



ADVANCES IN AGROFORESTRY

2



Valuing Agroforestry Systems

Methods and Applications

Edited by Janaki R.R. Alavalapati and D. Evan Mercer



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Advances in Agroforestry

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Aims and Scope

Agroforestry, the purposeful growing of trees and crops in interacting combinations, began to attain prominence in the late 1970s, when the international scientific community embraced its potentials in the tropics and recognized it as a practice in search of science. During the 1990s, the relevance of agroforestry for solving problems related to deterioration of family farms, increased soil erosion, surface and ground water pollution, and decreased biodiversity was recognized in the industrialized nations too. Thus, agroforestry is now receiving increasing attention as a sustainable land-management option the world over because of its ecological, economic, and social attributes. Consequently, the knowledge-base of agroforestry is being expanded at a rapid rate as illustrated by the increasing number and quality of scientific publications of various forms on different aspects of agroforestry.

Making full and efficient use of this upsurge in scientific agroforestry is both a challenge and an opportunity to the agroforestry scientific community. In order to help prepare themselves better for facing the challenge and seizing the opportunity, agroforestry scientists need access to synthesized information on multi-dimensional aspects of scientific agroforestry.

The aim of this new book-series, *Advances in Agroforestry*, is to offer state-of-the art synthesis of research results and evaluations relating to different aspects of agroforestry. Its scope is broad enough to encompass any and all aspects of agroforestry research and development. Contributions are welcome as well as solicited from competent authors on any aspect of agroforestry. Volumes in the series will consist of reference books, subject-specific monographs, peer-reviewed publications out of conferences, comprehensive evaluations of specific projects, and other book-length compilations of scientific and professional merit and relevance to the science and practice of agroforestry worldwide.

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D. EVAN MERCER AND JANAKI R.R. ALAVALAPATI

SUMMARY AND FUTURE DIRECTIONS

1. INTRODUCTION

This chapter summarizes the main results from the preceding chapters, identifies gaps, and provides direction for future economics research on agroforestry systems. Although a common theme throughout the 1990s was that economic research on agroforestry continued to lag the advances made in the bio-physical sciences, the wide range of systems, regions, and techniques presented in this book suggests that economists have taken up the challenges of Scherr (1992), Sanchez (1995), and Mercer and Miller (1998) and are pushing forward the frontiers of economic analysis of agroforestry.

2. SUMMARY OF FINDINGS

2.1. Economic analysis

The first section of the book consists of five chapters (Chapters 2-6) on general economic analysis of the relative profitability of agroforestry compared to alternative land use systems. In Chapter 2, Franzel tackles the problem of assessing financial returns to farmers for three agroforestry systems in Africa (fodder shrubs for milk production in Kenya, rotational woodlots for firewood in Tanzania, and improved fallows for enhancing soil fertility in Zambia). In contrast to much of the agroforestry literature (e.g. Adesina & Chianu, 2002; Bannister & Nair, 2003; Lapar & Pandey, 1999; Sanchez, 1995), Franzel shows why these three systems have been adopted by a large number of farmers (23,000 adoptees of fodder shrubs in Kenya, 961 farmers planting rotational woodlots in Tanzania, and over 20,000 improved fallows planted in Zambia). The financial benefit-cost analyses were all based on comparisons of results on treatment and control plots in on-farm trials designed by researchers (in consultation with farmers) and managed by the farmers. Depending on the system, enterprise and partial budget analyses calculated net discounted returns to land, labor, and capital, and annual net farm income and maize production. The widespread adoption is not surprising since annual net benefits from adoption ranged from \$US 68 to US\$ 212 (not including non-market environmental

benefits such as reduced soil erosion and deforestation) greater than non-agroforestry alternatives. Given these returns, low establishment costs, and short payback periods (2-5 years) Franzel concludes that credit is not a constraint to adoption.

