the earth's atmosphere resulting in global warming. Evidence of the increase of atmospheric greenhouse gases due to human activity can be seen in the following figure.

Figure 4. Indicators of human influence on the atmosphere during the industrial era



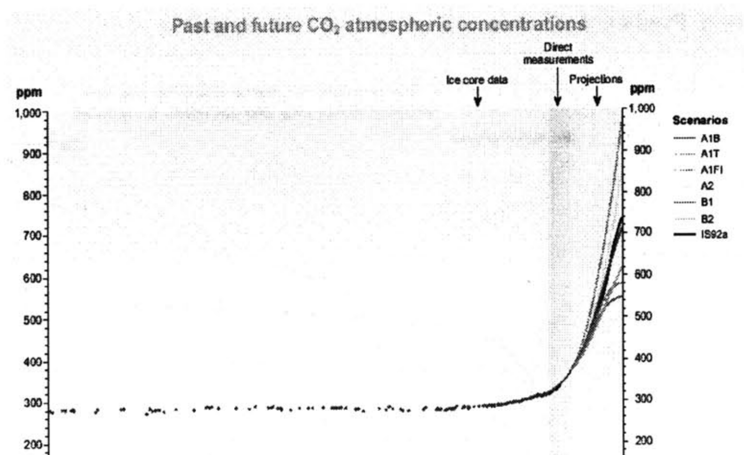
Records of past changes in atmospheric composition over the last millennium demonstrate the rapid rise in greenhouse gases and sulfate aerosols that is attributable primarily to industrial growth since 1750.

Source: IPCC, Synthesis of the Third Assessment Report, 2001.

It could be argued that there are already huge levels of natural occurring greenhouse gas emissions. However, one must consider the following argument: "Plant respiration and the decomposition of organic matter release more than 10 times the CO_2 released by human activities; but these releases have generally been in balance during the centuries leading up to the industrial revolution with carbon dioxide absorbed by terrestrial vegetation and the oceans" (EPA, 2003). Industrialization has thus broken this natural balance through the additional release of carbon dioxide and other greenhouse gases by human activities. Fossil fuels burned to run cars and trucks, heat homes and businesses, and power factories are responsible for most of the world's carbon dioxide emissions, and an important fraction (about 20%) of methane and nitrous oxide emissions. Increased agriculture, deforestation, landfills, industrial production, and mining also contribute a significant share of emissions.

Regarding the relative contribution of the different greenhouse gases to global warming, it is generally agreed that the most important greenhouse gas is CO_2 (Schneider, 1989; Houghton and Woodwell, 1989; Goudie, 1990; Dixon et al., 1994). It has even been estimated that about 71.5% of the greenhouse effect is due to CO_2 (Lashof and Ahuja, 1990). Humans are responsible for must of the excess of CO_2 by burning fossil fuels for energy and transport and land use change, particularly deforestation, thus pumping billions of tones of carbon dioxide into the atmosphere. The current level of concentrations (as measured in the pole) is much higher than ever in the existence of humans (130,000 years ago) and, according to IPCC (figure 5), carbon levels could be, by the year 2100, the highest in the history of the planet since 30 million years ago.

Figure 5. Past and future CO_2 atmospheric concentrations



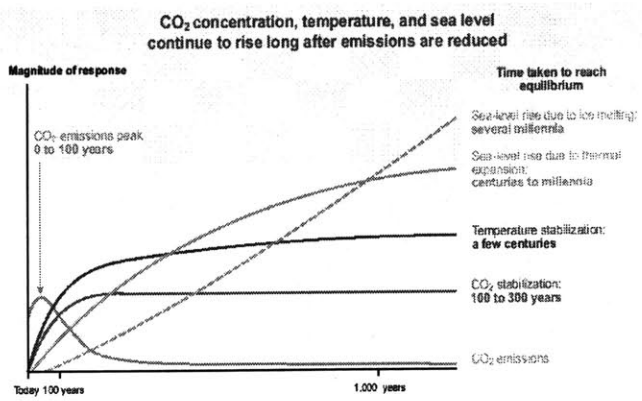
Observations of atmospheric CO_2 concentration over the years 1000 to 2000 from ice core data supplemented with data from direct atmospheric measurements over the past few decades. Over the period 2000 to 2100 projections are shown of CO_2 concentrations based on the six illustrative scenarios and IS92a used by IUCN.

Source: IPCC, Synthesis of the Third Assessment Report, 2001.

1.3 How can we fix the problem

The first thing that comes to mind when thinking on solutions to the problem is to get rid of the excess greenhouse gasses that are causing global warming. This, as most things in life, is easier said than done. It is true that, in principle, reducing GHG concentrations in the atmosphere would eventually result in lower temperatures but this would not happen even in the middle term as global warming and its effects would continue for a while. Additionally, we cannot simply reduce concentrations as they depend on multiple factors, many of which are beyond human control. What we can definitively control is the level of GHG emissions that are due to human activities, and even some of the naturally occurring ones. Unfortunately, even if we were able to cut all anthropogenic GHG emissions concentration levels would still not decrease immediately and would remain, at best, mostly constant. The following figures further illustrate these dynamics for the case of CO_2, which is the relevant gas for the purposes of this study.

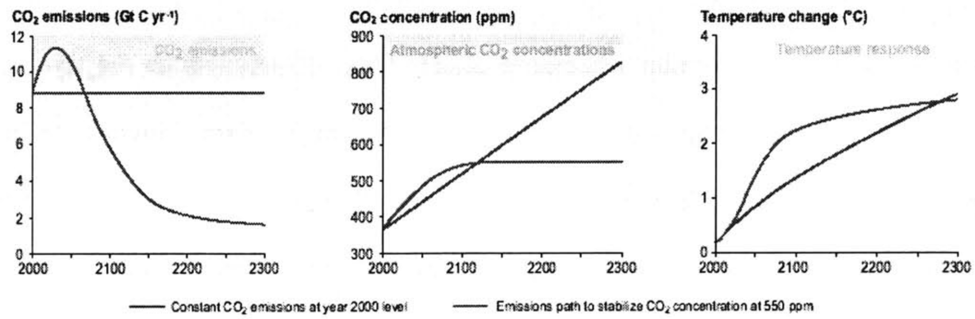
Figure 6. Predicted effects of reductions on CO_2 emissions



After CO_2 emissions are reduced and atmospheric concentrations stabilize, surface air temperature continues to rise by a few tenths of a degree per century or more. Thermal expansion of the ocean continues long after CO_2 emissions have been reduced, and melting of ice sheets continues to contribute to sea-level rise for many centuries. This figure is a generic illustration for stabilization at any level between 450 and 1,000 ppm, and therefore has no units on the response axis. Responses to stabilization trajectories in this range show broadly similar time courses, but the impacts become progressively larger at higher concentrations of CO_2.

Source: IPCC, Synthesis of the Third Assessment Report, 2001.

Figure 7. Impact of stabilizing emissions versus stabilizing concentrations of CO_2



Stabilizing CO_2 emissions at current levels will result in a continuously rising atmospheric CO_2 concentration and temperature. Stabilization of atmospheric CO_2 and temperature change will eventually require the emissions to drop well bellow current levels. In all three panels the red curves illustrate the result of emissions held constant at the level prescribed by the WRE 550 profile for the year 2000 (which is slightly higher than the actual emissions for the year 2000), while the blue curves are the result of emissions following the WRE 550 stabilization profile. Both cases are illustrative only.

Source: IPCC, Synthesis of the Third Assessment Report, 2001.

Taking this into account, we realize that emission control/reduction policies face a discouraging future, especially if they are used as the only tool. On the one hand, stabilization of CO_2 emissions would still result in rising CO_2 concentrations and temperature. On the other, emissions reduction, or even elimination, would take a long time to stabilize concentrations and temperature at current levels, not to mention to drop them to their pre-industrial levels. Emissions control policies focus on "not making the problem worse" but do not address the idea of "repairing" the harm that has already been done.

"Repairing the damage" would mean to decrease the GHG atmospheric concentrations and reduce global temperature back to their pre-industrial levels. In order to do this we need policy measures that make use of sustainable mechanisms that either destroy the excess GHG in the atmosphere or "capture" them into natural reservoirs. The first option has the potential of resulting in even more problems, as we still need to learn a lot about the atmospheric properties of the many compounds that would be involved. However, very clever techniques have been developed to address the second alternative. Probably the most promising technique to complement the emission control policies is carbon sequestration. The following sections will present a detailed description of this technique and an assessment of its feasibility in different scenarios.

2. What is carbon sequestration?

Research on carbon sequestration schemes is closely linked to research on the value of the ecological functions of natural ecosystems, the first being an important effort to try to protect the latter. Even though the concept of the carbon cycle in nature and the carbon absorption capacity of soil and oceans have been known for a long, long time, it was not until 1976 that the notion of forests as carbon storehouses of fossil fuel emissions was first proposed (WRI, 2001). Restored interest on this ecological function of terrestrial ecosystems occurred as researchers and public managers started to understand the true total value of nature and focused on developing schemes to conserve and restore such value.

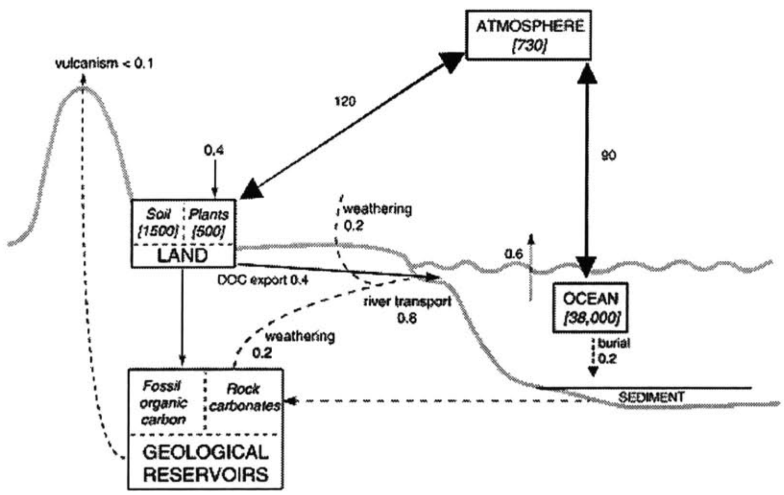
Acknowledging this relationship, Annex 1 briefly presents the rationale behind the existing methodologies for assessing the value of nature in an effort to provide a solid background for the discussion and understanding of carbon sequestration schemes. It is strongly recommended to keep the concepts and components of total value of nature in mind while reading this study, as we think that it is very important, particularly for policy making, to be aware of all sources of nature value and how they relate to each other. This in turn can help to understand the trade-offs and synergies between different policy measures.

We can sum up Annex 1 through the Total Economic Value (TEV) model presented there. It says that TEV is equal to the sum of the direct use, indirect use, option and existence values of nature. When we talk about carbon sequestration we are then talking about one of the many indirect use values of ecosystems, also known as ecological functions. Roughly speaking, carbon sequestration refers to the ability of ecosystems to act as natural reservoirs of carbon. The following sections present the scientific basis of this ecological function as well as an overview of the policy tools that have been designed to take advantage of the sustainable management of this indirect use value.

2.1 The carbon cycle

To understand how carbon sequestration works, one must first understand the carbon cycle in nature and the ecological processes involved. Carbon is everywhere in nature. It is dissolved in water (carbonates), solid in soil, as a gas in the air, and all living organisms have carbon compounds (about 50% of their dry-weight is carbon! – Smith et al., 1993). The following diagram presents the carbon cycle, its main components and estimations of their relative importance (carbon contents) in the process.

Figure 8. The natural carbon cycle



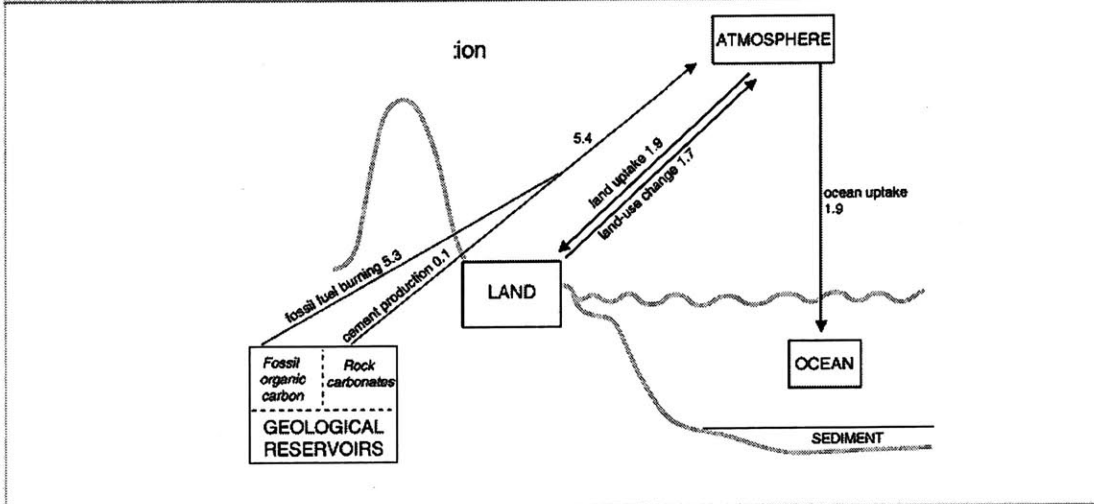
The global carbon cycle: storages (PgC) and fluxes (PgC/yr) estimated for the 1980s. The thick arrows denote the most important fluxes from the point of view of the contemporary CO_2 balance of the atmosphere: gross primary production and respiration by the land biosphere, and physical air-sea exchange. These fluxes are approximately balanced each year, but imbalances can affect atmospheric CO_2 concentration significantly over years to centuries. The thin arrows denote additional natural fluxes (dashed lines for fluxes of carbon as $CaCO_3$), which are important on longer time-scales. The flux of 0.4 PgC/yr from atmospheric CO_2 via plants to inert soil carbon is approximately balanced on a time-scale of several millenia by export of dissolved organic carbon (DOC) in rivers (Schlesinger, 1990, in IPCC, 2001). A further 0.4 PgC/yr flux of dissolved inorganic carbon (DIC) is derived from the weathering of $CaCO_3$, which takes up CO_2 from the atmosphere in a 1:1 ratio. These fluxes of DOC and DIC together comprise the river transport of 0.8 PgC/yr. In the ocean, the DOC from rivers is respired and released to the atmosphere, while $CaCO_3$ production by marine organisms results in half of the DIC from rivers being returned to the atmosphere and half being buried in deep-sea sediments - which are the precursor of carbonate rocks. Also shown are processes with even longer time-scales: burial of organic matter as fossil organic carbon (including fossil fuels), and outgassing of CO_2 through tectonic processes (vulcanism). Emissions due to vulcanism are estimated as 0.02 to 0.05 PgC/yr (Williams, 1992 and Bickle, 1994, in IPCC, 2001).

Source: IPCC, Synthesis of the Third Assessment Report, 2001.

The figure implies the understanding that there are both natural emission sources of carbon (i.e. animals, volcanoes, decalcification) as well as natural carbon reservoirs (i.e. oceans, forests, soil) and uptake mechanisms (i.e. photosynthesis, ocean mixing). Throughout time all of these tend to a balanced equilibrium.

Unfortunately this is not the whole story. As it was mentioned before, this natural cycle is affected by human activities as illustrated in the following figure.

Figure 9. Human perturbation to the natural carbon cycle



Fossil fuel burning and land-use change are the main anthropogenic processes that release CO_2 to the atmosphere. Only a part of this CO_2 stays in the atmosphere; the rest is taken up by the land (plants and soil) or by the ocean. These uptake components represent imbalances in the large natural two-way fluxes between atmosphere and ocean and between atmosphere and land.

Source: IPCC, Synthesis of the Third Assessment Report, 2001.

Roughly, we can describe the carbon cycle and current balance like this: carbon sources include fossil fuels that contribute about 5.5 GT C/year and deforestation that contributes approximately 1.5 GT C/year. Carbon sinks can take up approximately 4 GT C/y. The terrestrial biosphere absorbs approximately 2 GT C/y (through photosynthesis), and the oceans absorb ~2GT C/y. Everything is interrelated (i.e. soil and ocean absorption of CO_2 may decrease with warming). The excess of ~3 GT C/y accumulates in atmosphere each year and has changed atmospheric levels from what they have been for over 420,000 years.

