PHILIPPINE FOREST LANDS: OPPORTUNITIES FOR MITIGATING CLIMATE CHANGE

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ABSTRACT

Climate change is one of the most critical environmental threats mankind has ever faced. Because of their rapid biomass accumulation, tropical forests are viewed as one of the promising approaches to mitigate C in the atmosphere. The first part of the paper discusses the ways by which tropical forests could serve as C sink by conservation, expansion, and substitution. The second part provides a national estimate of the potential of Philippine forest lands to store and sequester C. All forest landuses are estimated to store about 1105 M tons C and sequester 34 M tons C per year. The latter is equivalent to almost 80% of total Philippine C emissions. The third part of the paper explores practical strategies for mitigating C through forestry interventions. These include: C-offset projects, reforestation by private groups, and urban forestry. Costs of C sequestration are also estimated. Finally, recommended research topics are identified.

Key words: C storage, C sequestration, climate change, tropical forests

1. INTRODUCTION

Global warming, or climate change in general, and its consequences are among the most pressing issues today. Consider the following recent findings (IPCC, 1995):

- the surface temperature this century is as warm or warmer than any century since at least 1400 AD
- the global average surface temperature has increased by 0.3 to 0.6°C over the last century
- the last few decades have been the warmest this century; sea level has risen from 10 to 25 cm
- mountain glaciers have generally retreated this century
- by the year 2100, the average surface temperature is projected to in-

In addition, the year 1997 was the hottest year since recording began. These changes have been attributed to the rise in concentration of greenhouse gases (GHGs) in the earth's atmosphere. GHGs like CO_2, methane, nitrous oxides, and chlorofluorocarbons absorb thermal radiation emitted by the earth's surface. Thus, rising concentration of GHGs in the atmosphere could lead to a change in energy balance and consequently the world's climate. The consequences of this change are disastrous. For instance, melting of polar ice caps will submerge many of the world's biggest cities. Changes in climatic patterns are also predicted to dislocate much of the world's population.

Among GHGs, CO_2 is the most abundant and is responsible for more than half the radiative forcing associated with greenhouse effect (Dixon et al., 1993; Moura-Costa, 1996). Scientists have pointed out that the global carbon cycle may be out of balance as indicated by the fact that the atmospheric CO_2 levels are 25% higher compared to the time before the industrial revolution. This rise has been rightly attributed to anthropogenic causes, primarily fossil-fuel combustion and, to a lesser degree, such activities as agriculture and deforestation.

Forest ecosystems play an important mitigating role in climate change because they can both be sources and sinks of CO_2 (Trexler and Haugen, 1995). At present, the world's tropical forests are estimated to be a net source of C (1.6 billion tons in 1990 alone) primarily because of deforestation, harvesting, and forest degradation. However, or the positive side, the tropical forests have the biggest long-term potential to sequester C (80% of the world's forest total) by protecting forested lands, slowing deforestation, reforestation, and agroforestry (IPCC, 1995).

The Philippines is one of the tropical countries that have a high potential for forestry options to mitigate climate change, specifically C emissions. It has a sizable forest land area that could be developed for C sequestration projects.

2. TROPICAL FORESTS AS CARBON SINK

Mitigating C emission through forestry in tropical areas like the Philippines is one of the most feasible ways of reducing CO_2, in the atmosphere. In fact, drawing CO_2 out of the air and into the biomass is the only known practical way of removing large volumes of GHG (Trexler and Haugen, 1995). Among the different zones, forestry in the tropics has the greatest long-term potential for C conservation and sequestration by (in decreasing order of importance): protecting lands for natural and assisted regeneration, slowing deforestation, forestation, and agroforestry (IPCC, 1995).

Tropical forestry is also receiving much attention because of cost effectiveness (is cheaper in the tropics), high potential rates of C uptake (because of fast growth), and associated environmental and social benefits (Moura-Costa, 1996).

