

Reforestation as a Carbon Sink: Toward Slowing Global Warming?

Somthawin Sungsuwan-Patanavanich*

Despite a very slim chance for a legally binding forest convention to be discussed in the 1992 United Nations Conference on Environment and Development (UNCED), the problem of forest management will continue to be a significant global issue in the next decade. For deforestation does indeed contribute to degradation of the global environment. Many proposals will no doubt call for significant reductions of deforestation, as well as measures for increasing forest cover through both afforestation and reforestation. The general agreement is that the world should conserve its natural forests and that any possible increase in forest cover will be of benefit to all nations.

Numerous debates have arisen over why *tropical* deforestation is singled out, while insufficient attention is given to deforestation in temperate countries. Another debate concerns the level of responsibility each country should take for the release of carbon caused by its own deforestation.

Many countries hesitate to discuss such responsibilities because of inadequate and poor quality forestry statistics and information. Nor do all countries define the relationship between deforestation and associated carbon emission in the same way.

With sincere commitment to arresting global environmental problems, Thailand has been actively involved in preparations for UNCED. Thailand has also conducted research relating its economic development to the global warming phenomenon. This study reflects one of Thailand's greenhouse research initiatives.

RESEARCH METHODOLOGY

The CO-PATH Model

The CO-PATH model used for estimating the carbon flows associated with forest areas in this study was first developed at the International Energy Studies Group, Lawrence Berkeley Laboratory, and has been described in detail by Makundi et al. (1991).

The model is divided into two main parts: BASIS and FORECAST. BASIS takes specific information about the forest and computes the stored carbon, emissions and uptake for the base year. FORECAST takes the base year estimates and by applying various assumptions on the projected states of forest resources, forecasts the extent of future carbon emissions and uptake.

The forecast is subdivided into four modules which undertake the computation for each major mode of deforestation, i.e., conversion to agriculture; conversion to grazing land; various management regimes guiding forest harvesting policy; other land uses such as dams, roads, and mining; and forest fires. The totals are summed-up to obtain the emissions and uptake for any given forest type. The process is repeated for each forest type and then added up for the country as a whole.

Key parameters employed in this study include:

Forest area and land-use activity
Carbon stored in vegetation

Carbon stored in soil

Production of biomass from reforestation

Decomposition rate of biomass

Forest fires

ESTIMATION RESULTS AND FORECASTS

Carbon Stored

In Thailand, the total amount of stored carbon can be divided into two parts, carbon stored in vegetation and carbon stored in soil. The carbon stored in vegetation was computed by multiplying the dry biomass density with the carbon content of the dominant species. Carbon stored in soil in this study was converted from the soil organic matters.

For the base year 1989, the total stored carbon estimated by using the CO-PATH model was approximately 3.5 billion tons, including 2.7 billion tons of carbon stored in vegetation and 0.7 billion tons in soil. The results show that more than 50 percent of the stored carbon is in the Tropical Evergreen Forest, which covers about 43 percent of Thailand's forest area. The estimates of carbon stored in soil follow the trend of the estimates of carbon stored in vegetation.

Carbon Released

When deforestation takes place, carbon is released in two stages: combustion and soil disturbance. The remaining biomass-based carbon is released through decomposition over a period of time. The amount of the carbon release varies according to the mode of forest conversion and the type of forest. In the CO-PATH model, carbon released refers to the sum of emission from combustion and decomposition of biomass cleared in the current year, together with releases from soil disturbances.

The total prompt carbon release due to deforestation is estimated at approximately 24 million tons ([Table 1](#)). Of this, 60 percent is from the conversion of Tropical Evergreen Forest. Of the four main land-use conversion modes, unclassified land utilization and forest fires contribute the highest prompt carbon release (52 percent). This is because all activities other than agriculture, pasture or harvesting are unclassified. Dam construction, mining, shrimp farming and salt-fields are examples. Forest conversion to pasture contributes the least carbon emissions, since grazing is not a major problem in Thailand.

Carbon Uptake

The amount of carbon sequestered after converting forest area to other uses depends on the type of vegetation replacing the primary forest. If a forest is converted into permanent agricultural land or permanent grazing land, the uptake potential is negligible, due to lack of woody vegetation. In this study the uptake of carbon is estimated, given the case that the land was abandoned after a number of years and reclaimed by natural secondary vegetation or reforestation. In the case that the land is covered with perennial agricultural crops or fruit trees, the carbon uptake is considered similar to that of forest trees.

