12

Larry D. Godsey
University of Missouri, Columbia, MO

D. Evan Mercer
USDA Forest Service, Southern
Res. Stn., Research Triangle Park, NC

Robert K. Grala
Stephen C. Grado
Mississippi State University, Mississippi State, MS

Janaki R.R. Alavalapati
University of Florida, Gainesville, FL

Agroforestry Economics and Policy

Essentially every living thing on Earth has applied the basic concepts of economics. That is, every living thing has had to use a limited set of resources to meet a minimum set of needs or wants. Although the study of economics is often confused with the study of markets or finance, economics is simply a social science that studies the choices people make. As a social science, economics is the study of human motivations. Or, as Landsburg (1993) put it, “most of economics can be summarized in four words: ‘People respond to incentives’.” Those incentives reflect the value of the trade-offs made between a limited set of resources and an unlimited set of wants, needs, and desires.

It is true that the concepts of money and price are often used as proxy values for economic decisions, but markets don’t always reflect the true value of natural resource benefits and prices do not indicate the actual cost of the services provided by natural processes (Sagoff, 2004). Remember the last time you drove through the countryside on a nice autumn day and admired the beautiful colors. How much did you have to pay for this benefit? If you paid nothing, does that mean that it has no value?

Economics characterize the mental calculus of a decision maker, whether a private landowner or a policymaker. In particular, economic models are abstract representations of the real world useful for hypothesis generation, forecasting, policy analysis, and decision-making (Buongiorno and Gilles, 2003). Alavalapati and Mercer (2004) recently discussed diverse economic models and their applications to agroforestry (Table 12–1). Some are designed to assess simple cost and benefits of outputs and inputs for which markets are fairly established, while others are amenable to a variety of environmental services and damages for which there are no established markets. Furthermore, some methodologies are more appropriate for assessing issues at a farm or household level, and others are applicable at regional and national scales.

The goal of this chapter is to present the concepts of economics and explain how it applies to natural resource management decisions so that students with limited backgrounds in economics may still understand the issues faced by decision makers. This chapter discusses many of the tools used by economists to measure and determine how choices are made at both the micro- (individual) and the macro- (aggregate) level. Financial concepts are the basis for many of the tools that economists use to measure market- and nonmarket-based values at the individual level. These tools include benefit–cost, discounted cash flow, and willingness-to-pay analysis. The appendices provide an overview of several basic economic concepts (interest rates, compounding versus discounting, and inflation) that form

North American Agroforestry: An Integrated Science and Practice, 2nd edition, H.E. Garrett (ed.)

Table 12–1. Economic methodologies commonly applied to assess agroforestry systems.†

Economic Approach/Model	Nature, Scope, and Scale of the Issue for Investigation
Enterprise/farm budget models	Estimate the profitability of a farm or enterprise by calculating indicators such as net present values (NPV), benefit/cost ratio (BCR), and internal rate of return (IRR).
Risk assessment models	Incorporate probabilities of events occurring and estimate the expected profitability of agroforestry.
Policy analysis matrix (PAM) models	Assess the profitability at a farm or regional level from both the individual and society perspective (similar to farm budget models, but also includes market failures).
Faustmann and Hartmann models	Optimization models to estimate land expectation values assuming that the land will be used for agroforestry (the best possible productive use) in perpetuity.
Linear and nonlinear programming models	Estimate optimum resource allocation subject to various constraints faced by the decision maker.
Econometric models	Estimate the relationships among variables under investigation for forecasting, policy analysis, and decision making.
Nonmarket valuation models	Stated and revealed preference models to estimate values for environmental goods and services such as reducing soil erosion, improving water quality, and carbon sequestration (examples include hedonic and contingent valuation models).
Regional economic models	Estimate changes in income, employment, and price levels at regional or national level, in response to a policy or program change and explicitly incorporate intersectoral linkages.

† Source: A revised version adapted from Alavalapati and Mercer (2004).

the basis for the financial analysis described below. To give a flavor of how the tools of economics can be used to analyze agroforestry, in the next sections we describe and provide examples of using two of the approaches in Table 12–1, enterprise/farm budget models and nonmarket valuation models. These are followed by an overview of policies and incentives to encourage landowners to adopt agroforestry systems.