Another important aspect of these processes is time. All of the processes occur in parallel, influencing each other. However the processes have widely differing time scales. Actually, according to IPCC, the net terrestrial carbon uptake that has developed over the past few decades is partly a result of the time lag between photosynthetic carbon uptake and carbon release when plants eventually die and decay. This dynamic is an important thing to keep in mind to better design policy options. For example, "the uptake resulting from the re-growth of forests on agricultural lands, abandoned over the last century in the Northern Hemisphere, will decline as forests reach their mature biomass, growth slows, and death increases" (IPCC, 2001). That is, time scales of the different processes must be taken into account both when planning policy and when it is being implemented.

After talking about the overall carbon cycle and the effects of human activity, we need to take an extra step before fully focusing on carbon sequestration policy options. The carbon sequestration instruments that are currently feasible[1] focus only on one sub process of the carbon cycle in nature: terrestrial sequestration, more specifically on carbon sequestration by forests ecosystems. These methodologies built on the idea that it has been estimated that, through effective conservation and reforestation strategies, forests could become net carbon sinks, amounting to a 20 to 50% reduction of net CO_2 atmospheric emissions (IPCC, 1995). These mechanisms also treat the forests as whole ecosystems (not just trees) recognizing the fact that about two thirds of the carbon in forest ecosystems is contained in the forest soil (Dixon et al, 1994).

The role of carbon in forest ecosystems can be roughly described as follows: Vegetation (plants and trees) incorporates CO_2 to their metabolism through photosynthesis. Carbon is a fundamental part in the composition of all the structures of vegetation (leaves, branches, roots, stems, etc). Vegetation takes up CO_2 as it is growing. Organic "wastes" of vegetation (dead leaves, branches and other organic matter) degrades into stable humus in the forest soil. During the time that the carbon is part of a forest structure (such as trees, plants, wood products, stable humus, unused fossil fuel, etc) it is considered a stock (sequestered carbon). When it is released to the atmosphere as a result of biomass burning or degradation (decomposition) it is considered a flow.

---

1 Current strategies to artificially enhance ocean carbon sequestration are fertilization of phytoplankton with micro- or macronutrients and direct injection of CO2 to ocean depths greater than 1000 meters. However, besides their cost and complexity, the long-term effects are unknown (US DOE, website, 2003).

Summing up, terrestrial carbon sinks refer to the carbon contained in the forest ecosystems (in vegetation, organic matter – including decomposed organic matter –, soil) and their products (wood and non-wood products, unused fossil fuel, etc). Analogously, carbon flows relate to degradation of both forest ecosystem as well as its products.

2.2 What are carbon sequestration programs?

Carbon sequestration programs are policy tools that were designed to take advantage of the ecological processes mentioned in the previous section in favor of environmental protection and pollution mitigation, namely the combat of climate change. But what are carbon sequestration programs?

There are two underlying ideas behind the concept of carbon sequestration programs:

- That the economic growth/activities, even if extremely efficient, cannot be achieved at a zero-emission level.
- That there are different activities that can be undertaken to lower atmospheric concentrations of carbon (thus helping the climate change cause).

The lower concentrations can be a result of either the avoidance of potential emissions (i.e. forests that are not burned) or the actual intake of atmospheric concentrations of carbon (absorption into a natural reservoir through vegetation/ecosystem growth).

From this, we can understand carbon sequestration programs as a way to offset the necessary (and even the unnecessary) carbon emissions of economic activities through the development/support of projects that result in the sequestration of atmospheric carbon or that protect the Earth's carbon reservoirs (thus avoiding potential emissions). If you are a carbon emitter, you can make up for the harm you are doing by undertaking carbon sequestration projects that make you a net carbon capturer.

There are, at least theoretically, many different types of carbon sequestration projects. However, this thesis focuses solely on forest carbon sequestration projects, which are potentially more feasible due to their low cost and high number of secondary benefits. Among these, we can roughly say that there are four main categories: afforestation, reforestation, conservation and sustainable forest management.

Reforestation projects refer to the establishment of trees on land that recently had a tree cover. Afforestation projects also refer to the establishment of trees but on land that has been without forest for a long time. Conservation projects refer to the protection of existing forests that already act as carbon reservoirs. This project is very effective because it both prevents the release of emissions from deforestation while enabling additional absorption of existing emissions. Finally, sustainable forest management projects include activities such as forest regeneration, forest fertilization, fire management, management of harvest quantity and timing, reduced forest degradation and reduced impact logging.

Undertaking any of these carbon sequestration projects would result in emission "savings" that could in turn be used to offset actual carbon emissions from economic activities. But how would this work in practice?

Making the jump from the theoretical to the practical plan is never an easy step. The first thing that is very clear is that undertaking a carbon sequestration program would most likely imply the interaction of different actors. If we think in a micro scale, it is easy to imagine that the people that undertake the carbon sequestration projects might not be the same that pollute. Meanwhile, polluters might be willing to support carbon sequestration projects but might not be in the best position to undertake them. Polluters and capturers would need to interact and, in order to do so, there would be a need to have clear rules for the interaction and ways to measure the "exchanges" being made.

Carbon sequestration programs need an adequate legal and institutional framework as well as a market (including a money-like instrument) for emission transactions to take place. Some countries are already underway to developing these requirements achieving different results related to their own sociopolitical systems.

The same arguments made for the micro level can be applied to an international level of interaction between polluters and capturers in the context of the interaction among countries. Accordingly, rules and tools need to be set up and the better this is done, the higher the chance of success the programs will have. The following sections of the study focus on carbon sequestration programs with the broad international context in mind (this does not mean that we will focus solely on international projects).

3. International background for carbon sequestration programs

Even though it is easy to imagine carbon sequestration programs at the micro level, one must be fully aware that the dynamics of the concept extend beyond this level and do not respect the different political boundaries (i.e. local communities, states, nations). However, design and implementation of CSPs should be fully aware of the existence of such boundaries and the different opportunities and restrictions related to each of them. Accordingly, we decided to briefly touch upon these contexts and their impact on CSPs design and implementation. The immediate levels (local, state and national) will be addressed specifically in the case study of Mexican CS efforts. Some of the major aspects, relevant to CSPs, at the international level will be briefly presented in this section to understand the major dynamics of this context and to present some important concepts of the implementation of CSPs.

Unlike other instruments, CSPs have the innate characteristic of being, at the same time, both a global impact and integral policy tool. Because of this particularity, when thinking on the international context of CSPs it is important not only to think on how current international dynamics and institutions may impact CS efforts but also on how these efforts can impact the international arena. Understanding this and the relative advantages and disadvantages of countries will enable to open new windows of opportunity to deal with the many issues of the international scene. Failure to do so could not only mean that we would be passing on an opportunity but that we could be contributing to making the problem worse.

To illustrate some of these dynamics let' reflect upon a few arguments related to the existing North-South inequities. Climate change is bound to have an effect on many parts of the planet. However, these effects will not be the same in different places and some places are more vulnerable than others and their adaptive capacity also differs. The North's adaptive capacity is generally much better than the South's capacity. The North is better prepared for change and has more resources and know-how to adapt. Thus, climate change might contribute further in the already rising inequities between North and South.

Meanwhile, income inequity can lead to environmental destruction for several reasons. This is particularly scary since inequity is already very high and has an increasing tend over time. Nowadays, about 20% of the world's population control about 87% of the world's resources. This means that the poor are many and the resources that they can use are less and of less quality. Income inequality means that a lot more are competing for a lot less. This can only result on an unsustainable stress on the resources that are left for the poor. Evidently, this argument applies to North and South inequalities. As the South gets poorer they are forced to live of the environment in more disruptive ways.

Finally, it could be argued that a driving force that is increasing both North/South inequalities and environmental degradation is globalization. For instance, the trade benefits of globalization stay mostly in the elite thus contributing further to increasing inequalities. The materials and wealth that are actually traded are extracted from the country, put in the hands of the elite, who keeps profits and not reinvesting them (giving it back to where they were extracted from) results in concentration of capital in a few hands and under-investment in natural capital thus environmental degradation. In a sense globalization perpetrates the capitalist model (and its inherent market failures!), which has proven to be environmentally unsustainable. This basically means that if we do not implement measures to make it sustainable, globalization will increase inequalities that will in turn result on further environmental degradation (thus accelerated climate change) closing a vicious cycle between inequity, environmental degradation, climate change and adaptability.

The point that is trying to be made with all these arguments is that it makes sense to deal with the issue of climate change with an international perspective and, by doing so, take advantage of the opportunity to link many topics that have traditionally been dealt with separately with limited success. Carbon sequestration programs offer an opportunity to link international issues on environment, society and economics, making it possible to better exploit the differences that countries have regarding these dimensions. This creates values by widening the range of options available for international negotiators.

3.1 Carbon sequestration and the UN Convention on Climate Change

At the international level, the United Nations Framework Convention on Climate Change (UNFCCC) is the tool better positioned to foster the use of these opportunities and the potential linkages. Formally, the goal of the Convention is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (article 2).

Fortunately, UNFCCC addresses both of the theoretical options to combat climate change: emission controls and removals by sinks. On one hand, it calls on countries to reduce their GHG emissions to 1990 levels. On the other hand, it states that the parties to the convention should "promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems" (article 4.1d).

An important concept related to carbon sequestration programs and UNFCCC is joint implementation (JI). It recognizes the fact that countries can work together to collectively reduce GHG emissions or promote sequestration. The underlying idea was that countries investing in these sort of projects, regardless of where they actually took place, could claim emission reduction credits that would in turn offset the country's total amount of GHG emissions (subtracted from the total). This would offer the possibility of undertaking projects in a more efficient way (i.e. where costs are lower, or where benefits are higher). Unfortunately these credit system was not officially endorsed by UNFCC.

A related concept is what is called Activities Implemented Jointly (AIJ), which refers to JI projects initiated during a pilot phase. Countries participating in AIJ projects were given the possibility of retroactive credit awarding once (and if) the credit system became official. Both the JI and AIJ concepts resulted in a variety of voluntary commitments waiting, and pressuring, for the credit system to become official.

While the open credit system has not been officially endorsed, the pressure from voluntary commitments has resulted, through the Kyoto Protocol, in four "flexibility mechanisms" with the same underlying principle but subject to certain restrictions. These are: bubbles (allowing groups of countries to trade emission credits among themselves), emissions trading (allowing countries with excess emission reduction units to trade), joint implementation (for annex B countries), and clean development mechanisms (CDM).

3.2 Description of selected international programs

In this section we offer a brief review of selected international projects. It is not intended to be exhaustive, but rather provide an overview of different efforts done around the world concerning carbon sequestration as a way to offset GHG emissions.

There is currently a wide variety of carbon sequestration projects with different objectives and source of funding. Although all of them are based on the same idea of increasing/protecting the stock of carbon stored in vegetation, the mechanisms to achieve such aim may differ and are related to those presented in the previous section.

Some of the early carbon sequestration projects such as the Reduced Impact Logging Project in Malaysia and CARE/Guatemala were based on bilateral agreements between private companies seeking to offset their greenhouse gas emissions and an implementing agency (WRI, 2002), but more recent projects have moved to investors pools project portfolios such as those offered by Costa Rica and Scolel Té project in southern Mexico. This change in strategy might be related with the risk of failure of the projects.

There are 19 projects reported by the United Nations Framework Convention on Climate Change (UNFCCC) in its web page which have been accepted, approved or endorsed by the designated national authorities for activities implemented jointly (AIJ) of the Parties concerned (Annex 2). Countries are encouraged to have their projects accepted, approved or endorsed by the governmental authority in each country, and to report them to the COP through the secretariat in order to offset the CO_2 for their GHG reduction commitment.

Out of those projects, 14 are carried out in Latin American in countries such as Mexico, Costa Rica, Chile, Argentina, Belize, Ecuador and Panama; 2 in Russia, 2 in Asia (Indonesia and Vietnam) and one more in the Czech Republic. The Annex 1 countries acting as partners in these projects are the United States of America in 16 projects, Norway, Netherlands and Australia.

These projects include a wide range of management practices, from strict protection of the forest, to afforestation using tree species and others like halophyte shrubs cultivation in the coast of Mexico. Within this range, agroforestry, agriculture and sustainable forests management can also be found in combination with the former modalities.

The cost of the projects, their duration and their GHG impact measured in CO_2 equivalent in metric tons also varies depending on the area included in the project and the type of practices carried out. In terms of GHG impact, the most ambitious project reported in this list is the Territorial and Financial Consolidation of Costa Rican National Parks and Biological Reserves with 57,467,261 CO_2 metric tons with a lifetime of 25 years.

This project intends to transfer the administration of forest, secondary forest and pasture land that has been declared National Park, to the Ministry of the Environment of Costa Rica in order to prevent further degradation by the current owners. By doing this, the carbon already contained in the forest will be preserved and sequestration will be incremented with secondary vegetation. As part of the project, a multidisciplinary development will be established to promote environmental education an eco-tourism in the area.

Another interesting project (considered as "pilot") is the Scolel Té in Southern Mexico. The project is trying to develop a model that could be applicable in similar regions of Mexico and Latin America. It aims to ensure the long-term success of carbon sequestration programs in systems that are economically viable and socially and environmentally responsibly. The project comprises 13,000 has in two indigenous communities and aims to have a GHG impact of 1, 210,000 CO_2 metric tones in 30 years. The project is presented in better detail in the specific chapter about the Mexican efforts on Carbon Sequestration.

The Forest Rehabilitation program in Krkonose National Parks in the Czech Republic is an example of the kind of environmental problems that European countries in transition are currently facing. This Park is located in the border with Poland and the former German Democratic Republic. The area has suffer severe damage by the intense acid deposition, and as result, the trees in about 16,000 have died or are severely damaged. In order to reverse that situation, a Dutch foundation called FACE (Forest Absorbing Carbon dioxide Emissions) and the Czech government have signed an agreement to afforest the area with the scientific advice of Dutch Universities. Their goal is to have a GHG impact of 9,834,120 CO_2 metric tones in 15 years.

Organizations like FACE are supporting Carbon Sequestration projects in Africa, Asia, Central Europe, Latin America and The Netherlands.

An organization called CTrade follows and reports different projects, some of them approved by the US Initiative in Joint Implementation. A summary table is provided in Annex 3.

World Resources Institute is also involved in the design and monitoring of some of these projects. Besides the programs implemented jointly between developing and developed countries, WRI reports those carried out in developed countries like the United States where electricity supplier companies have made contracts with forestry companies to offset their CO_2 emissions. In some cases, also Universities and governmental agencies are involved in order to provide advisory and meet environmental regulations while pursuing the emissions reduction goal. WRI reports 7 of this type of projects in states like Oregon and Louisiana, with a total of carbon sequestered over the lifetime of the projects of more than 1,250,000 metric tones.

PART II. CASE STUDY OF MEXICO

4. Are carbon sequestration programs a good idea in Mexico?

Without pretending to underestimate importance to the international issues presented in the previous section, we contend that the decision to whether undertake CSPs or not, does not need to wait for the international community to set its mind. Furthermore, we believe that the happenings of the international scene do not change the conclusion about the justification of undertaking these programs. In other words, why is it that despite the lack of success to internationally establish an open emission-credit system/market, there are so many CS efforts underway? Besides UNFCCC and international issues, what makes CSPs attractive and what doesn't? This section addresses exactly this issue focusing on the Mexican CS experience.

Mexico is among the five more diverse countries in the world (Mega-diverse) regarding ecosystems, species and genetic diversity. This might be considered as a privilege but also as a challenging responsibility to preserve such natural treasure.

I previously discussed about the many sources of value that are linked to natural resources, and particularly to forest ecosystems (see Annex 1). This is obviously no different in the case of Mexico. Besides biodiversity, Mexican forests provide different environmental services, ranging from soil conservation, wood and non-wood products, climate regulation and recreational activities (Massera, 1997). It is straightforward to realize that, all other things being equal, the protection of this total value is a desirable thing and is the backbone of all conservation policies.

Many efforts have been done in the last decades to develop different mechanisms and policies to protect and use in a sustainable way, the enormous amount of the forests remaining in the country. Still, social and economic circumstances have been pushing farmers to use and in many cases deplete the soil and forests in order to make their living, either as subsistence economy or for market oriented production.