Forests could serve as sinks of C through the process of photosynthesis which converts CO_2 from the atmosphere to carbohydrates. A large proportion of the C is released back to the atmosphere through respiration. However, a certain portion becomes "fixed" once it is incorporated in the biomass of trees. Thus, the higher the biomass accumualtion the greater is the potential to sequester C. Aside from the living biomass, forest soil also stores a substantial amount of C.

There are three general ways by which forest management practices can be employed to curb the rate of CO_2 increase in the atmosphere: conserving existing C pools, expanding the amount of C stored, and substituting wood products for fossil-fuel products.

2.1 Conservation of Existing C Sinks

The goal of this approach is to maintain or improve existing C pools in Philippine forests by protecting forest reserves, using of appropriate silvicultural practices, and controlling deforestation.

Protected (mainly old-growth and mossy) and second-growth forest cover 6.1 M ha (FMB, 1996). The NIPAS Law provides the legal foundation for the conservation of protected forests. However, there are fears that a substantial portion of protected areas are still without adequate protection. Activities that promote the conservation of these forest areas will contribute positively by preventing the release of C to the atmosphere.

The deforestation rate in the Philippines is 100,000 ha which translate to a loss of 8.8 M tons C every year. Strategies that will reduce the rate of forest loss will contribute to the reduction of C emitted to the atmosphere. Globally, it is estimated that tropical deforestation contributed 1.7 billion tons of C in 1990 alone, about 30% of total net yearly emissions (Trexler and Haugen, 1995; Muoro-Costa, 1996).

Certain silvicultural practices may lead to increased C sequestration. Many of these practices, such as timber stand improvement (TSI), improved harvesting, and fertilization, are directed to increasing forest growth. The exact contributions of these practices have not been quantified. As a general rule, the higher the biomass produced the more C fixed. However, this is not always true since different species and even age classes of trees affect the C density of the wood.

A good example of how silvicultural systems could be improved is the Reduced-Impact Logging Project in Sabah, Malaysia where the New England Electric System (NEES) provided funds to train personnel of the logging concession (ICSB) in improved harvesting techniques. By controlling logging damage, the project is able to sequester 25-45 tons C/ha after 2 years of operation (Dixon et al., 1993).

Another way of minimizing C emission from forest lands is by preventing fire. It is estimated that 68,636 ha of forest lands were burned from 1992-1996 (Castillo, 1997). The exact amount of C emitted from these lands has not been quantified. In addition, other GHGs such as methane and CO are also released to the atmosphere. Programs aimed at fire prevention will result in conservation of C in plant biomass.

While much of the attention is focused on plant C storage, tropical forest soils are significant sinks of C. It is estimated that up to 30% (90 t/ha) of C in the forest ecosystem is tied up in the soil (Moura-Costa, 1996). Consequently, practices that help maintain or improve soil organic C will have positive benefits. Examples of these practices are (Dixon et al., 1993):

- soil erosion control measures
- improving soil fertility
- reducing shifting agriculture
- retaining forest litter and debris after logging

In sum, all the various programs and initiatives in the Philippines geared towards the preservation of remaining forest cover could contribute to the prevention of rise in CO_2 concentration in the atmosphere.

2.2 Expansion of C Stocks in Forest Lands

The goal of this approach is to expand the amount of C stored in forests ecosystems by increasing the area and/or C density of natural and plantation forests and increasing storage in durable wood products.

Since C sequestration is a function of biomass accumulation, the simplest way to expand C stocks is to plant trees. In the Philippines, there are at leat 1.18 M ha of grassland areas that could be reforested. Aside from the many benefits associated with forests, these areas have the potential to sequester a substantial amount of C. Assuming a C fixation rate of 4.4 t/ha/yr (Lasco, 1997) for Philippine plantations, a minimum of 5.2 M tons C can be sequestered every year if all these areas are reforested. This rate is already equal to 15% of total current annual C emissions of the entire Philippines.