Thailand's total carbon uptake by vegetation after deforestation is approximately 0.4 million tons. As shown in [Table 2](#), the uptake is highest when Tropical Evergreen Forest (0.2 million tons) land has been converted to para-rubber plantation (in this study the amount of carbon is assumed to be the same as that of forest trees). The carbon released is approximately 60 times higher than the carbon uptake. Thailand's net carbon release through deforestation is estimated at 23.4 million tons ([Table 3](#)), less than one percent of the world carbon release estimated by other researchers (Houghton et al. 1987, Myers 1989). Assuming that Thailand's population totalled 56 million in the base year 1989, then the net carbon release from this source would be 0.4 million tons per capita. The estimates in this study are much lower than those given by Myers (1989) or the figure reported by the World Resources Institute.

Forecast

In this part of the analysis, sequestration by growing forests from past regeneration and emissions from past deforestation are not taken into account. The estimate of future net release is based on the knowledge of deforestation in the base year, decomposition period, rate of growth of secondary vegetation, rotation age and the change in the rate of deforestation. The net carbon release is the sum of prompt release and emissions from annual decomposition, less the amount sequestered in the year under consideration.

It is assumed that the deforestation rate is one percent, which was the rate of deforestation before the logging ban was announced and 0.3 percent, the present deforestation rate. From the forecast, the figures show that if deforestation is one percent, the future net emission will be as high as 47 million tons (double the 1990 level) within six years (1996). If the government can keep the rate of deforestation to 0.3 percent, the net carbon emissions in 1996 will only be 33 million tons. In the meantime, increasing forest area by reforestation will help to cope with future increases in net carbon emissions. The forecast shows a decreasing trend of net carbon release in the forest sector.

POLICY IMPLICATIONS

Policy Issues

In Thailand, forests and forest lands are all state-owned. The responsible body is the Royal Forestry Department (RFD), established in 1896. Initially, this Department was under the Ministry of Interior and exercised control over teak production in the Northern region. Subsequently, forest laws were introduced and the Royal Forestry Department became part of the Ministry of Agriculture and Cooperatives. Twenty-one Regional Forest Offices and 72 Provincial Forest Offices form part of this Department and are responsible for forest control and management at the regional and provincial levels.

Although the primary objectives of forest control and management are to maximize forest use for the greatest number of citizens for both forest production and environmental benefits, many problems have arisen from government control and management. Sources of these problems include the ambiguity of forest laws and regulations, inefficient management and weak enforcement. As a result, Thailand has experienced a very high rate of forest loss. The deforestation rate was 3 percent a year during the 1960s and 1970s (or approximately 480,000 ha per year). In the early 1980s, however, the rate fell to 2 percent with annual losses of 240,000-400,000 ha per year. The evidence indicates that, according to legal classification, forest reserves are lost at a higher rate than national parks or wildlife sanctuaries. This is due not only to the higher accessibility of forest reserves, but also to better surveillance in national parks and wildlife areas.

As of 1989, Thailand had 1,218 separate forest reserves, covering an area of about 230,000 km². In addition, there were 149 areas of preserved forest, covering an area of 34,000 km². Due to weak law enforcement, however, the actual forest cover of the whole country in 1989 was only some 140,000 km², or much smaller than the reserve area announced by the government.

The ambiguity of forest laws and regulations has been an issue for some time. An important problem is the inadequate categorization of protected forests. The legal definition of a protected forest did not, until recently, differentiate between upper watershed forest, now facing destruction, and other protected forests. The definition of exactly what constitutes a forest area is also not clearly spelled out. According to the Forest Act of B.E. 2484 (1941), "forest" is defined as "unowned" land and classified under the Land Act. This gives the false impression that such "unowned" land, even though forested, can be cleared for settlement, thus leading to endless conflicts between settlers and government officials.

The most controversial issue arose from some areas being legally declared forest reserves only after the forests had already been cleared and settled by low-income farmers. It is believed that the number of people who live in official forest reserves is as high as 7.8 million (Panayotou and Parasuk, 1990).

Although RFD attempts to enforce the Land Act and claims rights over these areas, it is generally understood that if an individual has occupied a piece of land for at least 10 years, then he or she is entitled to legal ownership.

Government attempts to manage and control the use of forest resources have continued since 1960. For example, in the first four National Economic and Social Development Plans, the government imposed forest reserve and forest exploitation control laws in many areas. In the Fifth Plan, the target for forest product growth was set at 0.3 percent. Moreover, the government is planning to reforest certain areas, in the North and Northeast in particular.