Thus, when considering the limited success of environmental conservation and protection policies in Mexico, CSPs offer a new opportunity to be considered in policy design and implementation. Taking into account both the inherent features of CS projects and the Mexican institutional, socio-economic and legal context we are bound to found diverse opportunities and obstacles related to the use of CSPs. This section of the thesis presents a reflection on some of the major benefits and obstacles that we foresee, grouping them into three main categories: environmental, socio/economic and institutional. It is important to note that even though the review focuses on Mexico and some of the aspects considered are specific to the country, many reflect an international or regional situation.

4.1 Opportunities

Environmental

This category can be grouped in direct and indirect benefits being the first obviously those directly related with the Carbon sequestered and those that result from the practices in place by the project.

The direct benefits of CSPs and the main argument used for their implementation is, of course, the actual carbon sequestered as consequence of reforestation, afforestation, conservation or sustainable forest management (i.e. agro-forestry, commercial plantations), as well as forest natural regeneration. As it was mentioned before, this direct impact not only refers to the carbon sequestered from the atmosphere but also to the potential CO_2 emissions that are prevented by stopping/reducing deforestation.

There are also many indirect benefits linked to CSPs, which might even exceed the environmental value of carbon sequestration. These benefits depend on the specific type of project in place and related activities. For example, when the project area is a Natural Reserve and the strategy is to preserve natural forest, biodiversity conservation and environmental functions like soil and watershed protection become good reasons to embrace this type of project.

In other words, the environmental benefits of CSPs far exceed those related to carbon sequestration and are related to the many ecological functions that are preserved as an indirect result of the program implementation. The consideration of this additional value preserved could be an important factor to approve wider use of CSPs and to foster the integral approach that these sorts of projects promote. Unfortunately, assessing these values has not been easy and is subject to the available technology, information and resources.

A good idea to assess the potential value of CSPs related to these indirect effects is to think about the magnitude of the problems they would contribute to reduce. However, assessing deforestation rates and land use changes in the country has been a tough task since contradictory studies and methodologies have produced different outcomes. Nevertheless, we can quote the latest report by the National Institute of Ecology, based on a study carried out by the National Autonomous University of Mexico, which concludes that the most reliable information regarding deforestation at national level comprises a period of 24 years (1976-2000). The annual deforestation rate identified for the period is 545,000 hectares (Velázquez, A. J. F. Mas & J.L. Palacio, 2002).

Another important figure, according to Ordoñez (1999), based on Gay, C & Martinez, J. (1995), is that by 1995, 25% of the greenhouse gas emissions of the country were produced by land use changes and forestry. Because of this situation, the Commission for Environmental Cooperation (CEC) has stated that Mexico's forests might be considered currently more as a source of net carbon emissions to the atmosphere than sinks to capture greenhouse gases (CEC, 2001).

The bottom line however is that, despite the high deforestation rates in the country, there are still huge natural forest areas with a substantive potential to contribute to offset national and international greenhouse gasses emissions by encouraging CS projects in the country.

Socioeconomic

Social contribution of CS projects to developing countries like Mexico might be considered even more attractive than their environmental benefits.

Pursuing better living conditions for the farmers by providing feasible farming alternatives and new skills is always a challenging goal, which could be achieved with the establishment of CS projects. The learning experience can allow farmers to improve their skills in farming their land in a sustainable way and to acquire technical knowledge unavailable to them otherwise.

For those projects established in Natural Reserves and/or communitarian or "ejidal" land, the income provided either directly by the investor, or derived from their produce sales could make a huge difference in their living conditions, preventing also their migration for economic reasons.

A common problem linked with the history of conservation policies in Mexico was that controls/limitations on natural resource exploitation was not accompanied with the promotion and support for alternative activities for the people directly affected by the restrictions on land use. This had a direct negative effect on the sustainability of such policies as the people always had the incentive to go back to the restricted forms of resource exploitation, and they did so either by pressuring the government to lift restrictions or by recurring to illegal practices. Carbon sequestration programs offer a way around this problem as they themselves imply the promotion of new, sustainable alternative activities for the people affected by the projects.

Another economic advantage of CSPs is related to their inherent flexibility. In a way, these programs foster cost efficiency by giving the flexibility to pursuit the establishment of the projects in the areas where it might be less costly and/or more efficient to do so. Establishing CS projects in a country like Mexico might be cheaper and more cost effective in CO_2 combat than through other mechanisms or establishing these projects in developed countries. Competitive advantages can be also added to the projects with an efficient design where administrative activities would be reduced.

Beyond those immediate benefits to the local people, it must be pointed out that the entire society benefits indirectly from the implementation of these projects since their establishment promotes scientific knowledge development and data generation.

It could finally be added that in a developing country like Mexico, which has scarcity of monetary resources to overcome many of its national problems, establishing projects funded by private national companies or international agencies can partly act as an alternative source of funding for the country's overall agenda.

Institutional

Given the international framework reviewed in previous sections and being Mexico signatory to both the UNFCCC and the Kyoto Protocol, it is easy to see that CSPs offer an opportunity for Mexico to comply with the Convention. Also, the country would demonstrate its willingness to comply by playing an active role in the international carbon emissions market. This could in turn improve its prestige and its ability to better negotiate at international forums. However, one must be careful not to link the future of the programs only to the international mechanisms. Though the international benefits are certainly attractive, there are more than sufficient benefits at the local and national levels to be able to free and separate their convenience from the international dynamics.

Many of the institutional benefits/opportunities at the local and national level linked to CSPs are a consequence of the integral perspective innate to these sorts of projects both across institutions and across sectors and topics. As a matter of fact, a first benefit is already the promotion of integral policy approaches that is fostered by CSPs. Instrumentation also implies bridging, through partnerships, collaboration and/or information sharing, the different stakeholders involved.

For instance, local farmer's organizations as well as participant NGO's could consolidate their structure and functioning as result of the participative approach required by the projects which is a valuable asset for their future existence.

Regarding the academic sector, it is not easy to create the right mechanisms to get the academic sector participation in national problems. In this case, the high level of scientific and technical knowledge needed for the design, implementation and monitoring of the projects may create strong links between national and international research institutions, farmers and NGO's. Additionally, the need of accurate and updated data has already stimulated and financed new fields and research groups, strengthening the national capacities to elaborate carbon sequestration projects.

These projects may also provide additional funding to address problems in the national agenda. In this regard governmental organizations would take advantage of this opportunity to design and implement integral policies since the support required combine issues from different governmental sectors.

4.2 Obstacles and limitations

Environmental

Rather than environmental barriers, this section reviews some of the issues related with environmental information availability and the intense debate on measurement methodologies and the diverse methodological limitations to design, implement and monitor the environmental component of CS projects.

To start with, the estimation of actual carbon sequestration and carbon stocks faces serious difficulties. In order to build an adequate model to predict the amount of carbon to be sequestered by local ecosystems, the rate of growth of the vegetation in that specific forest conditions has to be known in order to obtain its correspondent Carbon content. Besides this straightforward measurement, land use changes, their patterns and trends should also be established to identify the opportunity cost of the project. The dynamics of this process vary widely from region to region, and unfortunately in most cases the information available is not enough to elaborate accurate models either to establish the base line or to quantify the final output of Carbon to be offset at different stages of the projects.

As previously mentioned, deforestation assessments in the country have been highly controversial, and even the most reliable ones have been made at such scale that do not allow to infer local dynamics in land use, land changes patterns.

According to the Second National Inventory of Greenhouse Gasses (1994-1998), there is no data at national level for the average carbon contents of the main soil classes, original vegetation type and alternative land use, so the estimations of the inventory have high uncertainty and should be taken as a first indication of the current situation (INE, 2000).

As consequence every project would require the generation of its own data, which represents an increase in the project's budget.

An additional complication relates to the assessment of the collateral environmental benefits (biodiversity conservation, soil erosion prevention) of CSPs. Just as for the ecological function of carbon sequestration, the available technologies and methodologies to assess the magnitudes and values of all the other ecological functions of forest ecosystems have important limitations. This makes it very difficult to formally link this projects to their true total environmental impacts making it more difficult to promote them.

Socioeconomic

To design and find the right financing sources is probably the main obstacle for the establishment and success of the projects. In fact, most of the projects elaborated and already approved to be implemented in

Mexico have not been able to start due to the lack of an investing partner. Although there are institutions and private companies in developed countries interested in those projects, the main reason preventing the investment seems to be the uncertainty on the future of this kind of projects under the negotiations of the Kyoto Protocol and also weak support and promotion of governmental institutions added to a long history of limited success or even corruption of social programs in the country.

Regarding local farmers, some of the obstacles that may arise in trying to implement a project are the history of promises and disappointments received from all kind of agents. Even though these sorts of programs are better at providing an alternative and feasible land use to forest ecosystems, they would still struggle in trying to eliminate the perverse incentives that jeopardize these ecosystems in the first place. That is, even though it might be profitable for some, others might still have incentives to pursue the unsustainable activities (i.e. illegal forestry) as long as there are still important potential individual benefits linked to them (i.e. lack of punishment, market for illegal forestry products, high prices). The current characteristics of the Mexican system of property rights have to be strengthen to make sure that the property of both land and land use products can be enforced in favor of the owners and investing partners. Failure to do so can seriously jeopardize the future of CSPs.

On the other hand as has been mentioned formerly in this thesis, a solid farmer union is required to establish the long-term commitment needed in this kind of projects and the level of participation essential for their success. Unfortunately this condition is not easy to find in the country, which would limit those areas where projects can be located. The level of conviction and commitment of the farmers will play a key role in meeting the programmed goals preventing perverse practices such as displacement of emissions to surrounding areas.

Institutional

Inefficient coordination between the different government levels and instances, as well as with other institutions, and the weakness of legal frameworks for CS projects implementation is not the best setting for adequate promotion of these projects at the international and national levels. Although some efforts have been done to spread the national interest in participating in the still incipient international initiatives for offsetting Carbon emissions, such efforts are concentrated in environmental agencies.

Table 1. Summary of the opportunities and limitations for CSPs in Mexico

- **Opportunities**

Environmental	*Socioeconomic*	*Institutional*
• Carbon sequestered • Carbon not emitted • Biodiversity conservation • Forest conservation, i.e. preservation of ecological functions • Soil conservation • Watershed protection	• Better living conditions and farming skills • Offers feasible alternatives to locals • Fosters cost-efficiency in CO2 combat • Promotes scientific knowledge and data generation • Additional funding for national priorities	• UNFCCC compliance • May help negotiations • Promotes integral policy approaches • Strengthens links between stakeholders • Improves ties with academic sector • Strengthens NGOs / social organizations

- **Main obstacles / limitations**

Environmental	*Socioeconomic*	*Institutional*
• Intense debate on methods to measure CS and storage (baseline definition, additionality) • Difficult to assess all environmental impacts – no data and methodologies • Very limited *in-situ* research and low budget	• Funding complications • Difficult to eliminate perverse incentives • History of promises and disappointments • Insufficient or biased farmers organization • Displacement potential may result in worse problem (leakage)	• Inefficient coordination between government levels and instances • Weak institutional and legal frameworks for CSPs implementation • Lack of enforcement capabilities • Threat from corruption and illegal activities

Source: Defined by the author.

Additionally, even if the legal framework was fully appropriate and there was a good to high level of coordination and communication among government levels and instances, a major problem to ensure the success of the projects is the lack of enforcement capabilities, which is characteristic to must of the country's regulations. If property rights cannot be enforced, if illegal activities go unpunished, if there is no compliance with regulations and guidelines, then there will certainly be limited success if any.

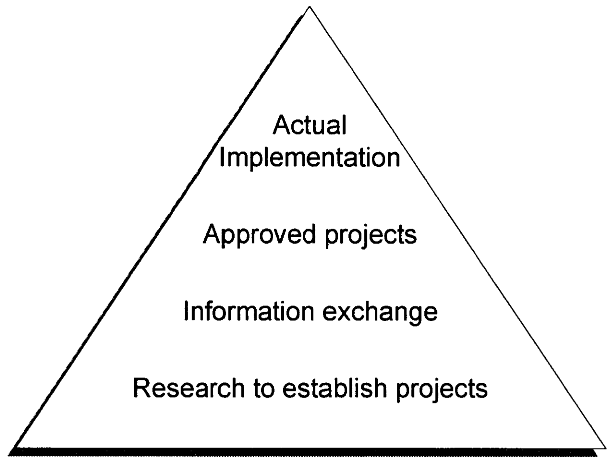
Finally, linked to the previous point, another important aspect that could obstruct the development of the projects is the threat from corruption and illegal activities. In rural areas in Mexico, different economic and political interests may play a pernicious role, blocking legitimate initiatives to develop impoverished communities.

5. Carbon sequestration efforts in Mexico

Mexico has been one of the developing countries willing to explore the Joint Implementation (JI) concept since the first international conferences on Climate Change took place. In 1995, during the COP in Berlin, Mexico expressed its interest in JI projects as an alternative way to fund social development projects of the country (INE, 2003). The National Institute of Ecology, a component of the Ministry of the Environment and Natural Resources of Mexico (SEMARNAT), is the designated national authority for activities implemented jointly (AIJ), and it has been supporting different efforts by academic institutions and NGO's in analyzing the feasibility of carbon sequestration projects throughout the country.

There have been numerous efforts in the country that study different aspects of the implications, feasibility and implementation of CS projects. These can roughly be categorized as in figure 10 that reflects a pyramidal distribution in terms of the number of projects in each category.

Figure 10. Efforts of CS projects in Mexico



Source: The author.

Regarding projects that have actually been implemented, there is only one with international funding to offset greenhouse gas emissions of a European company. There are also a few more studies and proposals for new projects on areas with significant potential for carbon sequestration activities, but they are still looking for a financing partner.

The National Institute of Ecology has also supported and organized seminars and workshops on topics directly related with the design, implementation and monitoring of projects. Some examples are the "Workshop on improvements to estimate GHG emissions for the LULUCF sector" and "Modeling Deforestation in Mexico and Implications for Carbon Sequestration Projects", both carried out during this year (Guzman, 2003).

Finally, most of the efforts in this field have been made by Mexican researchers who have carried out studies to develop and adjust methodologies to better estimate carbon emissions and carbon sequestration by forests at national level (INE, 2000; Massera, 1995) and to monitor the carbon sequestration by different land use and forests under local conditions (Ordoñez, 1999). Some cases will be shown in detail in order to provide an overview of these important efforts, and other cases can be found in the Second National

Communication under the United Nations Framework Convention on Climate Change (INE, 2001).

5.1 Searching for carbon sequestration options: San Juan Nuevo

Among the studies on the potential of carbon sequestration in Mexican forestry systems, there is an important project carried out to estimate the carbon sequestered by a temperate forest in San Juan Nuevo Michoacán, South Western Mexico (Ordoñez, 1999). This indigenous community is well known in the country for having a communitarian organization and being leader at national level in pursuing sustainable and certified managements systems in their forests. Since 1988 the community has been improving its forestry management, making good profit out of it and investing at the same time in the regeneration of the forest.

This study was carried out by researchers at the National Autonomous University of Mexico and was aimed to provide a technical tool that could be used as starting point in assessing the feasibility of proposing a project for carbon sequestration in temperate forests, an option that has had little attention in the country.

The study thus contributes to the national debate on CS by developing a methodology to estimate the potential for CS using modeling methods and to come up with a reproducible method to define growth curves for temperate forestry species (mainly Pinus (pine) species). The parameters considered are humus carbon content, residence time in forestry products, degradation coefficients and growth curve for species under evaluation (Ordoñez, 1999).

Due to the strong need for local and regional data about the dynamics of flux and storage of carbon in tropical and temperate forests, this kind of research plays a key role in successfully establishing CS projects. Besides this purpose, it can also help the owners of the forest to improve their forestry practices by having a better knowledge of the rates of growth in their forests. Unfortunately, up to this thesis's deadline, we have not been able to find information on the current status of the CS project proposal for San

Juan Nuevo.