Budgeting and Valuation in an Agroforestry Context

Agroforestry practices usually constitute part of a larger farm system that includes various operations in which agricultural production (annual crops and/or livestock) is combined with trees. They provide numerous market and nonmarket benefits that not only improve sustainability of the farm (Young, 1989) but also can lead to significant increases in monetary returns (Gordon and Newman, 1997). However, implementation of agroforestry alternatives as well as other farm practices is often constrained by available resources such as land, financial capital, equipment, production technology, and labor (Kurtz, 2000). Farmers and landowners allocate these limited resources in a way that allows them to attain their objectives in the most efficient manner. When the objective is to maximize financial returns on farm production, this implies that you are comparing costs and returns, and selecting, from a financial perspective, the most promising practices (Alavalapati and Mercer, 2004; Kurtz, 2000). In this section, we describe methods and tools commonly used to assess financial viability of agroforestry practices as well as the entire farm production.

Farm Budgeting for Agroforestry Alternatives

The process of financially determining the most effective farm operations is not an easy task. Increasing production costs and changing demands for farm products require continuous reevaluation of farm management objectives and adjustments of farm production to make it profitable. Possible adjustments might include lowering farm production costs, improving production technology, and introducing new farm operations such as agroforestry practices. These changes can have a significant impact on the financial viability of the entire farm. Thus, such enterprises have to be well planned and examined from a financial perspective to ensure that only alternatives improving overall profitability are implemented. This requires a consistent examination of short- and long-term financial effects of proposed changes in farm management. Farm budgeting is a method used to evaluate the attainment of farm financial goals by comparing revenues and costs associated with farm production. There are several types of farm budgeting, and we briefly discuss three: whole-farm, enterprise, and partial budgeting.

Whole-Farm Budgeting

A *whole-farm budget* is a snapshot describing the entire production on the farm. It identifies individual farm components called *enterprises* and shows how they contribute to the overall profit generated by farm production (Doye, 2007). A farm enterprise consists of any type of farm production such as corn, soybeans, wheat, tomatoes, and cattle production, as well as agroforestry systems (Chase, 2006). Therefore, a typical farm will include several enterprises.

Whole-farm budgeting serves as a guideline to accomplish the owner's objectives, given limited resources, and monitor progress in the attainment of these objectives (Doye, 2007). A whole-farm budget can be fairly extensive and complicated, depending on farm size and number of farm enterprises involved. Typically, it lists all of the farm's physical and financial assets and describes how they are allocated to whole farm production as well as particular farm enterprises (Doye, 2007). The pivotal part of the budget is the summary of costs associated with conducting outlined farm operations, expected revenues from selling farm products, and estimated net income generated by the entire farm (Smathers, 1992). A whole-farm budget can be used to determine the net value of farm production and how it will be affected by changes in costs, products prices, and expected crop yields. By comparing several alternative management plans, landowners can use this budget to determine farm potential and negotiate financing from lending institutions (Smathers, 1992).

Enterprise Budgeting

An *enterprise budget* describes costs and revenues associated with a specific farm enterprise and explains how farm resources are allocated in the production of farm products (Chase, 2006). As with whole-farm budgets, enterprise budgets also vary in format and amount of information provided. Most often they include information on revenues generated from the enterprise and costs such as planting, fertilizing, weed control, labor, machinery, land and building costs, and overhead (Doye, 2007; Smathers, 1992). In addition, these budgets often include break-even prices per unit of production and sensitivity analyses (Smathers, 1992). Enterprise budgets can be used in several ways to aid decision making. Most commonly, they are used to identify the most profitable farm enterprises and determine if current crop or livestock operations can be replaced with more profitable alternatives, such as agroforestry (Chase, 2006).