In Chapter 3, Grado and Husak compare the profitability of cattle-loblolly pine silvopasture systems to four traditional, single-use agricultural and forestland management systems in the southern United States (soybeans, rice, cattle, and loblolly pine plantations). Variations in the silvopastoral system include the impacts of hunting leases and pine straw production on profitability. In addition to the standard net present value (NPV), rates of return (ROR), and equivalent annual income (EAI) analyses, Grado and Husak also examine the impacts on landowners' willingness to pay for land or other assets using the land equivalent value (LEV) under the different scenarios. They find that although pine plantations yield the highest returns, land expectation values and EAI's were only slightly lower for silvopasture, which dominated all other alternatives (LEV for silvopasture was US\$ 1253/acre compared to US\$ 1284/acre for pine plantations and EAI for silvopasture was US\$ 63/acre compared to \$US 64/acre for pine plantations). However, risk reduction associated with the more even flow of revenues over the rotation period and the increased diversity of silvopasture may make it more desirable to some landowners.

Drew, Alavalapati, and Nair, use the Policy Analysis Matrix (PAM) method in Chapter 4 to extend profitability analysis by considering both private and social profitability of three agroforestry systems in Pohnpei, Federated States of Micronesia. This type of analysis is crucial because agroforestry is often promoted as a sustainable land use system that produces both private and public goods (e.g., environmental improvements that benefit the wider society such as reduction of soil erosion and carbon sequestration). If private profitability is not sufficient to encourage adoption of agroforestry systems that produce large amounts of public goods, analyses like these are required to determine whether government incentives are appropriate and if so the size and composition of incentives required to encourage socially efficient rates of agroforestry adoption. In addition, the PAM methodology provides a means to quantify the impacts of policy distortions and market failures on farmer decision-making and how potential government strategies may impact different sectors of the economy. Although the PAM has been applied to analyzing single crop systems (including agroforestry) this represents the first time that PAM has been used to examine social and private profitability of multiple crops in complex agroforestry systems and to internalize non-market externalities such as carbon sequestration and soil erosion for agroforestry policy analysis. The case study in Pohnpei provides a striking example of the necessity of policies such as taxes on soil erosion and subsidies for carbon sequestration to correct policy distortions and market failures to promote socially efficient land use with agroforestry.

Bright (Chapter 5) shifts the emphasis from comparing the profitability of agroforestry systems to alternatives to applying production function theory and

Cacho and Hean demonstrate, in Chapter 8, the use of dynamic optimization modeling to estimate the optimal combination of trees and crops and rotation period to reduce the costs of land degradation (salinization) and increase the benefits associated with carbon sequestration. Using a dynamic programming approach, where current decisions influence the range of future options, they estimate the direct (timber) and indirect (land degradation and carbon sequestration) benefits and costs of planting trees in association with agricultural crops compared with those of pure agricultural crops. They find that the optimal decision rules for tree stocking and rotation depend on initial land quality, with more trees on shorter rotations being optimal on poorer lands. Land degradation impacts are shown to be more important than carbon sequestration benefits for determining optimal tree stocking and rotation cycles.

In Chapter 9, Pattanayak and Depro demonstrate the use of household production theory for modeling the production of environmental services such as soil erosion and reduced deforestation from fuelwood collection in agroforestry systems. Following the development of the theoretical model they show how it can be used to generate hypotheses and test them econometrically using data from Mangarai, Indonesia. The model predicts that optimal production of environmental services from the household's perspective is determined by prices of consumption goods and production inputs, and factors influencing production possibilities and adoption choices. Both parametric (multivariate ordered probit) and non-parametric analyses of cross-sectional data support the hypotheses that agroforestry (depending on the specific system) reduces fuelwood harvesting from forests and reduces costs of on-site erosion.