Other projects regarding carbon sequestration by forests in different regions of Mexico are described in the 2nd National Communication to the UNFCCC (INE, 2001)

5.2 Projects ready to start

There are a few studies that have a complete proposal to implement a carbon sequestration project in Mexico. In this section we present those for which the available information is relatively consistent and which might actually be the only truly complete ones. These are the Communitarian Silviculture in Sierra Norte of Oaxaca, the Calakmul Biosphere Reserve and the Sierra Gorda Biosphere Natural Reserve.

Communitarian Silviculture in Sierra Norte of Oaxaca

The objective of this project is to improve forestry systems of two regional indigenous farmer organizations (Unión de Comunidades Zapoteco-Chinantecas (UZACHI) and Unión de Comunidades Ixtlán-Etla, Oaxaca (IXETO)) in order to face the needs of growing population without depraving their forest areas, protecting areas for biodiversity conservation and practicing sustainable farming systems in areas under conventional grazing and agriculture currently. The project targets to maintain more than 30,000 hectares and to expand the proposal to other neighboring communities having an impact of 836,000 tons of carbon captured in 30 years with 27,867 tons a year (Consejo Civil Mexicano para la Silvicultura Sostenible, A.C., 2003).

The proposal was an initiative of the UZACHI and IXETO with the technical support of Estudios Rurales y Asesoría Campesina, A.C. (ERA), an NGO experienced with rural communities. The monitoring and evaluation of the project would be in charge by the Consejo Civil Mexicano para la Silvicultura Sostenible, A. C. (CCMSS), which has been involved in advisory and training regarding forest management, as well as acting as forestry certifier agency. They have also had the technical assistance of the World Resource

Institute, and have been approved by the Mexican government and the United States Initiatives for Joint Implementation (USIJI), which has conditioned the approval to some data transparency. The external evaluator and the funding institution remain to be defined.

The implementation of this project would represent a great opportunity for the indigenous organizations to improve their financial situation and to have bigger incentives to protect and use in a sustainable way one of the areas with higher biodiversity in the country. The solid organization of the communities would help to warranty the long-term success of the project creating a win-win situation for investors and participant farmers.

Calakmul Biosphere Reserve

Calakmul Natural Reserve project has also the approval of the Mexican government and the US Initiative in Joint Implementation (USIJI). The project has been elaborated with the participation of: Winrock International a private non profit organization dedicated to support long-term productivity, equity, and responsible resource management world wide; the Consejo Civil Mexicano para la Silvicultura Sostenible; the National Institute of Ecology belonging to the National Autonomous University of Mexico; El Colegio de la Frontera Sur; and Ecosecurities Inc. EcoSecurities Ltd, an established environmental finance company which specializes in advising national governments, project developers and corporations on strategy regarding global warming issues.

The main objective is to combine the benefits of greenhouse gases effect mitigation with the flora and fauna habitat protection within the Biosphere reserve limits. Along with this purpose, it also aims to provide economic and social benefits to the local communities.

The estimated carbon capture in 260,160 hectares is between 1.1 and 1.9 Mt. The funding partner for this project is still to be defined (INE, 2003).

Sierra Gorda Biosphere Natural Reserve

This Reserve is part of the Mexican Natural Protected Areas system, under the management of the Federal Government through the National Commission of Natural Protected Areas. It was created in 1997 and it is located in East Central Mexico and comprises relevant ecosystems like Pine and oak forests, deserts and tropical forest among others. Animal and plant species living in this area are considered as rare, threatened or in danger of extinction, which increases the importance of preserving this transitional area between Neartic and Neotropical America.

The initiative to preserve Sierra Gorda started with the creation of Grupo Ecológico Sierra Gorda (GESG), which was recognized as a not-for-profit organization in 1989, and has been appointed as manager of the recently crated Biosphere Reserve. This organization has engaged more than 100,000 inhabitants in natural resources management programs such as reforestation and environmental education and is pursuing to generate employment and economic development for inhabitants of Sierra Gorda (Woodrising Consulting Inc., 2002).

New initiatives for the conservation of the area include the proposal for a Sustainable Forestry project, elaborated by GESG and Woodrising Consulting Inc., a Canadian environmental consulting Company specialized in "greenhouse gas emission management, Action Plan submission for Voluntary Challenge and Registry Inc. (VCR), Clean Development Mechanism, Joint Implementation (AIJ) and Domestic Offset project design, environmental project management, and communications including sales and marketing" (Woodrising Consulting Inc., 2003).

The project delivery mechanism is to recover forest by natural regeneration mainly in marginal agricultural lands to be selected by GESG in junction with the farmers. "Preference will be given to land on steep slopes and land surrounded by existing forest" and economic incentives will be given to the farmers for allowing the fallow lands to recover into forest (Woodrising Consulting Inc., 2002). After 7 years they will be allowed to thin the growing forest and they will receive some money from the wood fuel selling. Every 5 years, farmers will be able to harvest 25 % of the area, and each lot will be harvested again only after 20 year. This management system will allow forest regeneration as well as biodiversity conservation according with the objectives of the Biosphere Natural Reserve. Under this management system, the expectations are to sequester 236,000 tones of CO_2 equivalent by 2012 and 636,000 tones by 2052. Woodrising Consulting Inc. derived such estimations with a model using a "version of GORCAM1, an algorithm that tracks the flows of carbon in a forest system including wood products".

The system will be monitored every 5 years, assessing biomass accumulation after which greenhouse gas emission benefits will be transferred to the investor. The monitoring and verification will be overseen by Woodrising Consulting Inc. who has arranged to have the monitoring process to be undertaken by El Colegio de la Frontera Sur (Ecosur) a National academic institution with experience in this type of procedures.

The proposal points out that risks vary from negligible to moderate when evaluating factors as deliverability, additionality, permanence and leakage, which are generally considered as the most vulnerable aspects for the success of these projects.

"This initiative uses the Clean Development Mechanism to extend land protection efforts in Mexico's Sierra Gorda Biosphere Reserve".

Although the project has been conceptualized and organized for some time already, it still has not been financed due mainly to the climate change negotiations, according with the consulting enterprise in charge of the elaboration of the project. The feasibility study has been submitted to the World Bank's Biocarbon Fund, but so far there are not financial resources to start the project (Woodrising Consulting Inc., 2002).

5.3 Project in operation: Scolel Té

The only project already implemented in Mexico is Scolel Té. It is an international pilot project of carbon sequestration and community forestry, carried out in the State of Chiapas, Southern Mexico. "The project is part of Mexico's official Program of Joint Implementation to Reduce Climate Change and is also registered with the US Initiative for Joint Implementation".

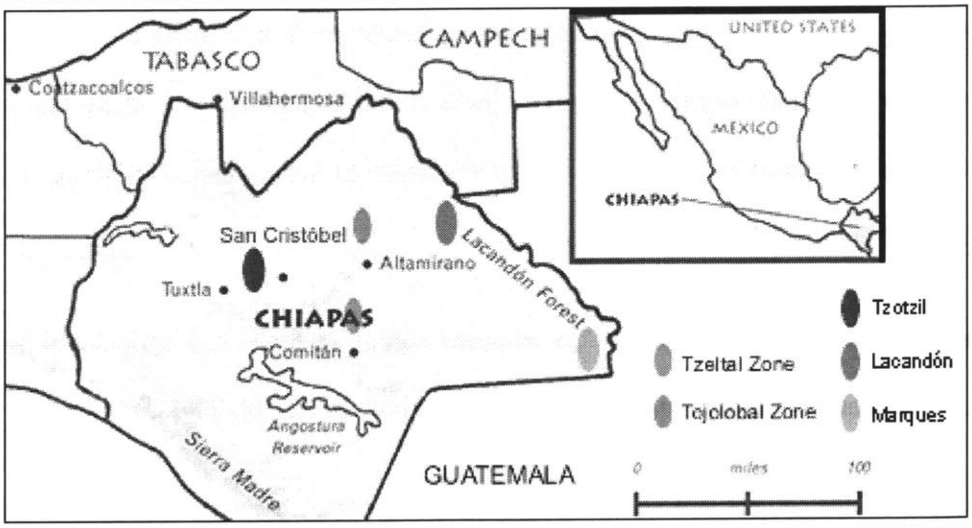
The main objective of the project is "to sequester carbon in forest and agricultural systems which also provide sustainable livelihoods among rural communities" (Scolel Té, 2003).

The model of this project intends to be reproducible in other parts of Mexico and Latin America with similar conditions. It aims to achieve the sustainable management of the forest in order to assure the carbon sequestration commitment in the long run, as well as to address the immediate social needs of the local people.

The project area comprises two ecological and ethnical regions covering 13,300 hectares. Temperate forest with tzotzil and tojolabal tribes settled in the highlands and tropical tzetzal and lacandones in the lowlands. So far there is participation of about 400 farmers from 20 different communities. The lifetime established for the project is 30 years with a GHG overall impact of 1,210,000 metric tons of CO_2 equivalent at a mean cost of approximately USD 10 /tC (to be reviewed annually in consultation with SEMARNAT and USIJI).

The project was designed to implement small forestry and agro-forestry enterprises with financial and technical assistance provided by the Trust Fund. The techniques proposed are assessed not only by its carbon sequestration potential, but also for their technical, social and environmental feasibility. The "viable plans are registered with the Trust Fund and are eligible to generate carbon services" (Scolel Té, 2003).

Figure 11. Location of the Scolel Té project.



Source: Scolel Té Website

The Fondo BioClimatico, a non-profit body run under Mexican banking law, forms the Trust Fund. The companies or enterprises interested in offsetting carbon emissions, may buy voluntary emission reductions (VER's) to the Fund Trust, which only holds the money until the transaction is accomplished. Participants in the Fund are the Edinburgh Centre for Carbon Management, UK and AMBIO, Mexico. The Fondo BioClimatico acts as an umbrella for farmers willing to sell carbon offset services, as a center for support and training of the producers and a point of contact between the enterprises buying the VER's and the local producers.

As with all CS projects, there are important issues related to the monitoring system. As mentioned previously, to monitor the performance of carbon sequestration projects is strongly debated in the academic arena since different methodologies and actors carrying out the process would change the results. In practice, this becomes a major threat to the credibility and success of the projects.

In this project, farmers are the primarily source of data, submitting reports on the performance of their practices to the so called Technical team, a group of professionals and local promoters who are in charge of estimating the Carbon fluxes of the systems proposed by the farmers.

On the other hand, the Research team (El Colegio de la Frontera Sur, a regional research Institute, and the University of Edinburgh, UK) developed C flux models specific for each management system and ecological region and is in charge of training the Technical team to assess Carbon fluxes and Impact Assessment of the project. These two teams jointly evaluate and check the accuracy of farmers' reports by sampling and cross checking.

The project offers different levels of carbon sequestration according to the management system original and the target. Ex. from pasture (20 tC/ha) to plantation (140 tC/ha). This format provides flexibility and allows the optimization of the system by combining those with higher sequestration rate and those with the best production performance for the local population.

So far, the "Federation Internationale de l'automobile (FIA) has agreed to purchase 5,000 tons of carbon credits per year, through the International Carbon Sequestration Federation, in order to offset the emissions from Formula 1 Motor Sport" (Scolel Té, 2003).

Table 2. Carbon sales of the Scolel Té project.

Year	Sales (tones carbon)	Purchaser
1997	5,500	FIA (Formula One)
1998	5,500	FIA (Formula One)
1999	5,500	FIA (Formula One)
2000	6,573	FIA (Formula One), Future Forests
2001	9,297	FIA (Formula One and World Rally), Future Forests
2002	13,297	FIA Foundation (Formula One and World Rally), Future Forests

Source: Scolel Té Website.

From 2000 on, Future Forests has joined the project providing additional funds. Future Forests is an innovative organization designed to inform the general public and private companies and organizations about issues related with global warming. At the same time, its website offers options to 'neutralize' personal greenhouse gas emissions by planting trees or by supporting one of the climate-friendly energy projects affiliated to the organization. Considering the data in Table 2, dissemination of Scolel Té information through the Future Forests website seems to have successfully incorporated additional funds to the project, which have been provided mainly by the World Economic Forum, D'leteren-Audi and Pink Floyd (INE, 2003).

This international pilot project represents an original and creative design that can act as an example to be reproduced in other regions of the country or other developing countries. With its dynamic and participative approach, where land-use decisions are taken by the owners of the land and the technical advisory of the researchers, it takes a significant step towards warranting the success of the project: the population has no alienation of its resources this in turn strengthens their commitment with the project.

The efforts that the country has been doing regarding CS in forests represent an important contribution to maintain and use in a sustainable way its natural ecosystems. Joint efforts between governmental agencies, academic institutions and rural population are helping to find new and more efficient ways for an adequate natural resources management. At the same time, the country shares the international concerns regarding global environmental problems and takes advantage of the international instruments available to support its national development priorities. Mexico has still a long way to go in overcoming the obstacles to achieve its sustainable development path and this is just a small sample of the challenges faced and an illustration of the effort put to search for solutions.

6. Measuring Success/failure of carbon sequestration efforts in Mexico

What is success? At first, it might sound as an easy question, however, the more one thinks about it, the harder it becomes. When it comes to evaluating CS efforts, the definition of success is not a unique variable as it depends on who is asking the question and the perspective (i.e. conservative, radical, etc.) from where it is being made. Success for some might be only partial success or even failure to others. In the same way, failure in achieving certain goal does not necessarily mean zero success.

Thus, when evaluating success or failure of a project, it is important to clearly establish what we mean by success and what will be the criteria to assess achievements. Different sectors in the society may have different standards and expectations for different projects, ranging from those for which any slight achievement would be considered a big success, to those that would only claim success when clear and drastic improvements are achieved. Therefore, we must take into account these differences and strive for a definition and assessment guidelines/characteristics that better reflect success and development from the point of view of society as a whole.

Any project has multiple facets, and the level of achievement in each can be evaluated as well as the overall performance. Weighting what aspect of the project will have more relevance in the analysis would depend on the objectives of the evaluation and the actor requiring the evaluation. This might also be influenced by the approach of the evaluator in terms of its expectations of the project.

For instance, while a company buying carbon-emission credits will be mainly interested in verifying if the payment matches the carbon actually sequestered, farmer's unions will be more focused in the financial success of those farming systems implemented, and their repercussion in their living conditions. Also, for an environmentalist, the basic measure of success might be the actual environmental benefits of the project while policy makers might be more interested in cost-benefit rations across sectors of the economy.

We believe that efforts to measure success of these sorts of projects should not focus on getting a single "magic" measurement of a particular characteristic. Rather, a holistic approach is recommended that identifies the main aspects of the performance of projects and allows for assessments of success from different perspectives while providing a balanced impression of overall performance. Still, the approach should differentiate between those aspects that are crucial for the substantive success of projects, and some other that are indirect or secondary measures of success.

It should also be added that, since evaluation is an expensive process, there is a trade-off between the information gathered and the cost of doing so, information with a lot of detail or information irrelevant for the final result, might increase the cost beyond its benefits.

With this in mind, this section aims at designing tools to assist the assessment of CSPs in Mexico to help measure success and, most importantly, be able to systematically identify obstacles in the instrumentation of the projects and areas/aspects of potential improvement.

6.1 The use of indicators

A valuable tool to assess the development and performance of any project are indicators. However, unlike many might think, indicators are not a magic tool that will solve all problems and will point to all solutions. Also, indicators have to be carefully designed and implemented to really be supportive for decision taking. Thus, before discussing specific indicators to help policy makers, we will present a few reflections on the nature, characteristics and limitations of indicators.

Indicator is an "in-vogue" name for an old tool. Any analysis requires the use of some parameters that describe different aspects of the process to be analyzed. A formal, systematic way of studying such parameters is through the design of indicators sets. By definition, an indicator is any measurement/parameter that tells us more than what it directly measures (OECD, 2001). Thus, an indicator does not necessarily need to be a complex manipulation of variables as long as it complies with this simple definition.

Indicators are constructed as a tool to aid in decision-making. Their adequate identification and analysis helps to have an accurate idea of the current situation of the projects, as well as the identification of some positive or negative trends. It is important to point out that the construction of an indicator's system has to be seen, at any time, as the development of a useful tool rather than a goal in itself, a way to carry on a systematic analysis of key characteristics of the projects. Thus, the resources used to develop such a tool, and the tool itself, should be flexible and adjust to the resources and characteristics of the specific project that they are bound to assist, and not, like too often happens, become the goal of the project and/or an excessive burden.