Partial Budgeting

A partial budget is used in situations where change in the farm operation only affects a part of farm production (Lessley et al., 1991). Thus, instead of developing an extensive whole-farm or enterprise budget, it is possible to examine only those costs and revenues affected by the change. To determine the net outcome of the proposed change it is necessary to identify associated positive and negative effects as outlined by the partial budget methodology. Increased revenues and reduced costs resulting from the change are considered as positive effects, whereas lost or decreased revenues and increased costs as negative effects. If positive effects exceed negative ones, overall farm income increases. In contrast, if negative effects are larger than positive ones, farm income will decrease (Doye, 2007).

Consider Chase et al.'s (2006) example of a situation where a farmer considers switching from organic soybean production to organic corn production on 16 ha of farmland. Current revenue associated with organic soybean production on this parcel of land is $20,160.00, whereas the cost is $3,150.00. If the land is shifted to organic corn production, it is expected that it will generate revenue of $27,000.00 at a cost of $6,530.00. The positive effects in this case include increased revenue of $27,000.00 generated from corn production and reduced costs of $3,150.00, amounting to a total of $30,150.00. The reduced cost of $3,150.00 is considered a positive effect because it is associated with soybean production. Since soybeans will be replaced with corn this cost won't be incurred again and thus represents additional savings. The negative effects include lost income of $20,160.00 and increased costs of $6,530.00 totaling $26,690.00. Again, since soybeans won't be cultivated, lost soybean revenue has to be accounted for as a negative effect. Similarly, the cost associated with corn production is considered as a new cost and consequently also a negative effect. The net outcome of the proposed change from organic soybeans to organic corn production equals $3,460.00 (positive effects − negative effects = $30,150.00 − $26,690.00). This value represents an amount by which overall farm income will increase if organic corn production is implemented versus organic soybean production.

Effect of Time on the Value of Agroforestry Practices

A common feature of agroforestry alternatives is that they involve long investment periods (often more than a decade), which require special approaches in financial evaluation. Comparing revenues and costs simply as they appear is misleading and will lead to an incorrect decision on the financial viability of an agroforestry alternative. We can't just subtract costs from revenues to determine if the investment is profitable because with such long investment periods, time becomes a cost itself and needs to be properly accounted for in the analysis.

Imagine a situation in which you have been offered $2,000.00 and are given an option to cash it in today or receive the same amount after 5 yr. The choice for most people would be simple—they would prefer to receive the money now. Why? One reason is that there are numerous investment opportunities available that can generate additional income during that 5-yr period. So, why wait so long to receive the same amount of money if you can deposit it, for example, in a bank account or invest in the stock market and collect a much larger sum after 5 yr? For instance, if you deposit $2,000.00 into a savings account that pays an annual interest rate of 4%, after 5 yr you will be able to withdraw $2,433.31 (see Appendices 12–1 and 12–2 for details on how to calculate this value). You gain an additional $433.31 by investing now and cashing in after 5 yr instead of doing so today. Others might have different investment opportunities available to them (such as agroforestry) and consequently will earn more or less than $433.31.

Figure 12–1 shows how much money will accumulate in the above account if you decided to make a deposit for a period longer than 5 yr. You can see that the initial amount will double after 18 yr, whereas after 50 yr you will accumulate about $14,213.37 (a seven-fold increase). In other words, you are lending your money to the bank, which will compensate you for the fact that you cannot use the money during this period. The longer you leave your deposit in this account, the more you will be able to withdraw at a later date.

So far, we have examined the problem only from the perspective of the future value. Another way to look at this issue is to establish today's value of the promise of receiving $2,000.00 in 5 yr. For someone whose best investment alternative is a savings account paying a 4% annual interest rate, that $2000.00 promise in 5 yr would only be worth $1,643.85 today (Appendices 12–1 and 12–2 explain how to arrive at this value). Why? This is the amount that would need to be deposited into a savings account today to generate exactly $2,000.00 in 5 yr. Notice that this is $356.15 less than the promised $2,000.00. This is one of the reasons why most people would rather have $2,000.00 now rather than wait five more years to collect exactly the same amount of money.

Figure 12–2 indicates how the present value of $2,000.00 decreases as it is received further in the future. For example, if you are offered $2,000.00 in 10 yr, it would be worth $1,351.13 now, whereas the same amount offered to you in 50 yr would be worth only $281.43. For someone who had an investment alternative paying a rate of return higher than 4%, the corresponding present values would be even smaller.