Other important forest policy changes include:

In 1960, the government established the National Land Classification Committee to carry out soil surveys and subsequent land classification. This committee implemented land classification in 1961 by establishing a center attached to the Land Department. The first National Economic and Social Development Plan (1962-1966) declared that 25 million ha of the existing 30 million ha of natural forest would be reserved as national property, while the remaining 5 million ha would be available for farming. Since 1964, this task has been handled by the Department of Land Development. In 1964, the National Forestry Reserve Act was passed, prohibiting encroachment on forest reserves. The Royal Forestry Department was assigned the task of setting forest reserve boundaries.

From 1962 to 1966, a total area of 26 million ha was classified as permanent forest. Permanent forests should later be gazetted by Royal Decree as forest reserves under the National Reserve Forest Act of 1964. In 1985, a National Forestry policy was enacted. The new policy reduced the targeted forest area to 40 percent of the Kingdom's total land area, subdividing it into conservation forest and economic forest (15 percent and 25 percent of the country's total area).

Despite the National Forest Reserve Act being put into law, forest encroachment has continued unabated. Since 1979, the gap between the declared forest reserves and the remaining natural forest has become ever wider. It is clear that a new approach to forest resource management is urgently required. This means getting to the root of the problem, and establishing the real causes underlying deforestation.

Causes of Deforestation

A systematic explanation of the causes of forest depletion has been offered by Panayotou. This 1983 study reviews the deterioration of natural resources and gives some of the underlying causes. It stresses the importance of using renewable resources. The cause-and-effect chain of forest depletion, and the relationships between resource degradation, yield decline and poverty, are also discussed and some hypotheses are suggested.

Among the causes of deforestation, the problem of open access is considered of primary importance (Panayotou, 1983).

Panayotou's point regarding open access is particularly compelling. Open access, or the impossibility of policing entire forests, results in the classic "tragedy of the commons." Individuals seek to maximize the benefits they personally derive from a common good, in this case, the forest, without taking into account the combined effect of their actions, i.e., deforestation. Such behavior has strong negative implications for both Thailand and the international community. Unfortunately, there are few proven solutions to open access problems.

Panayotou also conducted some preliminary tests for Thailand. One of the tests attempts to explain deforestation using population, irrigation, fertilizer use and crop prices as variables. Although the preliminary results reported were inconclusive, the study contributes some systematic suggestions for further research.

The most recent study on deforestation by TDRI argues that the main historical causes of deforestation are poverty, population growth and the price of cash crops (Tongpan et al., 1990). These results are in line with an earlier study by Sungsuwan that identified population, price of forest products, poverty, rural road networks, irrigation infrastructure, and crop prices as the main causes of deforestation in Northeastern Thailand (Sungsuwan, 1985). Both studies employ econometric models to analyze and explain the variation of forest cover. The two studies describe the relationship between rural poverty and deforestation as a vicious circle and conclude that any attempt to halt deforestation and to accelerate reforestation must deal with poverty first, or at the very least concurrently. It should be clarified that "poverty" reflects a government's inability to solve problems of unequal income distribution. It is extremely unfair to superficially blame the rural poor for deforestation. There is no doubt that Thailand's past development plans have worsened the income gap. This was also confirmed by the first presentation of the country's Seventh Plan in early September, 1991. To deal with poverty means to elevate income, as well as to solve the unequal income distribution problem. The elimination of poverty in absolute terms does not decrease the amount of deforestation.

Despite the recent introduction of intensive agricultural methods, relying on increased use of fertilizers and more frequent crop cycles, pressure for additional land remains acute. Pressure for cultivatable land is expected to level-off, however, within the next five to 10 years as, for the first time in its history, Thailand's rural population will decline in absolute terms. Unfortunately, much of Thailand's richest agricultural land is under increasing pressure from other types of economic activities fueled by urban growth, including industrialization in the urban fringe areas, land speculation and, even, the building of golf courses.

In sum, the primary causes of deforestation appear to be rural poverty, forest degradation, yield decline and the lack of effective enforcement by the RFD. Contributing causes also include the ambiguity of law and continuing high population pressure. Finally, new roads and other infrastructure, opening up previously inaccessible areas to encroachers without a compensatory increase in RFD resources to enforce forestry laws, must also be singled out as another cause of Thailand's current dilemma.