With this said, we can now point out that a desirable characteristic of indicators is that they are reproducible, in order to permit comparison between projects, having always in mind that the projects may differ in many aspects, and those indicators easily gathered for one project may not be adequate for another.

Also, for the sake of objectivity, it is desirable that indicators selected are quantifiable variables, but for some aspects, qualitative information would better reflect the current situation. Thus, indicators systems should not be limited to quantitative information, they should make good use of the qualitative information available in order to cover all the aspects that are deemed relevant for the project study.

Evaluating a project is an expensive process so an adequate indicator's system would concentrate efforts in an efficient way helping to make it affordable. Considering this, the system to be used should be simple, feasible, flexible and cheap. It is common in countries like Mexico that the information for those dates or geographic scales required is not available, then the system should be organized requiring as less information as possible and being flexible enough to use alternative parameters to assess the same dimension of the process. In this regard, a hierarchical structure in the design will provide additional options that would help to overcome difficulties during the evaluation process.

A main goal of indicator development is to systematize and structure information to facilitate its use and interpretation for decision making. Thus, before constructing specific indicators, one must reflect upon the conceptual framework that the indicator system should follow. What are we trying to capture and from what perspective(s) do we want to do it. This reflection leads to the development of indicator systems.

Indicators systems are multidimensional as they try to study different aspects, elements and dimensions of a project, which are not independent as they might overlap and interact with each other. Because of this, whenever someone tries to capture an indicator system into a two-dimensional list he or she is bound to have a hard time assigning indicators to the different categories. However, it is important to say that discussions about the proper categories to which a specific indicator belongs do not always have a unique answer and, most importantly, often do not add practical advantages for decision-making as long as the specific indicator is included in the system.

We will now present a first rough draft towards setting up an indicator system to assist in the evaluation of the development and the performance of Carbon Sequestration projects in Mexico and in the identification of trends and areas for adjustment.

6.2 Conceptual framework for an Indicator System

As it was mentioned before, the first step in establishing an indicator system is to decide from what perspective (success according to who) are we going to do the analysis and what aspects are relevant for the analysis.

Regarding the definition of a perspective, we believe that, since we are concerned with measuring success and performance from the perspective of Society as a whole, evaluating CS projects should be done using the optic of Sustainable Development. This perspective is consistent with both the UN and OECD major indicator efforts: the UN Sustainable Development Indicators (UN, 2001) and the OECD Indicators of Environmental Performance (OECD, 2001). The perspective of sustainable development assesses aspects within the projects as they relate to the ecological balance, social progress and economic growth, also known as the three pillars of SD. The UN system explicitly includes an institutional dimension as a fourth pillar. OECD's indicator system is consistent with this idea though it does not explicitly separates the institutional dimension as it focuses more on the environmental dimension following a Pressure-State-Response model.

We believe that it is desirable that environmental indicator systems ensure consistency with these general frameworks though it is not necessary to explicitly do so. Accordingly, we have designed the proposed indicators with these methodologies in mind so that the system is easily translatable to these structures. However, while it was important to ensure consistency, it is not convenient to adopt the explicit structures of the UN (economic/environmental/social/institutional) and OECD (pressure/sate/response) indicator sets. Rather, would be preferable to use a different set of dimensions that focus on the different aspects that reflect the level of success in the development and performance of the projects. These dimensions also might prove more useful to identify bottlenecks and areas of potential improvement. The chosen dimensions are presented in the following section.

6.3 Dimensions of success of carbon sequestration programs

Actual carbon sequestration

This dimension relates to the actual environmental impact of the project. Unfortunately, due to the difficulty in measuring all of the environmental impacts of such a project (biodiversity protection, watershed protection, erosion prevention, etc) and the limited resources available, we can realistically only focus on measuring the direct impact related to Carbon Storage, including both sequestering CO_2 or preventing its emission. This is obviously the most direct measure of the success of projects and, for many scholars, it is the only measure as it reflects the ultimate contribution of projects towards solving the global problem at hand. If information on other environmental benefits of the project is readily available it should also be taken into account to better reflect total benefits of the project.

Stability of the project

The long-term character of the projects, introduces a high risk factor related to the permanence of the project. This dimension tries to identify those factors that could affect its permanence in the long run. The idea is to measure how the project stands against the different components of sustainable development including social, economic, environmental and institutional issues. It should address issues such as the feasibility and economic soundness of the new alternative economic activities for the communities affected by the project, the elimination of perverse incentives, the improvement in local living conditions, profit from the project, land use and land tenure stability, all parameters that help to maintain the commitment of participants and preventing the emergence of unexpected situations. This "proof of time" is critical for long-term projects and to provide certainty to investors.

Economic efficiency

This aspect considers the capacity of the project to produce the higher output (C sequestered) with the lowest possible unit of investment, namely amount of money or land included in the project. The idea is to be able to assess how sound is a project from an economic, business-like, perspective. Additionally, the dynamics of supply and demand, marketing, transaction costs, etc., should be considered in this dimension. Such information will be closely related with the price established for each ton of Carbon storage, and consequently with the project's competitiveness in the global market. Finally, this dimension should be able to capture the impact on projects if the international framework leads to the establishment of an open emission-carbon market and with this, the need to become competitive.

Efficiency/ease in implementation

We are defining the implementation phase as all those project-related activities that take place before the project is operating on a routinely expected basis. This definition might differ for specific projects. The idea is to measure how difficult and efficient it is to start up CSPs in the country. This serves as an indicator of the adequacy of the frameworks and institutions that serve as context to the projects as well as of the efficiency of the particular stakeholders, obviously helping to point out the major bottlenecks and adjustments needed. Being the starting point of the project, implementation phase is key in the project's overall performance, pointing out the proportion of the available resources (training, organization, farming systems establishment, etc) and largely determining the timing which is also important considering that any serious delay will make the project fail in meeting its production targets on time. Good "signs" related to these indicators might also encourage more investment on these sorts of projects in the country.

Operational efficiency

This dimension addresses the routine operation of the projects once the implementation phase is over. The usefulness of this dimension is to identify any procedural obstacle that could be creating delays, unnecessary paperwork or misunderstandings among the stakeholders. The sooner this kind of problems are identify, the smoother the project will functioning, focusing only in the core aspects of the project.

Social capital and institutions

After Carbon storage, this might be the most important outcome of the projects for a country like Mexico. This dimension will consider the impact in different sectors of the society, either as individuals or as public institutions. Some of the indicators in this dimension are *sine qua non* conditions for the project's permanence (farmer's skills, farmer's organization) and others will play a supportive role to better achieve its goals (i.e. institutional strengthening). Beyond the role that these aspects play in the project, they would be the most permanent outcome since, even in the circumstance of failure of the project; these assets would be the starting point for many other initiatives.

6.4 The indicator set

In this section we present a first draft of an indicator set in the assessment of the success and performance of CS projects in Mexico and in the identification of obstacles and areas for improvement. It is only a first step that still needs research, particularly *in situ*, to become the truly useful tool that we hope it can be.

The indicator set is presented in Table 3. It presents, classified by the dimensions discussed in the previous section, the names and possible general formulas of the indicators. In the case of a particular project, most of these indicators should be specified further (keeping in mind the benefits of reproducibility) adjusted to the specific conditions and priorities. The table also includes a column with comments in which we address different particularities of each indicator or subset of indicators. Finally, a column is added to show how the indicators relate to the Sustainable Development framework discussed earlier, showing which of the four pillars (economic, environmental, social or industrial) is being addressed by the indicator.

As it was mentioned before, the development of the indicator set should not be seen as the goal itself, but rather as a decision tool. Accordingly, it should not become a major burden for the project. Because of this, the indicator set should be adjusted to the particular needs, priorities and available resources of the specific project at hand. The flexibility of the indicator set means that though all indicators are useful, their relative relevance might change between different projects. Even so, not all indicators included in the set are significantly relevant for all projects. This must be recognized in the early stages of the projects. However, there are some indicators that we believe must be included in all projects (though their specific measure might change related to the available resources and data). These "core" indicators are highlighted in the presented set.

Table 3. Indicator set to support the assessment of Carbon Sequestration programs in Mexico

Name of dimension/Name of indicator/ Proposed general formula	Comments	SD Pillar
Actual carbon sequestration		
Size of the project • Area units under management (absolute numbers and trends)	This indicator is not by itself a measure of success, however, it is important for the estimation of other indicators and as a parameter to compare different projects. It is recommended to include a distinction of the different land uses within the project.	Env
Total sequestered carbon • Estimated carbon sequestered units (absolute and trends)	Estimation methodology could change according to that which better suits each specific project and to available technologies to do so. However, if methodologies are revised, the whole series should be adjusted to ensure consistency throughout time.	Env
Carbon-stock balance • Units of carbon in stock (sequestered + prevented – emitted)	Similar to previous one but includes estimates of emission balance – carbon already in stock – carbon emitted) Methodologies could be different among projects, however, they should be comparable within the same project and consistent in time.	Env
Emission credits generated • No. of emission credits generated	Based on the carbon-stock balance.	Env, Eco
Other environmental benefits (some examples) • Ecotourism revenue • Value of protected water (from irrigation or public use) • Value of biodiversity protection	If information is readily available or generated at a very low cost. Should help to better assess total environmental benefits of project	Env
Stability of the project		
Social stability • Change in local income due to project related effects (direct project revenue, tourism, etc) • Migration	"Local" might refer to the individual persons directly involved, average income of community households, or other depending on the reach of the specific project. Migration is included as an indicator of the perceived sufficiency of the resources generated by the project. If people are still migrating it could be a sign that they still need to get additional income.	Soc, Eco
Economic stability • Annual profit from project land use relative to opportunity cost (profit from best alternative use). Both at the individual and community level. • Elimination of perverse incentives	These indicators address the question of whether or not the new land use (related to the CS program) is the best economic use of the land. To the extent that this is true the long-term economic stability will be ensured. Additionally the persistence of the incentives that put pressure on the conservation of the natural resources (now under management of the project) should also be evaluated to see the risk involved (sort of a "temptation" level).	Eco, Env
Institutional stability • Impact of other policy tools affecting the area • Institutional framework in place. Qualitative indicator based on surveys of experts.	A systematic revision of other policy tools affecting the area should be made. Ideally an indicator of the specific impact of such measures should be constructed, however, a simple list or qualitative indicator could be used. Additionally, qualitative indicators to assess the adequacy of institutional framework should be used through the identification of consensus areas and agreement of experts.	Inst, Soc
Legal stability • Legal framework in place. Qualitative indicator based on surveys of experts. • Property rights/Land tenure stability. Qualitative indicator based on surveys of experts. • Enforcement capacity. Qualitative indicator based on surveys of experts.	Qualitative indicators based on surveys of experts should be designed to assess the legal stability of the project. Particularly it should address the issues of the adequacy of the legal framework and the enforcement capacity of authorities and groups.	Inst
Scientific credibility • Soundness/credibility of scientific basis of the project and its methods. Qualitative indicator based on surveys of experts.	There is a need for a solid scientific foundation and a good level of consensus. Identify consensus areas and level of agreement.	Inst, Soc
Economic efficiency		
Production intensity per area • Emission credits generated per unit of area	Addresses the productivity of the project per unit of area. It is recommended to include a categorization by area type.	Eco, Env
Production intensity per dollar • Emission credits per dollar invested (investment return) or used	Addresses the productivity of the project per dollar invested in the project. Could differentiate stages and/or activities within project.	Eco
Efficiency in use • Emission credits used as percentage of emission credits generated • Price of emission-reduction credits (real terms and trends)	These indicators are presented taking into account the prospect of the establishment of an open emission-credit market. However, if this market is not established, they should be revised, by specific project characteristics, and should focus on measuring the dynamics of supply and demand (price, equilibrium/balance, etc).	Eco, Inst

Efficiency/ease in implementation	See definition of implementation phase on text.	
Time of implementation • Time used during implementation phase	This is an important indicator to compare across different projects. It helps to reflect whether the implementation of projects is becoming easier or not, thus related to the improvements in the adequacy of the different frameworks (i.e. institutional, legal) that provide context to the projects.	Inst, Eco
Implementation under schedule • Specific goals met on schedule relative to total specific goals	This is a measure of both the efficiency of stakeholders as well as of the unexpected obstacles that may come up during implementation. Obviously, there is a need to set specific goals for the different stages of implementation. These goals should be relatively feasible and comparable.	Inst
Implementation load • Resources used during implementation phase as a percentage of total resources used	The indicator focuses on the relative burden of the implementation phase with respect to the total project. Besides being important for the direct stakeholders, this indicator is helpful to compare across projects and induce investment.	Inst, Eco
Operational efficiency	These indicators focus on operation stage (post-implementation).	
Administrative load • Percentage of resources used on administrative issues	This indicator is design to keep in check the administrative efficiency of the project. It asks the question of where are the resources being used, including trends in real terms.	Inst, Eco
Operation under schedule • Specific goals met on schedule relative to total specific goals	This is a measure of both the efficiency of stakeholders as well as of the unexpected obstacles that may come up during regular operation. Obviously, there is a need to set specific goals. These goals should be relatively feasible and comparable.	Inst, Eco
Interaction between stakeholders • Information flows between stakeholders, based on surveys • Resources used for interaction of stakeholders	Designed to keep track of transaction costs of the project, particularly information.	Inst, Eco
Information flow • Information availability and accessibility for the general public	Refers to information that is available to people beyond the stakeholders. It is important as it keeps communities informed, and might impact future investments and fostering of other projects.	Inst, Soc
Social capital and institutions		
Improvement of farmers' skills • Qualitative indicators based on surveys of farmers and experts	Designed as a measure of the improvement in social capital and the permanent impact of the project on the communities. Surveys should focus on finding consensus areas and level of agreement.	Soc
Effects on health and education • Qualitative indicators based on experts surveys and consensus	Designed as a measure of the improvement in social capital and the permanent impact of the project on the communities. Surveys should focus on finding consensus areas and level of agreement.	Soc, Env
Institutional strengthening • Involvement of academic/research groups • Supportive policies design • Formal and informal partnerships among institutions and sectors	Designed to measure the permanent effects of the project on the capacity of institutions. The indicators should be based on surveys of experts identifying consensus areas and level of agreement.	Inst, Soc
Indicators of local support, participation and involvement • Qualitative indicators based on surveys of local communities, organizations and experts	Measure the acceptability of the project by the local stakeholders as well as the sense of belonging. This is relevant both as a measure of social capital and as a sign of social stability. Surveys should identify consensus areas and level of agreement.	Soc, Inst

Notes: - The indicators are presented in a very general form. A more detailed/specific definition would not be feasible from this general perspective, as it would depend of the specific characteristics of each project.
- SD Pillar refers to the dimension of sustainable development that is being addressed by the indicator.
- The 10 Core indicators are highlighted in gray.

Source: Developed by Armando Yañez

Finally, it should be mentioned that conclusions should not be drawn by judging indicators individually. Not all the indicators are direct measures of success, and they should be understood and use as a set. The set as a whole is what will provide the information to support the assessment made be decision makers.

6.5 Implementation of the indicators

The evaluation, valuation, monitoring or any other process of assessing the actual situation of a project will require, besides a careful design, a good amount of information that might not be available. Furthermore, in view of the long-term characteristics of the projects, those evaluations would be required a number of times during its life time so it is important to establish those mechanisms which allow to gather and analyze the information in a systematic way. This will give more consistency and reliability to any comparison and trends will be more easily identified.

Thus, provisions for the systematic assessment of the projects should be considered, designed and implemented from the early stages of the project, including provisions for the generation of the information that will be needed. What this means is that the first key to the successful implementation of the indicator set is to consider it from the beginning of the project, taking into account the projects specific characteristics, needs, priorities and resources.

Adjustment of the indicator set to the project is thus crucial. It is generally agreed by indicator experts that the success in the instrumentation and use on an indicator set is a function of its simplicity, feasibility, flexibility and cost. So, as long as these four keys are balanced while adjusting the indicators to the specific project there is a greater chance for success. Also, once a first simple, feasible, flexible and low-cost set of indicators is set in place and running, it can be further improved, buffed up and fine-tuned.

Finally, it could be added that, in order to not make an excessive burden out of the implementation of the indicator set, the early stages could focus only on the core indicators, and those deemed as a high priority to the project, and slowly build from that.