This relationship between time and present value has important implications for financial evaluations of agroforestry alternatives. Imagine a simplified agroforestry investment in which there was only one expense of $1,500.00 now and expected revenue of $2,000.00 in 10 yr. At first you might think that it is a good investment because it will generate a profit of $500.00 ($2,000.00 − $1,500.00). However, when you account for opportunity forgone (i.e., a savings account earning a 4% interest rate), the $2,000.00 is now worth only $1,351.13 thus indicating that the aforementioned agroforestry investment would generate a loss of $148.87 ($1,351.13 − $1,500.00 = −$148.87) in present value terms.

Net Value of Agroforestry Investments: Discounted Cash Flow Method

Financial viability of agroforestry investments is determined by their net present values (NPV). Typically, agroforestry projects are long-term investments with cash flows occurring in different years. Consequently, a project's net value cannot be determined by comparing nominal values of revenues and costs because they have different time values. Instead, the value of each cash flow has to be recalculated in terms of the

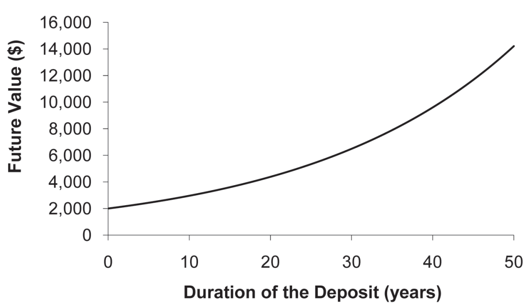

Fig. 12–1. Future value of a $2,000.00 deposit accumulated at a 4% annual interest rate through time.

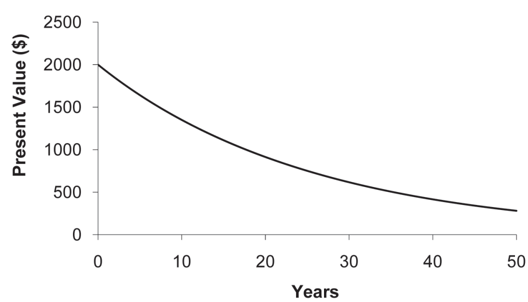

Fig. 12–2. Present value of a $2,000.00 income calculated at a 4% discount rate through time.

same point in time (the same base year). The discounted cash flow method (DCF) considers all of a project's cash flows expressed in terms of the starting year, Year 0 (i.e., present time) (Bright, 2001). A present value of each cash flow is determined through discounting by applying appropriate formulas for calculating the present values (formulas and examples are provided in Appendix 12–2). When all cash flows for a particular agroforestry project are discounted to Year 0, they are comparable, and the project's net present value (NPV) can be established.

When calculating NPV it is useful to prepare a discounted cash flow table that provides a summary of all of the project's activities and corresponding present values. Table 12–2 illustrates discounted cash flows of a silvopastoral system described by Grado and Husak (2004) that has been simplified for easy illustration. Present costs and revenues are expressed in terms of 2006 U.S. dollars. Projected activities, corresponding years of occurrence, and cash flow values are listed. Costs are assigned negative values, whereas revenues positive ones. The last two columns show formulas used to calculate the present value of each cash flow and present value calculated at a 5% minimum acceptable rate of return (MARR) (see Appendix 12–2 for descriptions of the formulas). The last column is crucial because it permits us to determine the project's NPV. When cash flow present values are summed, the NPV amounts to \$3,161.73 ha^{-1}. The positive value indicates that investment costs are more than offset by revenues, and therefore the investment should be profitable. The use of NPV and other financial indicators to evaluate agroforestry alternatives will be explained later in this chapter.

Financial Indicators for Agroforestry Alternatives

Above and in Appendix 12–2, we discuss how to calculate present and future values of single and multiple cash flows and determine the NPV of agroforestry investments. Now, we use financial tools to determine if the investment is profitable or not. There are various financial criteria

Table 12–2. Discounted cash flows for a southern silvopastoral system calculated at a 5% minimum acceptable rate of return (MARR); using 2006 as the analysis year. See Appendix 12–2 for explanation of formulas.