Aside from the grassland areas, brushland and agricultural areas could provide additional areas for rehabilitation (up to 8 M ha). Most of these areas have low C densities as a result of less than optimum use of the land. In shifting cultivation areas, the use of agroforestry is usually recommended. The introduction of woody perennial species will expand the C storage capability of cultivated areas. The great variety of agroforestry systems in the Philippines (Lasco and Lasco, 1989), in contrast to tree plantations, makes it imperative that research be conducted on their potential to sequester C.

The choice of species to be planted will affect the potential to sequester C (Muora-Costa, 1996). In the Philippines, fast-growing species such as *Gmelina arborea, Acacia mangium, and Eucalyptus* spp. are commonly used. They accumulate more biomas and C than slow-growing species for the same period of time. However, fast-growing species typically have lower wood density and thus contain less C than wood of slow-growing species.

A good example of this approach is the FACE Foundation project with Innoprise in Sabah, Malaysia (Dixon et al., 1993). Initially, 2000 ha of degraded forest stands will be rehabilitated. If successful, an additional 26,000 ha. will be rehabilitated over the next 25 years.

2.3 Substitution of Wood Products for Fossil-Fuel-based Products

Substitution aims at increasing the transfer of forest biomass C into products (e.g., construction materials and biofuels) that can replace fossil-fuel-based energy and products, cement-based products, and other building materials (IPCC, 1995). This approach is considered to have the greatest mitigation potential in the long term (> 50 years). For instance, the substitution of wood grown in plantations for coal in power generation can avoid C emissions by an amount up to four times that of C sequestered in the plantation (IPCC, 1995).

3. CO_2 SEQUESTRATION POTENTIAL OF PHILIPPINE FOREST LANDS

This section provides a national perspective of the potential of forest lands in the Philippines to mitigate C emissions as summarized from Lasco (1997) and Lasco and Pulhin (1997).

Fig. 1 shows the present allocation of forest lands in the Philippines. For the purpose of this analysis six major categories are identified: old-growth forests and other protected forests, second growth forests, brushlands, grasslands, tree plantations, and agroforestry farms.

The total C in the biomass of all Philippine forest landuse types is equal to 884 M tons (Table 1). On the other hand, annual C sequestration amounted to 27.2 M tons (Table 1). Not included in this estimate are C contained understorey vegetation, litter, and soil. If these comprise 25% of total aboveground biomass (IPCC, 1996), then the total C in the forest ecosystem is about 1105 M tons with an annual C sequestration of around 34.0 M tons.

It is reported that annual Philippine CO_2 emission is equivalent to 128.6 M tons (Murdiyarso, 1996). At present, Philippine forest lands are able to sequester an equivalent of about 100 M tons of CO_2 or 78% of total C released.

The total C sequestered per year by Philippine forests represent about 0.11 % of annual total global C emissions of 25 billion tons.

4. CARBON EMISSION MITIGATION STRATEGIES THROUGH FORESTRY

In the Philippines, the role of forest lands in mitigation of GHG emission, specifically CO_2, has not yet been given much attention. This is unfortunate for several reasons. First, with chronic fund shortage, there is little the government can do to reforest the millions of hectares of denuded areas. The C sequestration potential of forest trees provides a window of opportunity to encourage the involvement of the private sector in reforestation efforts as will be described below.

Table 1. C storage and sequestration of forest landuse in the Philippines

	Forest Type	Area (10^6 ha)	Total C in biomass (10^6 tons)	C sequestration (10^6 t/yr)
A.	Protection Forest	2.7	307	4.1
B.	Second-growth Forest	3.4	298	0.4
C.	Brushlands	2.3	81	6.4
D.	Grasslands	1.18	54	0
E.	Tree Plantations	0.6	25	2.6
F.	Agroforestry Farms	5.7	119	13.7
TOTAL		15.88	884	27.2

