Agroforestry and portfolio theory

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Key words: agroforestry, covariance, expected return, portfolio theory, risk

Abstract. Portfolio theory is used to analyse the risk of hypothetical agroforestry systems. It is shown that the relationship of the returns of the components of an agroforestry system, expressed in terms of the covariance or correlation of returns, is of vital importance in correctly defining risk. Agroforestry systems can be classified as efficient or inefficient. Inefficient systems are such that an alternative system exists which has a greater return for the same level of risk. Thus, inefficient systems do not represent rational choices for agroforestry systems. Finally, the conclusion is reached that it is impossible to design a 'best' system, but rather a set of efficient systems of differing risk and return can be defined. This set of efficient systems is referred to as the efficient frontier.

1. Introduction

In agroforestry, areas such as the actual implementation of agroforestry systems and their practical evaluation are, quite rightly, seen to be the priority areas for research. In such a situation a purely analytical and theoretical paper such as this requires some words of justification. The justification is that it is believed that the theory discussed in this paper highlights an important aspect of the economics of agroforestry which can be used in practical settings to aid in the design of agroforestry systems and to assess more accurately their benefits.

This aspect is risk, which is an area in the economics of agroforestry in need of explicit consideration [1]. In advocating the introduction of an agroforestry system — and therefore a change in the pattern of land use — a source of resistance might be the increased risk believed to be attached to an unknown system of cropping. The explicit consideration of risk might help to alleviate such problems.

2. Portfolio theory

The theory I wish to discuss here is so-called Portfolio Theory from the field of financial economics. In 1959 Markowitz presented a theory which defined
how to diversify a portfolio of stocks in an optimum way with regard to risk and return [6]. Financial assets markets, the area for which the theory has been developed, publish a vast amount of detailed data and so the theory is capable of considerable refinement and can be tested extensively when applied to that sector of the economy.* In agroforestry, of course, data sources are far more limited, as is the ability to invest and disinvest rapidly, and so the theory cannot be sensibly developed to the same extent as it can in financial economics. However, the basis of the theory does retain an applicability, even in situations of comparative data scarcity and when investments are of a longer term, because the factors which dictate the correct choice of a mixture of stocks are likely to be of relevance in the choice of a mixture of species to cultivate in an agroforestry system. Later a way to apply the theory in a situation of data scarcity will be discussed, but for now assume that we have the necessary data.

2.1 A two-crop agroforestry system

Many agroforestry systems contain only two crops, an ‘agricultural’ crop and a tree crop. Imagine that these are crops A and B respectively and that they can be combined in a perfectly flexible way so that, if \( w_a \) is the fraction of a hectare of land under crop A and \( 1 - w_a \) is the fraction under crop B, \( w_a \) can vary continuously from zero to unity. The expected net present value (ENPV) over some time period from one hectare of the agroforestry system will be given by equation (1).

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\text{ENPV} = w_a \text{NPV}_a + (1 - w_a) \text{NPV}_b
\]

Here \( \text{NPV}_a \) = the net present value of one hectare of crop A.

\( \text{NPV}_b \) = the net present value of one hectare of crop B.

Equation (1) contains the implicit assumption that there are no benefits from growing the crops together or economies of scale in establishing and tending. Thus, if \( w_a = 0.9 \), the net present value from crop A is 90% of its net present value if it alone were grown on one hectare of land. Such an assumption would, under some definitions, mean that the system under consideration is not an agroforestry system [5]. However, equation (1) and the subsequent equations can be fairly easily modified to allow for the mutual benefits or economies of scale associated with specific agroforestry systems. In doing so the exact form of the functions to be presented will alter but the interpretations and conclusions that can be drawn from them will remain the same.

The net present values in equation (1) are estimates of revenues and costs in the future and, therefore, subject to risk. It is usual to define the risk as

*For a full treatment of the theory and its development the interested reader is referred to [2].