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SANREM CRSP

ABOUT
SANREM CRSP

SANREM'S mission is to assist in the analysis, creation and successful application of decision support methods, institutional innovations and local capacity approaches to support participatory sustainable agriculture and natural resource planning, management and policy analysis at local, municipal, provincial and national levels.

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ASSESSING THE PROSPECTS FOR CARBON SEQUESTRATION IN THE MANUPALI WATERSHED, PHILIPPINES

How feasible is carbon sequestration on smallholder farms? What kinds of payments could be made to farmers to cover the cost of carbon sequestration? How should those payments differ for various types of farms? What land use systems are most cost-effective for purposes of carbon sequestration?

At current emission rates the accumulation of greenhouse gases in the upper atmosphere is expected to lift average global surface temperature by approximately 0.3-2.5° C in the next fifty years and 1.4-5.8° C in the next century. Although economic and ecological consequences of global warming are a subject of debate, numerous scientists believe that negative impacts will likely outweigh benefits. Given the intense focus on carbon dioxide as the most important greenhouse gas, finding low-cost methods to sequester carbon is emerging as a major international policy goal. Moreover, under the provisions of the Kyoto protocol, it may be possible in the future for a country that emits carbon in excess of Kyoto limits to purchase carbon offsets from a country or region that manages carbon sinks.

This brief presents results of a study to measure the costs of carbon storage on farms in the Philippines. The Philippines ranks seventh among the top twenty tropical countries in ability to sequester carbon. The method used in this study relies on a three-step process to assess the costs of sequestering carbon over a 10-year horizon. First, a measure of the value of land to farmers is derived. This is based on current and predicted agricultural land uses. Second, the potential for lands of different qualities to sequester carbon over time is measured, based on conversion to forest and agroforest systems. Third, the annual payments necessary to compensate farmers for changes in land use to sequester carbon are calculated.

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These payments, converted to present value terms, constitute the potential cost of sequestering carbon through changes in land use.

BACKGROUND

Data for the study come from the Manupali watershed, in the province of Bukidnon, the main site for SANREM CRSP research in the Philippines. The watershed is located on the southern island of Mindanao and drains into the Pulangi River, covering an area of approximately 60,000 hectares. More than 40% of the watershed is hilly, average annual temperature is 18.5 degrees Celsius, and average precipitation is 2400 mm. The watershed can be classified into four geomorphic units: mountains (1400-1900 meters above sea level (masl)), upper footslopes (700-1400 masl), lower footslopes (370-700 masl), and alluvial terraces (320-370 masl). Major crops grown in the watershed are corn, sugarcane, and rice in the lower elevations, and corn, vegetables, and coffee in the upper elevations.

METHODOLOGY

The study uses data from household surveys conducted in the watershed from results of farm-level programming and simulation models. Land values are computed for three land classes: high-input, crop-intensive production (primarily vegetable farms), low-input production (primarily corn producers), and fallow land. Expected farm incomes for different classes differ substantially according to input levels and crop choice. Such differences also reflect the influence of underlying land quality on levels of productivity.

These results indicate agroforestry systems are a lower-cost carbon sequestration alternative to pure forest conversion.

Calculating rates and levels of carbon storage
Carbon is stored in vegetation when plants convert gaseous carbon dioxide into structural carbon through the process of photosynthesis. For trees, the amount of carbon stored increases in parallel with biomass until the tree reaches maturity, at which point carbon storage reaches a steady state. The carbon in a forest is stored not only in tree biomass, but also in under-story vegetation, soils, and floor litter. Although annual crop systems are capable of providing some degree of long-term carbon storage in the root zone, for this study it was assumed that no carbon is stored by annual crop systems. Rates and levels of carbon sequestration in two tree-based systems were studied, based on a representative one-hectare plot of *Paraserianthes falcataria,* a fast growing tropical tree species. In the Philippines *P. falcataria* has been grown in tree plantations for pulpwood and can be readily incorporated into agroforestry systems. Using the computed measure of total permanently stored biomass, the amount of carbon sequestered in the stand was derived using a standard carbon conversion factor. This provided the total amount of carbon stored in tons per hectare.

In general, high quality land produces more carbon per hectare than low quality land, due to differences in the growth rates of trees planted on land of different quality. For this study, the total amount of carbon stored on the lowest quality land at the end of a 10 year period was estimated to be 72 tons per ha. For the highest quality land the estimate was 112 tons per ha.