7. Policy considerations

The Federal government of Mexico is currently carrying out different efforts to mitigate the effects of CO_2

emissions in the country in order to meet national goals and comply with international commitments. The international agenda plays an important role in Mexico's environmental policy and in the energy sector were joint projects are underway to minimize greenhouse gas (GHG) emissions.

In 1999 the National Strategy for Climatic Action (NSCA) was prepared by the Inter-Ministerial Committee on Climate Change (INE, 1999). Unfortunately the document remained as a working draft because consensus on its content was not reached.

Suggested objectives at the national level were established, in light of international commitments and concerns. The need for coordination between national and international objectives, as well as with the rest of the society, was stressed in the document.

The official statements of Mexico's national policy and proposed actions regarding climate change are contained in the First and Second National Communications to the UNFCCC. In the Second Communication (INE, 2001) there is an extensive description of the sectoral efforts required to prevent or mitigate climatic change in the country. Most of these actions are not explicitly related to CSPs. Indeed, the only reference to CSPs is in the section on Activities Instrumented Jointly (AIJ), with no clear link to the rest of the policies in the document.

To multiply and strength the implementation of CSPs in Mexico, it would be helpful to strength coordination mechanisms between different governmental agencies. As stated in the NSCA, clear inventories of forest resources, a transparent institutional framework and adequate policies, would encourage foreign investors interested in purchasing or developing offsets for their own GHG emissions.

Policies in each Ministry to encourage and support such projects in a coordinated way would enable NGOs and farmer's Unions to engage in local sequestration projects consistent with national and international objectives. Those policies that provide economic incentives for environmentally-friendly agricultural practices such as agroforestry would play an important part in encouraging the initiation of such project. At the same time, it is important to remove policies which encourage the conversion of forest to agricultural land and promote deforestation, or at least forest fragmentation in the country.

Little documentation is currently available regarding efforts at the state and municipal levels regarding CSPs, but it seems that such efforts are very few in number. It will take an increasing Federal commitment to encourage and support these government levels to promote CS activities within their jurisdiction.

7.1 The Forestry Sector

In the environment and natural resources sector, policies regarding forestry management, reforestation and the operation of commercial forestry plantations are important drivers of carbon sequestration activities. Currently, even when governmental forestry programs might contribute to reducing emissions and sequestering carbon, they are rarely linked directly with the establishment of CSPs in Mexico. This is very obvious when looking at the content of the new General Law for Sustainable Forestry (SEMARNAT, 2003) which reflects a more comprehensive approach to the forestry sector than ever before, but still includes no mention of CSPs.

7.2 Natural protected areas: natural location for carbon sequestration projects

Another policy instrument that could be successfully linked to the establishment of CSPs is the Natural Reserves System (NRS). Although this system is in place in the country, it is still in a consolidation phase. One of the main obstacles to achieving consolidation is to find economic alternatives for the local people that will prevent natural resource depletion through inappropriate use. One feasible alternative would be the establishment of CSPs targeting conservation on one side and better living conditions for the local people on the other. Currently, the National Commission on Natural Protected Areas does not consider carbon sequestration as part of its objectives or activities. (CONAMP, 2001).

Nevertheless, some of these Reserves (Sierra Gorda and Calakmul) have produced proposals to establish

CSPs within their boundaries, but are still struggling to find investor partners. It would be interesting to explore the possibility of creating a portfolio of CSPs with the participation of those reserves located in forested areas as in the Costa Rican Protected Area Project (PAP) where the objective is "the financial and territorial consolidation of the National Parks and Biological Reserves in Costa Rica" (OCIC, 2003).

This is not an easy task considering the enormous diversity of the ecosystems represented in the NRS. Rather, what would be required is a case by case analysis to estimate potential carbon sequestration in combination with *ad hoc* farming alternatives. A national effort along these lines would encourage social participation in different regions of the country and raise the issue of CO_2 emissions and the possibility of sudden climate change to a higher level.

7.3 Linking land use planning to carbon sequestration projects

As discussed before, land use changes are often the causes of deforestation, soil erosion and water pollution. This makes land use planning a powerful tool for redirecting practices with negative impacts on the environment. And, of course, land use planning links closely to the establishment of CSPs. Although land use planning is not a practice carried out exclusively by the government, NGOs and academic groups frequently appeal to environmental authorities for information and/or methodological advice to elaborate local or regional land use plans. In this sense, it is important to considered CSPs as a productive alternative when assigning uses to land.

7.4 Eco-tourism

An activity that has proved to be successful when combined with CSPs in Costa Rica is eco-tourism. Such activity in Mexico has not been strongly encouraged by the Ministry of Tourism, and very few efforts have been made by private organizations or NGOs concerned about environmental conservation to pursue this idea. Joint policies between the Ministry of Tourism and the Ministry of the Environment and Natural Resources supporting CSPs and eco-tourism would result in attractive economic opportunities for land owners with preserved forest ecosystems. Among those policies, financial support (perhaps for experimentation) and an on-going research program related to the integration of these activities would be most important.

7.5 Research and data availability

In spite of the various and important efforts in the country to produce the basic knowledge required to encourage carbon sequestration project design, there is still a lot to be done regarding the documentation of carbon flux in natural and man-made ecosystems. The National Institute of Ecology has funded a national survey to identify research groups involved with different aspects of climate change (INE, 2001) The objective is to develop cooperation between academic institutions and governmental agencies based on this information.

Under the heading of carbon sequestration, no more than 15 contact people are reported at the national level. This is a very small number compared to the enormous potential of the country in this matter. It is urgent that Mexico increase governmental attention to developing policies and mechanisms to support and fund research relevant to the establishment of CSPs.

What would strongly support CSPs is the establishment of institutional mechanisms to generate crucial information such as deforestation rates and patterns in land use change at the regional level on a periodic basis. An updated and accurate forest inventory would be also very helpful in identifying those areas with high potential for conservation and sustainable management. Special attention ought to be paid to creating accessible databases that can be used by research groups, NGOs and farmer's Unions to put together proposals for CSPs.

7.6 Private sector participation

The private sector in Mexico has participated enthusiastically in programs related to energy efficiency as reported in the 2nd National Communication to the UNFCCC. Unfortunately, there is no mention of similar participation in carbon sequestration in forests. This is not surprising considering how few incentives that are for industry to do so. In the absence of an internationally established emissions market, a national version of such a market, linked to compliance with national regulations (NOM) regarding GHG emissions or even other kinds of pollution, is needed. Such a mechanism would be even more attractive if it could be linked to other economic incentives for companies, such as tax deductions.

7.7 Linking buyers and sellers

Based on the analysis presented in previous chapters, it is clear that there is a lack of efficient mechanisms to link those organizations designing CSPs and foreign companies interested in offsetting their GHG emissions in developing countries. The only project currently implemented in Mexico (Scolel Te) has shown a remarkable increase in its carbon sales since its linked with Future Forests, an agency specializing in linking buyers with carbon sellers.

The Costa Rican Office of Join Implementation has involved a private organization specialized in attracting direct foreign investment. The participation of a similar entity in the Inter-secretarial Committee on Climate Change would help organizations preparing CSP proposals find appropriate investors. Now a days, such organizations (mainly NGO's) have to deal with the social and technical issues related with the establishment of a project of this nature. They also have to search in the international market to find the right investors. The need for such efforts are discouraging for most groups which might be interested in designing CSP projects. They need ongoing skilled assistance.

7.8 Regional Forum

The establishment and maintenance of carbon sequestration projects face a lot of obstacles in developing countries. Some countries in Latin America are already engaged in this process (Annexes 2 and 3) with different level of success. Considering the similarities among these countries, it would be interesting and useful to share experiences in this matter in order to learn from successes and mistakes along the way. The organization of regional forums where researchers, farmer's organizations and governmental agencies could present and discuss their projects would be a good way to create a network between the countries that in the future would act as a regional magnet for investors.

7.9 Legal and administrative framework

A solid and well-structured administrative and legal framework would lead to the most efficient use of the limited human and economic resources, avoiding duplication and contradictory policy signals that could create obstacles to CSPs. Adequate insertion of the related laws (forestry laws, environmental laws, etc.) would help produce coordinated participation of all relevant sectors in such projects.

Regarding the administrative framework, there is always the risk of creating a bureaucratic structure which, instead of facilitating the processes would act as a barrier for policy design and decision making. Nevertheless, there is a need to strength the Inter- secretarial Committee on Climate Change as a first step to increasing the priority that the matter has on the domestic agenda. The format that such a structure should take will depend on the commitment and responsibility of each sector in designing and implementing specific policies.

8. Conclusions

Several conclusions can be drawn from my analysis:

- The scientific community generally agrees that global climate change is a reality. It is urgent to inform and sensitize governments and public opinion to strengthen measures to reduce CO_2 emissions and other greenhouse species.

- Even though there have been important developments such as the adoption of the Kyoto Protocol, the international community has been slow to find an effective response to the problems likely to be created by growing CO_2 emissions.

- One tool, with a very large potential and the added attraction of being truly integral in nature, is carbon sequestration.

- Carbon sequestration programs (CSPs) offer important global, national and local advantages; however, implementation is not as straightforward as was originally thought.

- Regarding the international arena, the future of sequestration programs seems to be on hold while the world waits for effective implementation of a functional emission-credit market.

- The future of CSPs within individual countries does not need to, and should not, wait for international cooperation. The benefits of such projects are many and, even without the potential international benefits, more than sufficient to justify their development.

- Accordingly, both developed and developing countries have started to explore different options to take advantage of these instruments, to contribute to the reduction in the release of greenhouse gases.

- In the case of Mexico, the country has been generating useful scientific information to support the design, implementation and monitoring of such projects. At the same time, there is a strong effort underway to create databases that will provide the information required for the success of such projects. CSPs in Mexico will require collaboration between academic institutions, government and NGO's.

- Environmental and socio-economic benefits likely to flow from CSPs make this type of project very attractive for Mexico. Such is the case of the Scolel Té project in Chiapas where, after five years, carbon sales and farmer participation keep growing.

- When it comes to actual implementation of other projects, there has been very limited success. Scientific uncertainties, the inadequacy of the institutional/legal framework and the lack of enforcement capabilities seem to be the major obstacles to successful implementation.

- A consistent set of indicators are needed to monitor the performance of CSPs. Such indicators should be simple, feasible, flexible and inexpensive. These characteristics will help in making CSPs affordable, and overcome obstacles such as the lack of information, common in countries like Mexico. The dimensions identified are: actual carbon sequestration, stability of the project, economic efficiency, efficiency/ease in implementation, operational efficiency and social capital and institutions

- Measurement of actual levels of carbon sequestration, stability of projects, economic efficiency and creation of social capital are some of the dimensions that are considered in my set of proposed indicators.

Annex 1. The total value of nature.

Many scholars have reflected upon the reasons for the unsustainable human lifestyles across the globe. They have found a wide variety of causes ranging from completely unintentional side effects of human activity to shockingly perverse conscious actions frequently motivated by economic reasons. For the most part, however, actions with harmful environmental impacts are caused by a lack of understanding of how the specific action relates to its direct and indirect effects on nature and what we loose from this impact.

Understanding better what nature means (its true total value), why it is important, will help us to understand the consequences of our actions and come up with options to better protect and recover it. This is the basic idea behind nature valuation techniques: identify and assess the different sources of nature's value to support decision making and the design of policy options for their protection and recovery. It is important to clarify that the fundamental aim is not to put a "$ price tag" on the environment, or its component parts, but to express the effect of marginal change in ecosystem services provision in terms of a rate of trade off against other things people value (Randall, 2002; Hanley and Shogren, 2002 quoted on CSERGE, 2002). In general, valuation is used for: a) comparing net total benefits of development and conservation projects, using the same resources; b) comparing the total costs of different options for the same project, choose the least-cost option (project costs + environmental costs); and c) calculating the costs of externalities and other market failures.

In practice, assessing the value of nature is a very complex task. If we turn to the literature for help, we will find an intense debate over what values resides in nature and what are the possible valuation techniques. This only reflects that nature itself is complex and multidimensional. First, should we assess value from an anthropocentric point of view (nature's value resides on its usefulness for humans) or adopt a broader perspective and assess a non-anthropocentric value (where entities are assumed to have sakes or goods of their own independent of human interests – Hargrove (1992))? Though theoretically feasible, the latter perspective presents multiple difficulties in practice. Studies so far have focused predominantly on anthropocentric valuation, both because of its simpler, more graspable nature and because of the need to focus on human activity and decisions as related to their environmental impacts.

There is an additional debate within methodologies of anthropocentric valuation that relates to whether valuation should focus on instrumental or intrinsic values of nature. Instrumental values refer to value derived from direct use of resources as well as indirect use (value in addition to what arises from usage, i.e. ecosystem functions). Intrinsic value refers to an attribution to entities that have a 'sake' or 'good of their own', and instrumentally use other parts of nature for their own intrinsic needs. It remains an anthropocentrically related concept because it is still a human valuer that is ascribing intrinsic value to non-human nature (CSERGE, 2002).

A methodology that attempts to take these issues into account and is widely accepted is called Total Economic Value (TEV). This taxonomy of environmental value comprises the sum of use and non-use values of nature. It includes both the components of instrumental value as well as some of the components of intrinsic value.

Estimating the different components of TEV can be very challenging. The "production function" of nature is so complex, and little understood in many instances, that reliable estimates of all of nature's services cannot be made. Because of this valuation studies have tended to focus on assessing only one of the functions (components) of TEV or a few at best. This does not recognize the fact that joint products are inherent in most of nature's processes; for example, trees perform valuable hydrologic, nutrient cycle, and climate functions. Accounting for value must recognize all these joint product values. According to recent reviews (CSERGE, 2002), the type of studies that are most needed now are those that value multiple functions and uses of nature and which seek to capture the 'before and after' states as environmental changes take place. This type of studies is "most important as aids to more rational decision taking in ecosystem conservation versus development situations involving different stakeholders.

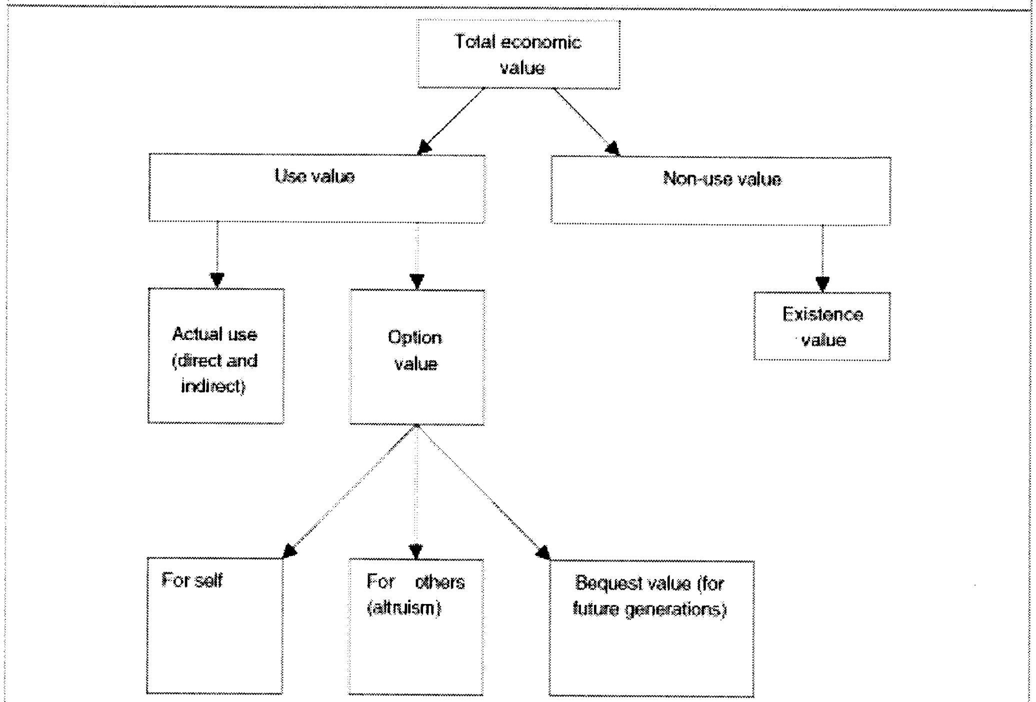
For the purpose of this document TEV offers a simple, schematic, presentation of nature's value, helpful to readily identify the different components and understand the role that each plays. Before describing TEV's components, a couple of notes should be highlighted:

- First, there is a source of value that hasn't been successfully incorporated to existing valuation techniques because of its complexity. It refers to value related to the fact that some combinations of ecosystem structure and composition are necessary to ensure the 'healthy' functioning of the system, or system status (Gren et al., 1994). For TEV this idea means that "the aggregate TEV of a given ecosystem's functions, or combinations of such systems at the landscape level, may not be equivalent to the total system value. The continued functioning of a healthy ecosystem is more than the sum of its individual functions (components). The difference lies in that the operating system yields or possesses primary, 'glue' or infrastructure value" (CSERGE, 2002). So, even though TEV reports usually focus only on its traditional components, the existence of the aforementioned value should be also kept in mind.