Assumptions:
1. C content = biomass x 0.5
2. C content = volume x wood density x 0.5
3. Wood density for Asian tropical forests = 0.57 t/cu m (Brown and Lugo, 1984)
4. Total biomass of mossy, pine, mangrove, submarginal, and production forests 50% of old-growth forest
5. Total biomass of agroforestry farms 50% of tree plantation
6. Biomass of old-growth forest = 350 tons/ha (Brown et al., 1991)
7. C sequestration of second-growth forest net of harvest and deforestation
8. Underground vegetation, soil, and litter not included in analysis
9. C content of grassland = 45.8 t/ha (aboveground)
(IPCC, 1996) 72.6 t/ha (underground)
10. Biomass of brushlands = 20% of OGF (70 t/ha)
11. C sequestration of brushlands = second-growth forests (2.8 t/ha)
12. Agroforestry farms include coconut farms and fruit orchards

Second, as an archipelagic country composed of thousands of small islands, the Philippines is very vulnerable to the impacts of climate change like sea level rise. Thus, it is in the nation's interest to mitigate C emissions. Lastly, the expansion of forest areas through C sequestration projects will result in many ancillary benefits: conservation of biodiversity, soil and water conservation, etc.

The following discussion presents various ways by which the Philippines can mitigate C emissions through forestry options.

4.1 C Offset Projects

C offset can be defined as any action undertaken to remove from and/or prevent the release of carbon dioxide into the atmosphere in order to balance GHGs emissions taking place elsewhere (Moura-Costa, 1996). The intent as well