Activities	Year	Cash Flow	Formulas	Present Value at 5%
		\$ ha^{-1}		\$ ha^{-1}
Establishment	0	−215.10	$V_0 = \frac{-\$215.10}{(1.05)^0}$	−215.10
Land rent	1–30	−145.28	$V_0 = -\$145.28 \times \left[\frac{(1.05)^{30} - 1}{0.05 \times (1.05)^{30}}\right]$	−2233.31
Management	1–30	−440.51	$V_0 = -\$440.51 \times \left[\frac{(1.05)^{30} - 1}{0.05 \times (1.05)^{30}}\right]$	−6,771.72
Steer/heifer sales	1–30	649.60	$V_0 = -\$649.60 \times \left[\frac{(1.05)^{30} - 1}{0.05 \times (1.05)^{30}}\right]$	985.94
Hunting lease	1–30	13.53	$V_0 = -\$13.53 \times \left[\frac{(1.05)^{30} - 1}{0.05 \times (1.05)^{30}}\right]$	207.99
Thinning	15	421.38	$V_0 = \frac{\$421.38}{(1.05)^{15}}$	202.69
Thinning	20	183.80	$V_0 = \frac{\$183.80}{(1.05)^{20}}$	69.27
Thinning	25	1388.15	$V_0 = \frac{\$1,388.15}{(1.05)^{25}}$	409.92
Harvest	30	6509.04	$V_0 = \frac{\$6,509.04}{(1.05)^{30}}$	1506.05

available for examining profitability of agroforestry alternatives. In this section, we will focus on the five most commonly used criteria: net present value (NPV), annual equivalent value (AEV), benefit/cost ratio (BCR), internal rate of return (IRR), and land expectation value (LEV). The following section will present the basics of each criterion, as well as guidelines for accepting and rejecting agroforestry alternatives according to each criterion.

Net Present Value

Net present value is often used to determine financial viability of an investment. It is calculated by subtracting the present value of an investment's total costs from the present value of the investment's total revenues (Klemperer, 2003; Bullard and Straka, 1998; Gunter and Haney, 1984). The general formula for calculating NPV is as follows:

$$\text{NPV} = \text{Present value of all investment revenues} - \text{Present value of all investment costs}$$

As the above formula indicates, an investment's NPV is determined by discounting all revenues (R_n) and costs (C_n) to the present (i.e., Year 0 in the life of the project) with interest rate i. Net present value is calculated by summing present values of costs and revenues. Calculated NPV can be a positive or negative dollar value or zero.

A positive dollar value (where NPV > 0) indicates that discounted revenues exceed discounted costs and a profit is generated. In such a case, an agroforestry alternative should be accepted because it is profitable. A negative dollar value (i.e., where NPV < 0), on the other hand, indicates that discounted costs exceed discounted revenues. Such an agroforestry alternative should be rejected because it doesn't generate enough revenue to offset costs and will result in a monetary loss. A zero dollar value (i.e., where NPV = 0) indicates that discounted revenues equal discounted costs. The agroforestry alternative should be accepted because it still generates enough revenues to offset costs—this is referred to as the financial break-even point.

Annual Equivalent Value

Annual equivalent value is an indicator that expresses NPV in annual equivalents distributed equally over the years of the lifespan of the investment. Since AEV is calculated based on NPV, it is positive when NPV is positive and negative when NPV is negative. Annual equivalent value is useful in an agroforestry context because it allows for comparing alternatives on an annual basis, which is particularly helpful when comparing long-term tree investment with annual agricultural crop production (Bullard and Straka, 1998). The formula for calculating AEV is as follows:

$$\text{AEV} = \text{NPV}\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

A 10-yr agroforestry investment with a NPV of \$910 ha^{-1} calculated at an 8% minimum acceptable rate of return will have an AEV of \$118.89 ha^{-1}:

$$\begin{aligned}\text{AEV} &= \$910\ \text{ha}^{-1}\left[\frac{0.08(1+0.08)^{10}}{(1+0.08)^{10}-1}\right]\\ &= \$910\ \text{ha}^{-1}\left[\frac{0.08(1.08)^{10}}{(1.08)^{10}-1}\right] = \$118.89\ \text{ha}^{-1}\end{aligned}$$