- Second, from the perspective of decision-making, it makes more sense to carry out economic valuation on a small scale focusing on marginal changes in the conditions of natural assets. For example, assessing the value of mangrove at a local scale and the impact of additional loses is more usable by policy than determining the global value of all mangroves. While the first one is easier to understand and use, the latter might just result in overwhelming value that lies "beyond the margin of analysis" (CSERGE, 2002). This rationale withholds both when analyzing TEV as a whole as well as when analyzing exclusively only one of its components, as will be the case in the later sections of the thesis.

With this said, we can now describe the framework of Total Economic Value. It sustains that total value of nature is conformed by adding up different components derived from instrumental and intrinsic utilities of nature. The following figure presents a summary of the main components of TEV.

Figure A1.1 Components of total economic value*



* Different authors classify the components differently. Thus, bequest value is often classified as a non-use value because the person expressing the value makes no use of the asset in question. But the bequest is effectively for potential future use and hence is classified under option value here.

Source: UK Department for Transport, Local Government and the Regions, 2002.

Once TEV has been assessed the common following step is to compare this value with total values of alternative land uses of the valued ecosystem. TEV methodology attempts to assign a monetary value to the use and non-use values of nature. The purpose of expressing the value in terms of money is to be able to compare with respect to marketable values. A main difficulty and source of debate arises from the fact that, other than direct use values, most of the environmental values have no prices or markets thus need a special calculation. There are many techniques to calculate values of each component ranging from widely accepted straightforward methods to highly debated and complex pricing systems. The most common valuation techniques for the specific valuation of TEV's components are: a) doze-response; b) replacement cost; c) human capital; d) hedonic pricing; e) contingent valuation; f) benefit transfer; g) prevention cost; and h) travel cost.

Direct use values

These refer to the values derived from the direct use of resources. The most "obvious" direct values are those that are considerable marketable and, thus, prices exist for them. In the case of a forest for example, the most clear direct value is that of timber production. However, there are other direct values derived from non timber forest products and refer to the variety of physical goods, other than timber, that are derived from forests and that are used either for subsistence purposes or traded or sold. They include plants and plant based products (fruits, latexes and medicines) as well as animals and animal based products. Not all of these values are as clear since not all of them have formal markets and prices.

Another source of direct use value comes from activities of tourism and recreation. It refers to what people pay to visit and use the region for recreation. Thus it includes travel costs, entry fee to the region, and general travel expenses. However, in practice information on the demand for the recreational services of is usually not available from markets, because many natural ecosystem areas are accessible to the public free of charge.

A final direct use source of value could come from research benefits. Natural ecosystems and their resources can be used as research and education facilities and the valuation of these benefits could be based on specific expenditures within the sites.

Indirect use values

Indirect use values of nature refer to the benefits derived from the biogeophysical functions of nature, also called ecosystem services. Nobody uses them directly but many benefit of them indirectly. Valuing these services present some of the most interesting and difficult challenges, as usually creative ways to indirectly assess them have to be design because there are no markets for these services and there are no clear-cut proxies. The first complication is that, in order to identify all relevant benefits, all the biogeophysical processes and functioning that yield the services flow must be characterized and quantified. This knowledge is obviously constrained by the complexity of nature itself. We still have a long way to really understand everything there is to know about how nature works. However, it is clear that ecosystems deliver life-sustaining services, and in many cases on a scale so large and complex that humanity would find it practically impossible to substitute them thus their disruption could have catastrophic effects (CHGE, 2002).

Ecosystem services could be understood according to the type of process they relate to (CHGE, 2002). Some services relate to cycling and filtration processes such as air purification, watershed services, purification of fresh waters, maintaining water quality in estuaries, binding toxic elements, detoxification of sediments and soils and maintenance of soil fertility. There are also services related to stabilization processes such as control of potential pest and disease-causing species, mitigation of floods, stabilization of landscapes against erosion, buffering the land against ocean storms and carbon sequestration on land an global climate. Processes related to biodiversity preservation would include providing critical habitat and genetic library function. Other processes could refer to translocation such as pollination of crops and dispersal of seeds and to life-fulfilling functions like recreation and aesthetics.

Option and existence values

Even though individuals might not use or have used the values of a particular resource, they might still assign value to them. They might want to use it in the future or they might simply value its existence. Option value refers to what individuals would be willing to pay for the option of using the resource in the future. If the option relates to their own use, the value is known as option value. If the future use is for others (e.g., their children or future generations), it is termed bequest value (UKDT, 2002). Existence value (the only clear cut non use value) refers to individual's willingness to pay for the conservation of the resource regarding their future plans of using it. Regarding the identification of the distribution of benefits and costs it is clear that option and existence value go far beyond the local scale. These values could thus help support the need for higher scale approaches of policy.

Annex 2. Carbon Sequestration Projects reported by UNCCC

The following table contains projects that have been accepted, approved or endorsed by the designated national authorities for AIJ of the Parties concerned.

1.Title of project: Increasing carbon sequestration in planted forests in Vietnam through the use of genetically improved planting stock, and modeling to quantify carbon sequestration of planted forests.

Participants: Vietnam and Australia

Description: The project consists of two components.

The first component will establish a 5ha seedling orchard for each of two imported forest plantation species, and develop these seedling orchards for production of genetically improved seed for use in plantations within Vietnam. Seed production from seedling orchards will enable 8,250 ha of *A.crassicarpa* and *E.tereicornis* to be planted over a five-year period. The established plantation will have a wood productivity 15% greater than routinely collected seed plantations.

The second component involves the collection of data on the growth of *Acacia mangium* plantations and using this data to calibrate the 3-PG growth and carbon sequestration model for Viet Nam. This will also entail the development of a girded program to provide climate data to run the 3-PG model in Viet Nam. Example locations in Viet Nam will be used to test the model by predicting the growth and carbon sequestration in different regions. Training and technology transfer will be provided to enable Vietnamese scientists to calibrate and apply the 3-PG growth and carbon sequestration predictive model to other key forest plantation species. The models will be applicable, with only minor recalibration, to nearby SE Asian countries such as Laos, Thailand and Cambodia.

The genetically modified seed will improve sequestration rates and improve growth rates above what would otherwise have been achieved through other less productive species or poorer quality seed. The IMH and RCFTI will monitor the growth and measure the carbon sequestration of the improved plantations.

Lifetime: 30 years

GHG Impact[a] (CO_2equivalent in metric tons): 646,590

2.Title of project: RUSAFOR-Saratov Afforestation Project

Participants: Russian Federation and United States of America

Description: The Russian Federation/USA Forestry and Climate Change Project-Saratov Afforestation Project (RUSAFOR-SAP) was conceived as a Russian-American forest carbon offset joint implementation demonstration project. The purpose of the project is to evaluate the biological, operational, and institutional opportunities to manage a Russian forest plantation as a carbon sink. The project established plantations on four sites in the Russian Federation, totaling 900 hectares. The sites were composed of marginal agricultural land and previously burned forest stands. Greenhouse gas benefits accrue from avoided carbon dioxide emissions (due to avoided soil erosion and biomass decay), and from carbon sequestration (due to tree growth and soil carbon accumulation).

Lifetime: 60 years

GHG Impact[a] (CO_2equivalent in metric tons): 292,728

3.Title of project: SIF Carbon Sequestration Project

Participants: Chile and United States of America

Description: The SIF Carbon Sequestration Project ("Project") will bring about the afforestation and sustainable management of approximately 7000 hectares in regions VII and VIII of Chile. The Project expects to sequester up to 385,280 tons of additional carbon during the life of the Project by expanding the total area of carbon sinks in the country. The Project will result in a net addition of approximately 55.04 tons of carbon storage per hectare on lands included in the Project. The Project seeks to generate cultivation alternatives for small and medium farmers by converting approximately 7000 hectares of marginal agricultural land to forest plantations. The structure of the Project minimizes the forestry risks to farmers by efficiently managing the planted hectares. The average plot size per farmer is expected to be 60-100 hectares. This shift in land-use will provide additional annual income to small and medium farmers, providing liquidity while allowing them to maintain their property rights.

Lifetime: 51 years

GHG Impact[a] (CO_2equivalent in metric tons): 3,977,307

4.Title of project: Community Silviculture in the Sierra Norte of Oaxaca

Participants: Mexico and United States of America

Description: The Community Silviculture in the Sierra Norte of Oaxaca Project will improve various aspects of existing silviculture and forest protection activities in six communities in rural southern Mexico. The project encompasses 49,027 hectares (ha) of land, of which 31,847 ha are closed forest. The remaining land is a mix of open forest, agroforestry, permanent and shifting agriculture, degraded or grazed land, fallow, restored forest, and tree plantations. The main project activities are the rehabilitation of degraded forest through agroforestry and plantation establishment, and the prevention of further degradation of standing forest by controlling pests, disease, and fire. The project involves other actions, including improved forest management (e.g., increased growth and reduced impact logging); increased agricultural efficiency; and increased wood-use efficiency. The project's greenhouse gas (GHG) benefits accrue from conservation of existing carbon stocks and increased carbon sequestration on forest and agricultural land.

Lifetime: 30 years

GHG Impact[a] (CO_2equivalent in metric tons): 3,065,333

5.Title of project: Project *Salicornia*: Halophyte Cultivation in Sonora

Participants: Mexico and United States of America

Description: Project *Salicornia* is Phase I of a two-phase project to cultivate a native halophyte (a salt-tolerant euphorb plant, *Salicornia bigelovii*) in a coastal desert region of northwest Mexico. Phase I is designed to research and demonstrate *Salicornia* cultivation on 30 hectares of coastal land. The estimated greenhouse gas (GHG) benefits of the project result from carbon accumulation and storage in the sandy soil. If Phase II is initiated, the cultivated crop could potentially serve as a valuable source of biomass material and food (cooking oil and fresh vegetable products), and could generate income for the local population.

Lifetime: 60 years

GHG Impact[a] (CO_2equivalent in metric tons): 3,255

6.Title of project: Bilsa Biological Reserve

Participants: Ecuador and United States of America

Description: The Bilsa Biological Reserve Project in Ecuador will preserve 2,000 hectares (ha) of tropical rainforest through the purchase and incorporation of these lands into the newly created Bilsa Biological Reserve in the Montañas de Mache in the Esmeraldas province of Ecuador. By preventing the conversion of these lands to marginal cropland and cattle pasture, the project will avoid emissions of carbon dioxide (CO_2).

Lifetime: 30 years

GHG Impact[a] (CO_2equivalent in metric tons): 1,170,108

7.Title of project: ECOLAND: Piedras Blancas National Park

Participants: Costa Rica and United States of America

Description: The ECOLAND Project will preserve tropical forest through the purchase of approximately 2,500 privately-owned hectares in the Piedras Blancas National Park (formerly named the Esquinas National Park) in southwestern Costa Rica. The purchased land will be conveyed to the Costa Rican Park Service for permanent protection. Greenhouse gas benefits accrue from conservation of existing carbon stocks on the parkland that would have otherwise been deforested.

Lifetime: 16 years

GHG Impact[a] (CO_2equivalent in metric tons): 1,342,733

8.Title of project: Forest Rehabilitation in Krkonose and Sumava National Parks

Participants: Czech Republic and Netherlands

Description: Not available.

Lifetime: 15 years

GHG Impact[a] (CO_2equivalent in metric tons): 9,834,120

9.Title of project: Noel Kempff Mercado Climate Action Project

Participants: Bolivia and United States of America

Description: The Noel Kempff Mercado Climate Action Project is a forest protection and sustainable management project located in eastern Bolivia. The project has expanded the existing Noel Kempff Mercado National Park, and will reduce future GHG emissions within both the existing Park and the Park expansion area, by eliminating legal and illegal logging activities (Component A). The project also will sequester carbon over time through the long-term protection and regeneration of the Park expansion area's already logged mahogany, oak, cedar, and palm forests, and through a mix of income-generating activities designed to support long-term preservation (Component B). Finally, GHG mitigation will also result from leakage prevention activities (Component C). Although GHG emission reductions and carbon sequestration are anticipated to occur within both the existing Park and the Park expansion area, the project will only claim GHG benefits associated with activities within the Park expansion area.

Lifetime: 30 years

GHG Impact[a] (CO_2equivalent in metric tons): 55,345,286

10.Title of project: Reduced Impact Logging[()] for Carbon Sequestration in East Kalimantan

Participants: Indonesia and United States of America

Description: This project will implement reduced-impact logging techniques (RIL) to reduce net greenhouse gas emissions associated with logging practices in East Kalimantan on the island of Borneo. The project involves the development of guidelines and procedures for implementing RIL techniques, on-site training in directional felling, and the implementation of RIL techniques on a total of 600 hectares (ha) of forested land targeted for imminent harvesting. Special strategies, including collaborative planning and management, will be undertaken to ensure that RIL ultimately contributes to local sustainable development. This to ensure that the locals will gain economic benefits.

Lifetime: 40 years

GHG Impact (CO_2equivalent in metric tons): 134,379

11.Title of project: Rio Bermejo Carbon Sequestration Project

Participants: Argentina and United States of America

Description: The Rio Bermejo Carbon Sequestration Project is a sustainable management and forest protection project located in degraded mountain forest and agricultural lands in northern Argentina. The project will combine tree plantations in agricultural lands, enrichment planting and sustainable management in degraded logged forests, and forest preservation to increase carbon sequestration. The major goals of the project are to: sequester carbon to help reduce greenhouse gas emissions, protect biodiversity, and to offer local communities sustainable economic alternatives.

Lifetime: 30 years

GHG Impact (CO_2equivalent in metric tons): 1,430,130

12.Title of project: Rio Bravo Carbon Sequestration Pilot Project

Participants: Belize and United States of America

Description: The Rio Bravo Carbon Sequestration Pilot Project is a forestry project located in northwest Belize, within the Rio Bravo Conservation and Management Area (RBCMA). The project combines land acquisition and a sustainable forestry program to achieve greenhouse gas (GHG) benefits from forest growth (i.e., carbon sequestration) that would not have occurred in the absence of project activities. The objective of the project is to demonstrate an optimal balance between cost-effective carbon sequestration, economically sustainable forest yield, and environmental protection.

Lifetime: 42 years

GHG Impact (CO_2equivalent in metric tons): 6,023,992

13.Title of project: Rio Condor Carbon Sequestration Project

Participants: Chile and United States of America

Description: The Río Cóndor Carbon Sequestration Project is reducing carbon emissions from a 272,880 hectare forest management project in Tierra del Fuego, Chile. The land is owned and managed by Forestal Savia Ltda., a Chilean company. CFix, L.L.C., a Washington State Limited Liability Company, is managing the carbon offset opportunity in partnership with Fundación Chile, a Chilean non-profit organization focused on technology transfer, new business development and sustainable development in Chile. The Project will achieve additional carbon storage by preserving old growth forests that would have been converted into young, managed stands in the baseline scenario. Sustainable forest management will continue on the lands not protected by the carbon project. In the future, the project will reduce emissions by preserving sphagnum bogs that are found on the property and that are vulnerable to third-party concessionaires.The forest preservation measures will result in approximately 15,469,278 million metric tonnes of avoided CO_2 emissions over the 60-year life of the project. Emission reductions over the life of the project will increase by 20,247,390 tonnes to 35,716,668 tonnes when the bog component is incorporated into the project.All measures are dependant on the eventual sale of carbon offset credits at a price that justifies the forgone revenues associated with limiting harvest. Furthermore, Forestal Savia, Fundación Chile, and CFix reserve the right to alter the carbon project in the future.