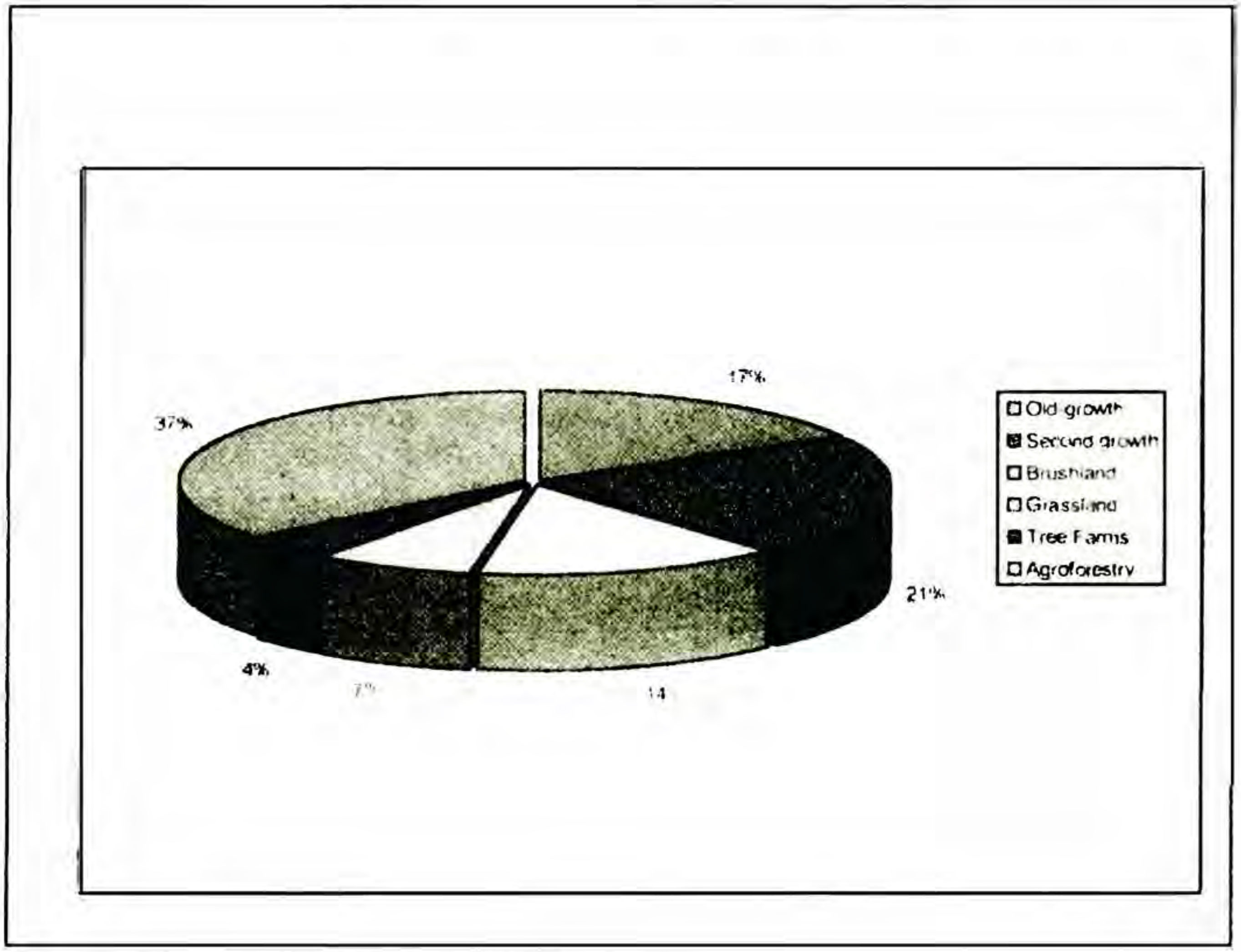

Figure 1. Current landuse in the Philippines.

as incremental effect criteria are considered vital for valid offset projects. Simply renaming existing projects as "C offsets" is not acceptable if there is no added C sequestered. For example, an existing reforestation project could not be automatically considered a C-offset project (although it does sequester C). However, if a forest area that is in danger of destruction is protected primarily to prevent C release to the atmosphere, then it is a valid C offset since C would have been released without the project.

The idea of using trees to sequester C is premised on the global circulation of CO_2. Thus C released in any part of the Philippine (or the world), could be sequestered by forests in another location. A review of existing C-offset projects in different countries of the world reveals the following project objectives and characteristics (Muora-Costa, 1996):

- C conservation and sequestration
- cost-effectiveness
- sustainability
- local participation
- ancillary benefits aside from C storage

- potential for C credits under joint implementation of the 1993 US Energy Policy Act process

In spite of pollution control devices, there are industries that release substantial amount of C to the atmosphere such as power plants and industrial factories. For instance, 30% of total C emissions worldwide can be traced to power generation (Muora-Costa, 1996). The rapid industrialization of the Philippines will result in higher C emissions from these sources.

Corporations emitting C could reforest and maintain an area corresponding, either fully or partially, to the C they release to the atmosphere. This approach could be implemented as part of the EIA system of the country. Their license to operate and level of operations could be made contingent on the success of the reforestation program.

To illustrate, Table 2 shows the CO_2 emissions of three hypothetical power-generating plants and the equivalent forest area in the Philippines needed to store and sequester the C released (Lasco and Pulhin, 1997):

From Table 2, it may not be practical to require power-generating industries to sequester all the C they release. Besides being too expensive, there will be insufficient forest land areas for all of them. However, for some industries like geothermal power plants, it may be feasible to sequester 100% of the C emitted.

Aside from implementing C offsets within the framework of the EIA system, private corporations should be encouraged to participate in a voluntary manner. A mechanism that will pave the way for this kind of involvement should be developed.

One advantage of this approach is that money does not need to go through the government coffers where little will most likely reach the field. Private corporations can directly finance its operation. The Department of Environment and Natural Resources (DENR) or a third party will just monitor the compliance of the firm.

While the details of this approach need to be carefully thought of, a C offset program could substantially reduce the backlog in reforestation. Safeguards must

Table 2. Carbon dioxide emissions of three power-generating plants (Lasco and Pulhin, 1997).