Reforestation in Thailand

The concept of reforestation was introduced into Thailand more than 80 years ago. Initially, most tree plantations were designed to increase timber production. Teak plantations, for example, proliferated throughout the North. Since 1967, two government agencies and one state enterprise—the RFD, the Forest Industry Organization and the Thai Plywood Co. Ltd.—have launched plantation projects. Only in the last decade has the private sector become involved in the reforestation program.

By the end of 1989, the total planted area came to approximately 697,000 ha (Royal Forestry Department, 1989). Reforestation policies have also been incorporated into all of Thailand's National Development Plans. The targets were set at 12,480, 22,400, 38,800, 400,000 and 264,000 ha during the First, Second, Third, Fourth and Fifth Plans, respectively. In the Sixth Plan, the target was not specified in terms of ha per year. The government instead stated that the Kingdom's forest cover should be increased from 28 to 40 percent (15 percent for protected forests and 25 percent for economic forests) of total land area. This target was reversed in the Seventh Plan, i.e., 25 percent for protected forests and 15 percent for economic forests.

Recognizing that it did not have the resources to accomplish this target on its own, the RFD promoted private-sector involvement. Encroached land in forest reserves is thus rented to private companies for eucalyptus plantations at a rate of 10 baht per rai (6.25 rai equals one hectare). The government also grants promotional privileges to participating companies through a Board of Investment (BOI) promotion program. This policy has led to a major controversy as private firms have to pay farmers living on encroached land to move out. If this policy were widely implemented, the primary complication would be ensuring the welfare of the approximately 7.8 million poor farmers now living in forest reserves. The National Forest Reserves Act of 1964 cannot be enforced unless the government finds a way to deal fairly with such a large number of settlers. Past experience has shown that driving people out of the forest reserves without appropriate compensation is a sure recipe for trouble.

Factors obstructing the progress of reforestation programs include the lack of political will to protect the natural forest, financial problems, and the identification of suitable land. That is to say nothing of caring for the welfare of farmers.

Although the concept of reforestation, accepted in Thailand for almost a century, led to the first teak plantation in Prae province in 1906, the government did not come up with a clear reforestation plan until its First Plan in 1961. Moreover, for the first five Plans, the budgets allocated to the RFD for reforestation were much too small.

During the past decade deforestation has become a major issue in Thai agriculture. The Thai government, in response to dramatic changes in soil conditions, widespread flooding, and other unhappy afflictions, was compelled to act promptly to save at least a part of the remaining Thai forests. A decision to ban logging was made and took effect in February, 1989. But such a ban should probably be viewed as only a temporary expedient and as a means of regenerating resources. It is economically sub-optimal and usually ineffective over the long term. Critical forest depletion has also forced the government to accelerate reforestation programs. Unfortunately, by the time the government begins to reforest encroached land, it is practically always already settled by farmers.

The government has tried to solve its forest problems by implementing two programs-commercial plantations of fast-growing trees, and community, or "social," forestry. Commercial plantations are intended to mobilize resources from the private sector to reforest large areas of encroached land. The government has promoted fast-growing species, hoping this will quickly increase forest cover as well as provide greater rural employment. Social or community forestry attempts to offer a better way to foster local participation in forest management. The premise here is that local people know best how to protect their own forests and have more incentive to do so than anyone else.

Whether these two policies are viable is still highly controversial. Assessment, however, should be based on how well these policies work in improving the standard of living of farmers and in solving income disparity.

Global Policy Implications

In recent years, concern over deforestation has gone well beyond the issues of biological diversity, watershed protection, and the supply of forest products. At the global level, forest resources are now viewed as a crucial carbon sink. Slowing the rate of deforestation and expanding the forest area are expected to be important in slowing the atmospheric buildup of CO₂ (carbon dioxide). At present, a number of international initiatives are being prepared for the 1992 UNCED Conference to be held in Brazil. Issues of particular interest include the possibility of international protocols for forests in response to the need to increase the role of global forests as a carbon sink, as well as a source of genetic material and as wildlife habitats. Many international instruments-Declarations, Charters, Agreements and Conventions-are also being considered (Maini, 1991).

Growing support for the idea of having more forest to help sequester CO₂ in the atmosphere was clearly reflected in the Declaration of the Noordwijk Conference of December 1989. That conference also proposed a target of 12 million ha global net increase per annum in forest cover.