Lifetime: 60 years

GHG Impact (CO_2equivalent in metric tons): 6,359,828

14.Title of project Territorial and Financial Consolidation of Costa Rican National Parks and Biological Reserves

Participants: Costa Rica and United States of America

Description: The Territorial and Financial Consolidation of Costa Rican National Parks and Biological Reserves Project will transfer to the Costa Rican Ministry of Environment and Energy (MINAE) primary forest, secondary forest, and pasture lands that have been declared National Parks or Biological Reserves but have not been registered in the National Property Registry as part of the Forest Patrimony of the State. Until the registration process has been completed, these lands will remain under the management of their current owners and will be vulnerable to deforestation. The greenhouse gas (GHG) benefits of the project accrue from the preservation of carbon stocks in the primary forest and from biomass growth (i.e., carbon sequestration) in the secondary forest and pasture. The project will also involve the construction of an Earth Center: a multidisciplinary development combining residential, commerce, and work activities to provide public education and entertainment and to promote ecotourism. Two previous

USIJI projects, Project BIODIVERSIFIX and the protected area component of Project CARFIX: Sustainable Forest Management, have been incorporated into this project and are no longer reported as separate USIJI projects.

Lifetime: 25 years

GHG Impact (CO_2equivalent in metric tons): 57,467,261

15.Title of project: Commercial Reforestation in the Chiriquí Province

Participants: Panama and United States of America

Description: This project will reforest 500 hectares (ha) of currently degraded lands in the Chiriquí Province in the western region of Panama. The project area will be planted with teak (*Tectona grandis*), established as a certified teak plantation, and managed in a sustainable manner as a source of high quality hardwood. The project is estimated to result in net sequestration of approximately 16,000 tonnes (t) of carbon through tree growth and production of durable wood products over a 25-year lifetime.

Lifetime: 25 years

GHG Impact (CO_2equivalent in metric tons): 57,640

16.Title of project: Klinki Forestry Project

Participants: Costa Rica and United States of America

Description: The Klinki Forestry Project will convert pastures and marginal farmland to commercial tree plantations by promoting the planting of 6,000 hectares of private farms with mixtures of selected fast-growing tree species in a matrix, with the Klinki tree as a major component. The trees will be harvested periodically for use in long-lived lumber products (such as utility poles) or left standing. The project will include small, medium, and large farms, educational pilot projects, and investor farms. Farmers will be given incentives for plantings in return for the rights to the sequestered carbon. The objective of the project is to develop a demonstration of the involvement of the farmer in carbon sequestration as an economic activity using the latest tree farming technology while providing greenhouse gas (GHG), wood production, and conservation benefits.

Lifetime: 46 years

GHG Impact (CO_2equivalent in metric tons): 7,216,000

17.Title of project: Reforestation and Forest Conservation AIJ Pilot Project.

Participants: Costa Rica and Norway

Description: The project will be developed in the Virilla river basin, in Costa Rica, where four thousand hectares (ha) of reforestation and forest conservation/regeneration will take place. One thousand ha will be reforested and 3,000 ha of existing forest area will be conserved, 2,000 ha in a natural primary forest area and 1,000 ha in a secondary forest area. The implementation period will be ten years in successive and overlapping stages covering the micro-basins in the zone. A 25-year active life of the project is estimated.

The project will sequester or avoid emissions of carbon (C) through reforestation and forest conservation activities. The "cumulative effect" or net benefit of this forestry project is 230,842 metric ton of Carbon (mt C) In addition, it will displace fossil fuel emissions from the Costa Rican energy system, due to increased output from the several hydroelectric projects located in the Virilla river basin.

This project is part of the "Private Forestry Project" (PFP), a national scope forestry project designed to use AIJ foreign investments to compensate farmers for their conservation and reforestation efforts. The PFP will allow for the expansion of privately held conservation areas, through expanded and long-term use of the state's forestry incentives. Under PFP, such incentives would change from governmental subsidy to a payment for environmental services.

Lifetime: 25 years

GHG Impact (CO_2equivalent in metric tons): 230,842

18.Title of project: Reforestation in Vologda Pilot Project.

Participants: Russian Federation and United States of America

Description: This project is a reforestation project located in Vologda, about 300 miles northeast of Moscow. Two thousand hectares (ha) of collective state farmland adjacent to and within the Russky Sever National Park will be converted from hay fields back to forest. The land will be removed from hay production, and allowed to regenerate naturally, supplemented initially by planting on about 15% of the area. If regeneration proceeds slowly, additional planting or soil preparation will be implemented during the third year of the project. Greenhouse gas benefits accrue from forest carbon sequestration that would not have occurred in the absence of project activities.

Lifetime: 60 years

GHG Impact (CO_2equivalent in metric tons): 858,000

19.Title of project : Scolel Té: Carbon Sequestration and Sustainable Forest Management in Chiapas

Participants: Mexico and United States of America

Description: Scolel Té is a forestry and land-use project located in northeast Chiapas, Mexico. This project will assist farmers primarily in nine Mayan indigenous communities located in highland and lowland ecoregions with developing small agroforestry and forestry enterprises. The greenhouse gas (GHG) benefits of the project accrue from forest growth (i.e., carbon sequestration) that would not have occurred in the absence of project activities. In addition to reducing forest degradation and conversion to agriculture and improving the sustainability of local farming systems, this project is expected to contribute to the social and economic welfare of these communities as well as the preservation of the region's rich biodiversity.

Lifetime: 30 years

GHG Impact (CO_2equivalent in metric tons): 1,210,000

Annex 3. CTrade and WRI reported projects

CTrade reported projects.

COUNTRY	TYPE	VALUE ADDED	COST	DESCRIPTION
Figi	Reforestation	carbon farming	$4/ton	6,400 hectares Figi Pine
Indonesia	Reforestation	bio-diversity	$3/ton	1,000,000 tons
India	Sustainable Forestry	tree planting	$4/ton	2,500 acres, USIJI cert
Malaysia	Reduced Impact Logging	bio-diversity	$2/ton	Host Country Certification
Malaysia	Sustainable Forestry	habitat conservation	$2/ton	1,000,000 tons
Paraguay	Sustainable Forestry	habitat conservation	$4/ton	50,000 hectares
Paraguay	Sustainable Forestry	return on investment	$5/ton	10,000 hectares, Chaco

Source http://www.ctrade.org/project.html

World Resource Institute reported projects. Those that were already included in the report of the UNCCC and by CTrade had been removed to avoid duplicity

Project / Partners / Components	Country	CO sequestered over project's lifetime (tons)	Cost
CARE/Guatemala *Allied Energy Services Corp. (AES), CARE* Agroforestry, reforestation, protection, silvo-pastoral	Guatemala	15.5 - 58 million	$14 million Total $2 million from AES
RIL Logging *New England Electric (NEES), Innoprise, Rainforest Alliance, COPEC* Reduced-impact logging	Malaysia	300,000-600,000	$450,000
Paraguay Forest Protection *AES, The Nature Conservancy, FMB Foundation, U.S. Agency for International Development* Preservation, sustainable agroforestry	Paraguay	14.6 million	$3.4-4.5 million (AES provided $3 million)
Amazon Basin Forest Protection *AES Corp., OXFAM* Land tenure	Peru, Bolivia, and Ecuador	70 million	$2 million
Uganda Reforestation *FACE*	Uganda	7,172,550	$5.6 million

Bottomland Hardwood Forest Restoration *UtiliTree Carbon Co., Louisiana Tech University, Louisiana Dept. of Wildlife and Fisheries* Reforestation of marginal farmland	United States	470,000	$176,493
Reduced-Impact Logging *UtiliTree Carbon Co., Rakyat Berjaya Sdn., Forest Rsearch Institute of Malaysia, Sabah Forestry Dept., Center of International Forestry Research (CIFOR), Rainforest Alliance* Reduced-impact logging	Malaysia	379,000	Less than $1.00
Pacific Forest Stewardship *UtiliTree Carbon Co., Pacific Forest Trust, Oregon State University* Improved forest management and conservation easements	United States	242,082	Less than $1.00
Reforestation in Eastern Washington *Tenaska Inc., PacifiCorp, Trexler and Associates* Reforestation	United States	250,000	$2.00 per ton (Project cost confidential)
Forest Resource Trush Carbon Offset Project *PacifiCorp, Forest Resource Trust, Trexler and Associates* Reforestation	United States	45,000	Less than $2.00 per ton $75,000 total
Southern Oregon Reforestation *PacifiCorp, Trexler and Associates* Reforestation	United States	66,150	$2.00-2.50 per ton
Salt Lake City Urban Tree Project *Tree Utah, PacifiCorp, Trexler and Associates* Urban forestry	United States	5,000	$10-15 per ton
Western Oregon Carbon Sequestration Project *UtiliTree carbon Co., Trexler and Associates, Oregon Woods, Inc., participating landowners* Afforestation and sequestration in wood products	United States	564,000-747,000	Less than $1.00

Source: http://www.wri.org/climate/sequester.html

References

Center for Health and the Global Environment (CHGE). 2002. Biodiversity: Its importance to human health. Harvard Medical School. Massachusetts, U.S.

Center for Social and Economic Research on the Global (CSERGE), 2002. "Valuing nature: lessons learned and future research directions". CSERGE working paper EDM 02-05. ISSN 0967-8875

Comision Nacional de Areas Naturales Protegidas, (CONAMP) 2001. Programa de Trabajo 2001-2006 SEMARNAT Website accesed May 20a03.
http://www.semarnat.gob.mx/programas/documentos/index.shtml#sector

Commission for Environmental Cooperation. 2001. Mexico and Emerging Carbon Markets. Investment Opportunities for Small and Medium-size Companies and the Global Climate Agenda. CEC Website accesed March 2003 (http://www.cec.org).

Consejo Civil Mexicano para la Silvicultura Sostenible, A.C. Website accesed February 2003 (http://www.laneta.apc.org/ccmss/summary.htm).

Costa Rican Office On Joint Implementation (OCIC, 2003), Activities Implemented Jointly National Programme,Costa Rica. UNFCCC Website accesed May 2003.
http://unfccc.int/program/coop/aij/aijprog/aij_pcri.html

Department for Transport, Local Government and the Regions 2002. "Economic valuation with stated preference techniques: summary guide". DTLGR, United Kingdom.
(http://www.dtlr.gov.uk/about/economics/index2.htm)

Dixon, R.K., S. Brown, R.A. Houghton, A.M. Solomon, M.C. Trexler, J. Wisniewski, 1994. Carbon Pools and Flux of Global Forest Ecosystems. Science, 263, pp. 185-190.

Environmental Protection Agency (EPA). US. Website accesed March, 2003 (http://www.epa.gov)

Goudie, A., 1990. The Human Impact on the Natural Environment. Basil Blackwell Ltd, Oxford, U.K. 3rd Edition. 388 pp.

Gren, I-M., Folke, C., Turner, R.K., and Bateman, I.J., (1994). Primary and secondary values of wetland ecosystems. Environmental and Resources Economics, (4): 55-74.

Guzman, A., 2003. INE. Personal Communication.

Hargrove, C., (1992). "Weak anthropocentric intrinsic value". The Monist, 75: 183-207.

Houghton, R.A., C.M. Woodwell. 1989. Global Climate Change. Scientific American, 260:4, pp. 36-40.

Instituto Nacional de Ecologia (INE). 1999. Estrategia Nacional de Accion Climatica. INE Website accesed May 2003.
http://www.ine.gob.mx/ueajei/publicaciones/consultaPublicacion.html?id_pub=134&id_tema=1&dir=Consultas

Instituto Nacional de Ecologia (INE). 2000. Segundo inventario de emisiones de gases. Efecto Invernadero 1994-1998. INE Website accesed February 2003 (http://www.ine.gob.mx).

Instituto Nacional de Ecologia (INE). 2001. Segunda Comunicacion Nacional ante la Convencion Marco de las Naciones Unidas sobre el Cambio Climatico. INE-SEMARNAT.

Instituto Nacional de Ecologia (INE). 2001 Potencial de la Investigación Científica y Tecnológica en Materia de Cambio Climático en México. INE Website accesed May 2003. http://www.ine.gob.mx/dgicurg/potencial.html .

Instituto Nacional de Ecologia (INE). 2003. Proyectos de Implementacion Conjunta. INE Website accesed April 2003 (http://www.ine.gob.mx/dgicurg/cclimatico/ic/index.html).

Instituto Nacional de Ecologia (INE). 2003. Calakmul. INE Website accesed April 2003 (http://www.ine.gob.mx/dgicurg/cclimatico/ic/calakmul.html).

Intergovernmental Panel on Climate Change (IPCC), 2001. Third Assessment Report, IPCC, UN. New York, 2001.

Intergovernmental Panel on Climate Change (IPCC), 2001. Climate Change 2001: The Scientific Basis. IPCC, UN. New York, 2001.

Lashof, D.A, D.R. Ahuja, 1990. Relative Contributions of Greenhouse Gas Emissions to Global Warming. Nature, 344:5, pp. 529-531.

Massera, 1995. Carbon mitigation Scenarios for Mexican forests: Methodological considerations and results. Interciencia. Vol. 20 no. 6.

Massera, 1997. Carbon emissions from Mexican forests: Current situation and long-term scenarios. Climatic Change 35: 265–295. Kluwer Academic Publishers.

Ordoñez, J.A.B.1999. Captura de Carbono en un Bosque Templado: El caso de San Juan Nuevo, Michoacan. Instituto Nacional de Ecologia. SEMARNAP, Mexico.

Organization for Economic Cooperation and Development (OECD). (2001). Towards sustainable development: environmental indicators 2001. OECD, Paris, France.

Organization for Economic Cooperation and Development (OECD). France. Website accesed May, 2003. (http://www.oecd.org).

Pearce, D.W., E. Barbier, and A. Markandya 1990. "Blueprint for a Green Economy". Earthscan, London.

Pearce, D.W. and D. Moran 1994. "The Economic Value of Biodiversity". In Association with the Biodiversity Programme of IUCN. Earthscan Publications Ltd: London.

Schneider, 1989. The Greenhouse Effect: Science and Policy. Science, 243:10, 271-281

Scolel Té, 2003. Website accessed April 2003. http://www.eccm.uk.com/scolelte/.

Secretaria de Medio Ambiente y Recursos Naturales (SEMARNAT). Mexico. Website accesed May, 2003 (http://www.semarnat.gob.mx

Secretaria de Medio Ambiente y Recursos Naturales (SEMARNAT), 2003. Ley General de Desarrollo Forestal Sustentable. Diario Oficial de la Federacion. Febrero 2003.

Smith, T.M., W.P. Cramer, R.K. Dixon, R. Leemans, R.P. Neilson, and A.M. Solomon, 1993. The Global Terrestrial Carbon Cycle. Water, Air and Soil Pollution, 70, pp. 19-37

Tickell C, Sustainable Development in the Global Context. House of Commons Environmental Audit Commission. House of Commons, 16 January 2002.

United Nations Commission for Sustainable Development (UNCSD). (2001). Indicators of sustainable development: guidelines and methodologies. UN, New York.

United Nations. Text of the United Nations Framework Convention on Climate Change.

Velázquez A. J. F. Mas & J. L. Palacio. 2002. Análisis del cambio de uso del suelo. Instituto de Geografia UNAM-INE, SEMARNAT. INE Website accesed March 2003. (http://www.ine.gob.mx/dgoece/xid/dgioece/i_usv/)

Woodrising Consulting Inc., 2002. About Grupo Ecológico Sierra Gorda, I.A.P. Woodrising Consulting Inc. Website accesed March 2003 (http://www.woodrising.com/gesg/about.htm).

Woodrising Consulting Inc., 2002. Sustainable Forestry in the Sierra Gorda Biosphere Reserve, Mexico. Website accesed February 2003 (http://www.woodrising.com/woodrise/Offsets/sierra2002.pdf).

Woodrising Consulting Inc., 2003. Website accesed March 2003 (http://www.woodrising.com/).

WRI (2001). "Evaluating carbon sequestration projects: A first attempt". WRI, Washington D.C. (http://www.wri.org)

WRI. 2002. Forest and land-use change carbon sequestration projects. WRI Website accesed February 2003 (http://www.wri.org/climate/sequester.html).