Source (100 MW power plant)	CO_2 emission (t/yr)	Equivalent area of OGF (ha)	Area of plantation needed to sequester CO_2 released (ha)	Cost of tree plantation establishment (10^6 pesos for 3 years)
Coal-fired	876,000	682	54,248	1,085
Natural Gas	372,300	290	23,055	461
Geothermal	46,618	36	3,010	60

be installed so that the program will not be used as a "license to pollute". In this regard, the credibility of the project must preserved by a transparent monitoring scheme.

The following issues and criteria must be addressed to ensure success (Dixon et al., 1993; Lasco, 1997):

Project credibility. Any C project must be able to show that its implementation will positively modify existing C flaws. That is, additional C is actually sequestered compared to the baseline scenario.

Reliability. The project must have a fairly good chance of success. Experience with projects involving the private sector could be a good gauge of this. In the Philippines, private participation in reforestation and tree farming has been going on for many years.

C sequestration rate of forest trees. There must be a consensus among scientists, policy makers, and the private sector on the rate of C sequestration of major forest types and species. Limited data are available in the Philippines and extrapolation appears to be necessary, at least initially. The Environmental Forestry Program of UPLB is conducting research to determine more accurately C storage and sequestration rates.

Determination of value-added of the project. The proposed project must show that without it the intended C sequestration or conservation benefit will not be realized. A "with" and "without" project analysis is a must.

Allocation of C credits. How the C that accumulates over time will be credited should be resolved. For instance, as a forest plantation matures there is little biomass added although the biomass stock is larger. A simple solution is to monitor biomass growth yearly and credit the C fixed that year.

Monitoring. A third party auditor of C to be credited seems essential to the success of the program. Academic and research institutions as well as NGOs with technical ability could participate in this effort.

4.2 Reforestation by NGOs and Volunteer Groups

Another possible approach to promote C sequestration is by encouraging NGOs and other volunteer groups to engage in reforestation activities. There are more than enough upland areas that could be allotted for this purpose. Just like C-offset, reforestation of these areas will also result in many ancillary benefits.

There are international agencies that provide support of this kind of activities. C credits could be claimed if the primary purpose of the reforestation project is C sequestered.

The main advantage of this approach is that there will be greater private sector participation in both mitigation of climate change and forest land rehabilitation. Even if the total area of reforested is not as large, every bit of effort will make an impact.

4.3 Urban Forestry

Urban areas could also be tapped so sequester C via the establishment of tree parks along roadsides and even around the houses. The total area for this activity is even smaller. However, their added benefits to urban community could make them worthwhile.

4.4 Cost of C Sequestration

In the Philippines, the establishment and maintenance of tree plantations typically cost about PhP 25,000/ha (US$620) for three years. Thus, a 10-year plantation which could sequester up to 44 tons C, will have a unit cost of US$ 14/ mgC. This is comparable to Thailand where a teak plantation costs US$ 13-26/ MgC (IPCC, 1995).

4.5 Joint Implementation

The UN Framework Convention on Climate Change provides for the possibility of parties cooperatively implementing their obligations. In essence, this mechanism allows a developed country to obtain credits for C-offset projects implemented in a developing country. Activities Implemented Jointly (AIJ) is the international pilot phase for cooperation between countries to reduce, avoid, or sequester GHG emissions (DPIE, 1997).

This funding mechanism is designed to provide a "win-win" solution for both developing and developed nations. However, for political reasons the Philippine government has not yet approved the country's participation in this program.

5. CONCLUSION

The preceding discussion has shown that Philippine forest lands do have an excellent potential in mitigating climate change, one of the most critical environmental threats mankind has ever faced. However, this potential will not be fully realized without the coordinated efforts of government and private organizations. The research community has a strategic role to play. It should endeavor to provide solid scientific information to the current debate on how to combat climate change.

Toward this end, the following research topics are recommended:

- determination of C storage and sequestration rates of different forest ecosystems;
- long-term biomass monitoring study of forest ecosystems;
- policy studies to promote the use of forests in C sequestration;
- landuse and land cover change studies;
- modeling C storage dynamics of forests.

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