Benefit/Cost Ratio

Benefit/cost ratio is calculated by dividing the sum of investment discounted revenues by the sum of discounted costs. It is also referred to as the profitability index because it indicates a return generated for each dollar invested in the project (Klemperer, 2003; Bullard and Straka, 1998; Gunter and Haney, 1984). The formula for calculating BCR is as follows:

$$\text{BCR} = \frac{\text{Present value of all investment revenues}}{\text{Present value of all investment costs}}$$

A BCR value greater than one (i.e., where BCR > 1) indicates that each dollar invested in the agroforestry alternative generates more than one dollar in return in present value terms. Therefore, the alternative should be accepted. However, if the BCR value is less than 1 (i.e., where BCR < 1), the alternative should be rejected because each dollar invested generates less than one dollar in return—this indicates a loss on each dollar invested. A BCR value equal to one (i.e., BCR = 1) indicates that each dollar invested generates one dollar in return. This means that an agroforestry alternative has broken even and also should be accepted.

Internal Rate of Return

Internal rate of return is a discount rate (see Appendix 12–1 for a discussion of discount rates), at which an investment's NPV equals zero (Klemperer, 2003; Bullard and Straka, 1998; Gunter and Haney, 1984). This is the maximum discount rate at which an agroforestry alternative can break even. Internal rate of return is determined by an iterative process, in which an investment's NPV is calculated at various discount rates. Two interest rates, one at which the NPV is positive, and the other one at which NPV is negative, need to be selected to calculate IRR. The reason for using this iterative process is that there is an inverse relationship between NPV and the discount rate used to calculate NPV. More specifically, NPV decreases as the discount rate used to calculate NPV increases. When the discount rate is increased sufficiently high, the NPV will become negative (the opposite will hold if the discount rate is decreased). This means that between the two discount rates (resulting in positive and negative NPVs, respectively) there is one that will result in an NPV equal to zero. This is the IRR and it can be approximated by using the following formula (Bright, 2001):

$$\text{IRR} = \begin{array}{c}\text{Discount rate resulting}\\ \text{in negative NPV}\end{array} + \left(\begin{array}{c}\text{Difference between}\\ \text{discount rates}\end{array} \times \frac{\text{Positive NPV}}{\text{Incremental NPV}}\right)$$

As an example, we calculate an IRR for an alley cropping system that generates a NPV of \$650 ha^{-1} at a 6% discount rate. To determine the IRR for this investment, we need to find a rate of return whereby the NPV will become negative. Since NPV was positive at 6%, this means that we need to increase the discount rate. If the discount rate is increased to 8%, NPV is still positive at \$320 ha^{-1}. Consequently, the discount rate needs to be increased even further. At 10%, it generates NPV of \$130 ha^{-1}, but at 12% NPV drops to −\$28 ha^{-1}. To determine IRR, we need to select the highest discount rate at which NPV is still positive and another discount rate where NPV becomes negative. This is 10 and 12%, respectively. Now, we know that IRR is greater than 10% but smaller than 12%. By inserting this information into the above formula we can approximate that the IRR for this agroforestry alternative is 11.65%:

$$\text{IRR} = 10\% + \left[2\% \times \frac{\$130\ \text{ha}^{-1}}{\left(\$130\ \text{ha}^{-1} + \$28\ \text{ha}^{-1}\right)}\right] = 11.65\%$$

How can the IRR be used to determine if an agroforestry alternative is financially acceptable? If the farmer's acceptable rate of return is smaller or equal to the IRR, the alternative should be accepted. However, if the minimum acceptable rate of return is greater than the IRR, the alternative should be rejected. This is because the minimum acceptable rate of return that is higher than the IRR will result in a negative NPV, and a financial loss for the agroforestry alternative. If the minimum acceptable rate of return for the alley cropping system mentioned above is 6%, then it would be a good investment because the actual IRR is well above that acceptable rate. In fact, this alley cropping system would break even at a minimum acceptable rate of return as high as 11.65%.