Thailand is one of the few developing countries with a clear forestry target. Forty percent of the Kingdom's total land area has been set as Thailand's target. This much is needed to protect the country's watersheds and to reverse soil erosion.

A study by Thaiutsa indicates four different estimates of the additional annual forest cover required under the following assumptions:

1. According to Sir H.G. Champion, if every citizen demanded at least 0.4 ha of forest and Thailand's population remained at the 1988 level, an additional 8.5 million ha of forest would be required. This

- implies an annual reforestation rate of 0.4 million ha for a period of 20 years.
2. Following the national target of 40 percent forest cover, it is estimated that 0.32 million ha per annum should be planted for the next 20 years.
 3. If the sustainability of timber production were applied as the criteria and all incremental products were domestically consumed, then no new timber plantations would be required as the RFD reports that Thai per capita timber consumption is only 0.047 m³/person/year.
 4. Assuming that the rate of deforestation is 0.53 million ha per year (the average for 1961-1988), maintaining the present forest area, then 0.5 million ha per year would have to be planted. If Thailand wanted to conserve all existing natural forest and also meet the 40 percent target in 20 years, then as much as 0.9 million ha of plantation would be required each year for 20 years (Thaiutsa, 1988).

To see the implications of CO₂ reduction for the forest cover requirement, it is important to be able to assess the relationship between changes in forest area and emission of CO₂. This was first quantified in Thailand at the end of 1990 by TDRI. TDRI's preliminary findings indicate that if 0.16 million ha is planted annually with a deforestation rate as low as 40,000 ha per year, then in 40 years there would be enough forest to absorb all CO₂ emissions from fossil fuel burning (Chongpeerapien et al., 1990).

In this study, the application of the CO-PATH model indicates that in 1989 changes in forest land use contributed some 24 million tons of carbon to the atmosphere. The forecast shows estimates of 30, 33, 20, 8 and 2 million tons in 1991, 1996, 2001, 2006 and 2011, respectively. TDRI's 1990 estimates showed that carbon released from energy consumption in the corresponding years were 24, 35, 50, 70 and 100 million tons. This means that the total carbon emissions are estimated at 54, 68, 70, 78 and 102 million tons by the end of the Sixth, Seventh, Eighth, Ninth and Tenth Plans.

If we want to control atmospheric carbon by requesting all nations to find ways to stop further emission, then Thailand would need an additional reforested area of about 3.7 million ha. If 0.16 million ha per year target can be achieved, it will take 23 years, until the end of 2014, for Thailand to generate enough forest cover to absorb this amount of carbon. This implies that Thailand's forest should cover as much as 35 percent of the country's total land area by 2014. It should be noted that with a reforestation rate of just 0.16 million ha per year, Thailand will not be able to rely on its newly planted trees as a carbon sink. In other words, Thailand needs an additional 2.4 million ha of forest immediately if it wants to have enough forest to absorb the 1991 total carbon emitted from all sources. If Thailand has to stabilize its carbon emissions at the 1991 level (54 million tons), then it must have enough forest cover to absorb 48 million tons of carbon. With the absorptive capacity of 2.5 tons per hectare, Thailand will need to have 16.8 million ha, or about 33 percent of the country's land area, of forest cover.

The assumption of achieving 0.16 million ha, or one million rai, of reforestation every year seems optimistic though not impossible, provided barriers now obstructing reforestation programs are overcome.

Major barriers to the implementation of reforestation programs in Thailand can be summarized as follows:

The encroached forest reserves, some of which have been rented to private firms, cannot be considered a promising supply of land for tree plantings because of the immense difficulties of dealing with some 7.8 million settlers. Although there is some still identified unused land, it is not necessarily true that it will be available for reforestation. The opportunity cost of converting such land into tree plantations must also be taken into account.

Financial and technological problems will also effect the rate of growth in forest cover. A national effort is, of course, necessary but external funds will also very much be needed.

CONCLUSIONS

The principal conclusion drawn from this study is that if carbon emission is to be stabilized at the current

level, then approximately 33 percent of the country's area must be covered with forest. While the national target of 40 percent established by the government has already accommodated the global warming concern, the reverse is not true. In other words, reforestation should not be considered as only a policy response to CO₂ reduction. Solving major problems in protecting Thailand's remaining forests and increasing its forest areas for the country's benefit should be given priority. Clearly, progress toward obtaining a better understanding of the basic issues and of formulating more coherent policies should be made. A review of the overall impact of conservation and protection policies is badly needed and long overdue.

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