# ECONOMICS OF FORESTS FOR SITE PROTECTION AND ENERGY PRODUCTION IN DEVELOPING COUNTRIES

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## Introduction

This paper is concerned with financial and economic analysis of forests for site protection and energy production in developing countries. The primary focus is on the Dominican Republic and on the economics of agroforestry and other practices in controlling siltation of hydropower reservoirs. Deforestation, desertification, and soil loss problems have reached critical levels in many developing countries. Increased tree cutting for fuelwood (due to population pressures and rapid increases in imported fossil fuel prices) is one of the contributing factors. Thus reforestation and afforestation projects have been proposed for both site protection and the production of fuelwood and other renewable energy sources.

While the petroleum crisis continues to make daily headlines, for more than a third of the world's population the real energy crisis is a daily search to find firewood for cooking. The search for wood, which was once an easy task, is now a day's labour in some places as forests recede. The total forest area in developing countries exceeds one billion ha. However, if the current rate of depletion were continued and if reforestation efforts are not expanded, the World Bank (1978) estimates that this stock of forest resources would disappear within 60 years. World Bank (1980) estimates show that the gap between current forest replanting and projected demand by the year 2000 for domestic cooking and heating is fivefold in the developing countries as a group and fifteenfold in African developing countries.

Forests play a significant role in economic development. They have an important influence on the environment and provide innumerable products of vital use to humans. The ecological usefulness of forests includes their beneficial effect on water catchment areas, where they have a regulatory influence on stream flows. They also protect soils from erosion and prevent silting of dams and canals. They have pronounced microclimatic effects of benefit to humans and livestock, provide a habitat for wildlife, and are attractive places for recreation. Forest products are used extensively in most societies. They provide food, fuel, fibre, building materials, industrial products (such as gums, resins, and oils), transmission poles, newsprint and other papers, packaging materials, textiles, and clothing. Thus they provide many resources for the development of other sectors.

Immediate response to the deforestation problem has been to propose establishment of agroforestry schemes on eroded lands or energy forests on large expanses of marginal lands unsuited for agriculture. However, implementation of the reforestation concept has not been that simple. Thomson highlights some technical, legal, political, and economic impediments to reforestation, as follows: (1) the availability of appropriate seeds or seedlings and the extent of the species' compatibility with crops, effects on soil fertility, and valuable by-products; (2) land tenure, tree tenure, and associated residential patterns which may discourage wood production and affect the ease with which trees are protected; (3) the enforceability of property rights in land which influences the decision to invest in slow maturing crops like trees; (4) the enforceability of property rights in trees which influences damage claims when protection fails; and (5) the collective action capabilities at the local level, given the distribution of political authority there and in overriding regimes.

## Dominican Case

The Dominican Republic is heavily dependent on foreign sources of energy. All oil is currently imported. According to Trehan, Newman, and Park, there are some indications of limited domestic sources of oil, coal, peat, and geothermal resources, but reserves of these have not been verified. Hydroelectric sites with a potential of one gigawatt electric installed capacity have been identified and small scale hydrosites are presently being inventoried.

According to FAO, there are about one million hectares of forest in the country covering 22 percent of the surface area. Of this forest area, 34 percent was found to be in its natural state, the remainder having been depleted by logging (38 percent), charcoal production (17 percent), and other uses and causes (11 percent). Due to restrictions on logging since 1967, the deforestation rate has slowed down somewhat. The current estimate of wood production for firewood and charcoal is $10^{12}$ BTUs annually of which 90 percent is for firewood. However, Trehan, Newman, and Park estimated that there were 1.3 million acres of arid and semi-arid land available for the development of unirrigated forest energy plantations.

Gross estimates of deforestation can be misleading, particularly when deforestation on hillsides is a major contributing factor to massive destruction of watersheds throughout the country. A recently completed country environmental profile by JRB Associates estimates soil erosion rates to average 300 mt/ha/yr in most of the nation's watersheds. Sedimentation is filling up the nation's water reservoirs. The useful lives of very costly hydroelectric facilities have already been cut to less than half by siltation. In addition, siltation damage to hydroelectric facilities often results in lower-than-planned power output levels and frequent power outages.

## Conceptual Framework

Most conceptual and measurement issues for economic analysis of forests for site protection and energy production result primarily from poorly defined property rights and pervasive technological externalities (e.g., soil erosion and reservoir siltation) associated with deforestation. Thus the remainder of this paper will focus on developing a conceptual framework and presenting some preliminary empirical analysis. The concern is the estimation of financial and economic costs, benefits, and income distribution impacts of reforestation (including agroforestry) and other alternatives for soil erosion and reservoir sedimentation control in the Dominican Republic. The conceptual framework builds on concepts developed by Gregersen and Brooks, and Schuster. The empirical estimates are from USAID.

The financial and economic internal rate of return (r) of the alternative methods of reservoir sedimentation reduction (i) can be estimated for each income class or group (y) for the expected life of the project (t) from the following generalized formula:

$$\sum_{i=1}^{I} \sum_{y=1}^{Y} \sum_{t=1}^{T} \frac{(B_{iyt} - O_{iyt})}{(1+r)^t} - K = 0$$

where $B_{iyt}$ = on-site productivity gains and off-site reduction in sedimentation costs from soil conserving practices,

$O_{iyt}$ = the recurring annual operation and maintenance costs of each soil conserving practice, and

$K$ = summation of any initial capital outlays for the soil conserving practices.