Table 12–3 gives a summary of the how the indicators of NPV, IRR, and BCR can be used to assist in the decision making process. The landowner should accept investments with NPVs greater than or equal to 0, a BCR that is greater than or equal to 1, and an IRR that is greater than or equal to the minimum acceptable rate of return.

Land Expectation Value

Land expectation value (LEV) is a financial tool used to estimate land value based on all expected future costs and revenues generated from the use of this land. The LEV (known also as the Faustmann formula) has been used primarily to calculate the value of land parcels for which timber production was determined to be the best land use. Its major assumption is that timber production will be continued on a particular parcel of land in perpetuity under the same management regime (Klemperer, 2003; Bullard and Straka, 1998). However, the LEV can also be used to establish the value of a specific land parcel based on costs and revenues associated with both tree and agricultural production. In this case, the LEV is interpreted as the maximum amount of money a landowner can pay for the land and still earn the minimum acceptable rate of the return on an agroforestry investment.

The LEV can be computed in several ways. We calculate LEV for the silvopastoral system presented in Table 12–2 based on its NPV of \$3,161.73 ha^{-1}. However, this NPV already includes land rent, whereas the LEV calculates land value based on future costs and returns. Therefore, we need to exclude land payments that occur during the investment period. When they are removed from the analysis, the recalculated NPV is \$5,395.04 ha^{-1}. Now, we are ready to calculate LEV by using the following formula:

$$\begin{aligned}\text{LEV} &= \frac{\text{NPV}(1+i)^t}{(1+i)^t - 1}\\ &= \frac{\$5,395.04\ \text{ha}^{-1} \times (1.05)^{30}}{(1.05)^{30} - 1}\\ &= \$7,019.10\ \text{ha}^{-1}\end{aligned}$$

Table 12–3. Guidelines for accepting or rejecting agroforestry alternatives according to net present value (NPV), benefit/cost ratio (BCR), and internal rate of return (IRR).

	Decision rule		
Accept the investment	NPV ≥ 0	BCR ≥ 1	MARR† ≤ IRR
Reject the investment	NPV < 0	BCR < 1	MARR > IRR

† Minimum acceptable rate of return.

The value of $7,019.10 ha^{-1} represents a maximum amount a landowner can pay for this land and still earn a 5% minimum acceptable rate of return on this silvopastoral system, cycle after cycle in perpetuity, provided that cash flows occur as presented in Table 12–2.

Limitations of Financial Indicators

So far we have discussed five economic criteria used to evaluate agroforestry alternatives. However, we haven't discussed how to choose between these criteria. When deciding if a particular investment is acceptable or not, the choice is easier than it may appear. Any of the three criteria, NPV, BCR, and IRR, can be used to evaluate the alternative because they will provide the same recommendation (Bullard and Straka, 1998; Gunter and Haney, 1984). If the agroforestry alternative is acceptable according to one criterion, it will also be acceptable according to the remaining two because all three criteria involve calculating NPVs. For example, a NPV of $750 ha^{-1} indicates that the investment is acceptable according to the NPV because it is greater than zero. A positive NPV means that discounted revenues are greater than discounted costs. This indicates that the BCR is greater than one and the investment is acceptable also according to the BCR. Furthermore, a positive NPV indicates the minimum acceptable rate of return used to calculate NPV for this agroforestry alternative is smaller than the IRR. As a result, the alternative is also acceptable according to IRR criterion (Bullard and Straka, 1998).

Landowners often need to decide not only if an agroforestry project is acceptable but also must select the best agroforestry alternative among several financially acceptable options. One reason is that capital, labor, or land available to landowners is often limited (Klemperer, 2003), allowing for implementation of only one or a limited number of viable investment alternatives. Second, even if all considered alternatives can be financed, some of them might be mutually exclusive, thereby allowing for the implementation of only one alternative. For example, if a landowner decides to use part of the farmland for production of organic soybeans, this part of the farm cannot be used for cultivation of other crops during the same season.