The final chapter (10) in the environmental economic analysis section by Shrestha and Alavalapati, applies contingent valuation to the problem of estimating the amount of compensation Florida ranchers would be willing to accept to adopt silvopastoral systems, that produce environmental services (improved water quality, soil conservation, wildlife habitat, and carbon sequestration) for the citizens of Florida. This innovative application to producer decision-making (as opposed to the more common consumer focused contingent valuation) based on a survey of 421 ranchers found that an average of US\$ 0.19 per pound price premium would be required to encourage Florida ranchers to adopt silvopasture. The authors have demonstrated the applicability of survey-based non-market valuation methods to evaluate the adoption potential of agroforestry in the US.

2.3. Household constraints and adoption

It has long been recognized that achieving the full promise of agroforestry requires a fundamental understanding of how and why farmers make long-term land-use decisions and applying this knowledge to the design, development, and "marketing" of agroforestry innovations to improve adoption rates. During the 1990s, a relatively large literature on adoption of agroforestry was produced to facilitate this understanding. Most of this literature is based on *ex-post* binary choice regression

sequential nature of agroforestry production processes (physical and socio-economic) with micro, macro, formal, and informal institutions and requirements for social, economic and ecologic sustainability as evaluative criteria. Kant and Lehrer conclude that applying this framework is a first step in a comprehensive and consistent institutional analysis of agroforestry systems to inform effective policy interventions.

3. GAPS AND FUTURE DIRECTIONS

The research reported in this book demonstrates the rapid advances being made in applying economic theory, modeling, and empirical analysis to the study of agroforestry. Although the authors have made significant strides in improving the quantitative rigor of economics and policy research in agroforestry, there is a large potential to take the work presented in this book to a higher level. Areas for future research include:

- Economic analysis can be extended and strengthened by explicitly accounting for variation in future prices of inputs and outputs and risk and uncertainty associated with production processes. Extensive sensitivity analyses and probabilistic modeling might improve the accuracy and credibility of the information.
- Future research should emphasize more whole-farm analyses rather than enterprise-specific budgets to examine potentially crucial interactions between enterprises on a farm and a broader examination of returns beyond profitability to include the impacts of cultural taboos, farmer preferences, resource bottlenecks, policy constraints and market failures.
- Greater emphasis needs to be placed on the role that markets play in determining the profitability and adoptability of agroforestry. Particularly important is analyzing the role of agroforestry production as substitutes for purchased inputs and how prices and markets for the substitutes will influence farmer adoption and vice versa.
- Research on dynamic optimization of agroforestry systems should concentrate more on reducing assumptions of land homogeneity under single management and to include stochastic processes for prices, yields, and weather in the models.
- Econometric analyses could be improved by developing time series or panel data sets and apply the instrumental variables to account for potential endogeneity associated with agroforestry adoption.
- Extensive research and diverse applications of contingent valuation have enabled resource economists to identify various biases and account for many of those anomalies. For example, a variety of elicitation formats (open-ended questions, iterative bidding games, and payment cards) that were explored in resource economics can be introduced to agroforestry. Also, the methods of combining the stated preference data with revealed preference data in estimating environmental values can be applied in agroforestry context.

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There is a growing interest and need for enhancing economic and policy research in agroforestry. So far, no single reference book provides adequate coverage of applied economic and policy analysis methodologies for agroforestry professionals. This book, written by the leading experts in economics and agroforestry, addresses this need with 14 case studies (covering all the continents of the world) that describe and demonstrate the application of a wide range of cutting edge economic analysis techniques to agroforestry systems, policies and projects. The applied economic methodologies include enterprise/farm budget models, Faustmann models, Policy Analysis Matrix, production function approach, risk assessment models, dynamic programming, linear programming, meta-modeling, contingent valuation, attribute-based choice experiments, econometric modeling, and institutional economic analysis. This book provides a unique and valuable resource for assisting upper division undergraduate and graduate students and rural development professionals to conduct rigorous assessment of economic and policy aspects of agroforestry systems and to produce less biased and more credible information.

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