Gittinger argues for distinguishing between financial and economic analysis where financial analysis refers to net returns to private equity capital based on market or administered prices. Financial analysis also treats tax as a cost and subsidy as a return. Interest paid to outside suppliers of money or capital is a cost while any imputed interest on equity capital is a part of the return to equity capital. By contrast, Gittinger sees economic analysis as concerned with net economic returns to the whole society, frequently based on shadow prices to adjust for market or administered price imperfections. In economic analysis, taxes and subsidies are treated as transfer payments; i.e., taxes are part of the total benefit, and subsidies costs, of a project to society.

The income classes or groups (y) have been defined by farm size in the preliminary analysis completed by USAID. Small (2 ha) and medium (11 ha) size farms were identified, based on a bimodal frequency distribution of farm size in the Ocoa Watershed in the Dominican Republic. Some revisions of this methodology are needed to reflect income classes more closely.

Examples of soil conserving practices (i) in the Dominican Republic case application include contour ditches, vegetation barriers, outlets planted with ground cover, gully control, range renovation, fence windbreaks, and fruit trees. The erosion and sediment rates associated with each of these soil conserving practices or crops can be estimated utilizing the following modified universal soil loss equation:

$$A = R \bullet K \bullet LS \bullet VM,$$

where A = soil loss (tons/ha),
R = rainfall erosivity factor,
K = soil erodibility factor,
LS = topographic factor, and
VM = vegetation management-erosion control factor.

Estimates of the independent variables (R, K, LS) for the Domincan Republic are available from Paulet. The VM factor changes according to the vegetation management and the project conservation measures. In consultation with soil scientists, the effects of watershed conservation practices on soil erosion and sediment rates can be estimated by calculating the associated VM factors. The different rates of sedimentation produced by different VM factors can be used to calculate a physical flow table showing soil loss rates associated with alternative conservation practices.

In calculating the costs of the project, the topographical conditions, soil characteristics, and the amount of topsoil remaining in the watershed play a critical role in determining the conservation practices required to meet the objective of reducing soil erosion. Those practices, in turn, affect the costs of the project because each implies a different cost per hectare. The total area of the watershed can be divided according to these factors with particular emphasis on slope class and current land use and field size. In doing so, a set of conservation practices can be specified along with their associated costs.

The "with and without" test needs to be applied to both benefits and costs. Only the difference between both scenarios can be attributed to the project (Gregersen and Brooks). Under this procedure, the difference in water storage capacity with and without the project can be translated into estimates of crop value losses avoided. In the same way, the losses avoided in hydroelectric power generation can be evaluated at their opportunity costs; i.e., at the cost of generating the same amount of kilowatts using oil based fuels. Shadow pricing must also be done for foreign exchange since oil based fuels in the Dominican Republic are imported and the local currency is overvalued.

The analysis will also evaluate the foreign exchange net gains or losses from alternative soil conserving practices as well as from converting some sugarcane land to the production of food crops (e.g., beans) and export crops (e.g., tobacco). This latter alternative would facilitate converting the most erosive areas of the watershed to forestry (e.g., fuelwood production) and cover crops without reducing the acreage of food and export crops other than sugarcane. The additional reduction in soil loss (and reduced siltation at the reservoir) may result in foreign exchange savings on oil exports due to increased hydroelectric production.

If foreign exchange savings or earnings are a critical issue, the following version of the Bruno Criterion from Ward can be utilized (in addition to the internal rate of return formula) to evaluate alternative agroforestry and other soil conserving scenarios.

If SER $\geq$ DRC/NFE then accept project.

where SER = shadow exchange rate which can be determined from the Central Bank,
DRC = domestic resource costs for each of the soil conserving practices (i) and the sugarcane substitution scenario, and
NFE = net foreign exchange saved or earned from each of the soil conserving practices and the sugarcane substitution scenario.

## Preliminary Empirical Evidence

Preliminary internal rate of return estimates of financial and economic feasibility have been made for the earlier mentioned soil conserving practices (i) for the Ocoa Watershed in the Dominican Republic. The alternative levels of aggregation or accounting stances include: small farmer (2 ha); medium size farmer (11 ha); the Watershed (Ocoa); and the national critical area.

The internal rates of return (r) for each analysis are estimated to be greater than 50 percent in both financial and economic terms. The cash flow analysis indicates an increase in the small farmer's net cash balance from the current to $1,794 in year five and indicates an increase in the medium sized farmer's net cash balance from the current $2,266 to $4,598 in year five. Thus, the small farmer's net cash balance goes from an average of 22 percent of the medium sized farmer's cash balance without the project to 39 percent with the project. The preliminary sensitivity analyses, utilizing substantially lower yields, prices, and incentive payments, suggest that the project would be sound even under adverse conditions.

The pre-feasibility analysis of the Ocoa Watershed (USAID) includes some assumptions regarding shadow pricing of labour, definitions of income groups, and future market prices of project outputs that may need to be modified. It also excludes several externalities and ignores foreign exchange shadow pricing and any direct estimates of net foreign exchange savings or earnings from the project. The opportunity and need are great for much more economic analysis in this important area.

## Note

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