Economic model
To compute the price of a ton of carbon, it was assumed that payments would be made to farmers at a level that would completely compensate them for lost agricultural incomes. In other words, the payments would leave farmers "just as well off" maintaining a tree plantation (or agroforest) as engaging in annual crop agriculture. Payments were derived for each type of farm type and a range of land quality indices. For agroforestry, the

income gained from crops grown as a component of the agroforestry system was included in farm income, thereby reducing the cost of sequestering carbon. The estimated carbon cost per ton was computed by dividing the net present value of the stream of estimated payments to farmers by the total amount of carbon stored at the end of the tenth year.

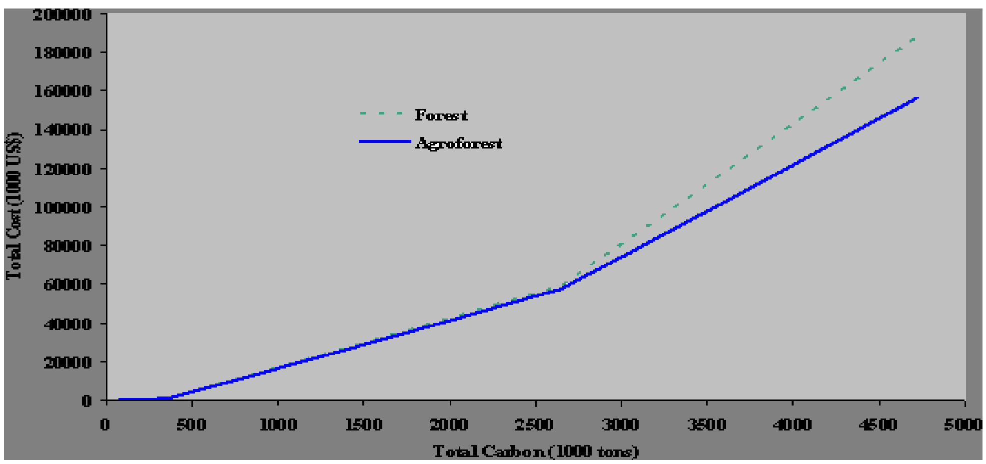
RESULTS

Estimated marginal costs for carbon storage on fallow land range between $3.30 and $3.90 per ton of carbon sequestered. For fallow land, estimates are the same for forestry and agroforestry systems due to the absence of agricultural production on the land. When crops are grown, the costs of sequestering carbon via forestry and agroforestry differ due to lower opportunity costs for agroforestry systems. As a result, carbon prices are lower for agroforestry systems than for pure tree-based systems. On low-input farms the estimated cost of carbon storage ranges from $25.00 to $26.10 per ton (for pure tree stands) and $24.20 to $25.30 per ton (for agroforest). On high-input farms the carbon cost ranges from $61.10 to $62.50 per ton (for trees alone) and $46.70 to $48.00 per ton (for agroforest). Average per-ton costs of carbon storage are up to 17 percent lower in the agroforestry system than in the pure tree stand.

These per-farm sequestration costs were used to estimate total costs of reaching an aggregate carbon target in the watershed, using land classification data to estimate the total amount of land in each farm class, and hence the total carbon storage potential of the watershed. Average costs of reaching carbon storage targets range from $3.30 on fallow land to $39.80 for forestry conversion and $33.10 for agroforestry conversion.

To further illustrate these patterns, total costs of carbon sequestration in the Manupali watershed are displayed in Figure 1. Carbon levels are displayed on the horizontal axis and the total cost of reaching the carbon target is displayed on the vertical axis. The total cost curve for agroforest is identical to that for forest up to the point where the carbon target exceeds 361,000 tons (the amount of storage potential on fallow land). Carbon costs then diverge as increasingly productive agricultural land must be used to sequester additional carbon. The cost curve for agroforest lies below that for trees at all points because the addition of annual crops in the agroforestry system compensates for some of the opportunity cost of converting from annual crop agriculture, especially in the early years of the planning horizon.

Figure 1. Total cost curves for aggregate carbon sequestration in the Manupali watershed



CONCLUSIONS

Results from this study suggest that when the opportunity cost of productive agricultural land is taken into consideration, carbon prices derived from afforestation rise significantly to a level that coincides with the lower end of the range estimated for industrial source reductions and fuel switching. Results also indicate that agroforestry systems are a lower-cost alternative to pure forest conversion, with average per-ton carbon costs that are up to 17 percent lower than the costs for carbon storage via a pure tree stand. The estimated cost of sequestering carbon over a 10-year period in the Manupali watershed ranges from $3.30/ton on fallow land to $48.00/ton on land planted to high value crops.

This brief draws from the following articles: G. E. Shively, C. A. Zelek, D. J. Midmore, T. Nissen, *Carbon Sequestration in a Tropical Landscape* and C.A. Zelek and G. E. Shively (2003) "Measuring the opportunity cost of carbon sequestration in tropical agriculture," *Land Economics* 79(3):282-298.

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