When the goal of a financial analysis is to rank available alternatives to determine the best land use, the process of selecting an appropriate financial indicator is more challenging. This is because NPV, BCR, and IRR might provide conflicting recommendations regarding the ranking of a particular agroforestry alternative. Furthermore, they do not specify the scale of the investment or the amount of capital required to implement it. Consequently, it is not difficult to imagine a situation in which even acceptable alternatives might not be undertaken due to, for example, limited funding.

So, which indicator should be used to rank agroforestry alternatives? Generally, it is recommended that NPV should be used to rank agroforestry alternatives to select, from a financial viewpoint, those that are most viable and feasible (Bullard and Straka, 1998; Gunter and Haney, 1984). However, it is recommended that a two-step ranking process be used to ensure that the best financial decision is made. In the first step of the ranking process, NPV should be used to determine if considered alternatives are acceptable. Unacceptable alternatives should be removed from further consideration. In the second step, the list of acceptable alternatives should be created and mutually exclusive alternatives identified. If mutually exclusive alternatives are present, the best alternative from each set of mutually exclusive alternatives should be selected (e.g., by computing AEV). The most poorly performing alternatives are removed from further analysis because their implementation would be inefficient. The final ranking list consists of only acceptable and mutually nonexclusive alternatives ranked in order of decreasing NPV. The ranking also should include information on the cost required to implement each alternative. This two-step analysis process provides the information needed to determine which agroforestry alternatives can be implemented given an existing budget and a landowner's financial objectives.

Agroforestry Practices as a Strategy to Diversify Financial Risk

As in the case of other economic undertakings, the financial performance of agroforestry projects is associated with risk and uncertainty. Dayananda et al. (2002) specified that risk is involved whenever there is a possibility that an investment will generate revenues smaller than were expected. Price (1993), on the other hand, presented a broader definition that also includes a possibility that return on investment will be higher than expected. The nature of agroforestry production implies that the viability of a particular agroforestry alternative is affected not only by changing market conditions but also by nonmarket factors such as biological and climatic characteristics.

There are numerous market factors affecting the financial feasibility of an investment. Examples include changing interest rates, production costs, prices, inflation, and taxes (Peterson and Fabozzi, 2002). Unfavorable changes in these factors might result in decreased monetary returns on an agroforestry investment. For example, decreases in prices of agroforestry commodities will have a negative impact on the investment profitability. A similar effect will be caused by increases in interest rates and production costs. Nonmarket factors can also have a significant impact on the financial performance of an agroforestry alternative. Growing conditions such as soil type and weather can significantly affect the harvest and, consequently, the revenue generated. Selecting tree species and agricultural crops resistant to harsh weather conditions and pests will help protect monetary returns. Catastrophic events such as fire, insect and disease outbreaks, hurricanes, tornadoes, and ice storms are much more difficult to predict, but they can have large impacts on agroforestry production.

In previous sections of this chapter we calculated present values and applied financial criteria to determine if an agroforestry investment is worthwhile. Notice that in those calculations we were precise "down to the penny". This might imply that a computed financial outcome is a sure venture. However, this outcome will be achieved only if all assumptions regarding interest rates, as well as the magnitude and timing of cash flows, are correct and take place as predicted. In real life, any of the market and nonmarket factors mentioned above can cause the financial outcome to differ from the computed value. The greater the change, the greater the difference in the investment outcome. Therefore, computed financial values should be treated only as predicted average values that can change due to any of a multitude of risk factors.

What then is the rationale for learning all of these financial techniques if the final outcome cannot be predicted with certainty? While we cannot in all certainty predict the financial outcome for a particular agroforestry investment, we can define acceptability ranges and identify suspect projects that are likely to be unacceptable even with small changes in the assumptions (Gunter and Haney, 1984). To do so, we can use sensitivity analysis, which examines how responsive the predicted financial outcome is to changes in these assumptions. Sensitivity analysis should be used when there is uncertainty about projected costs and revenues or if the investment was barely acceptable according to any of the economic criteria we have discussed (Bullard and Straka, 1998). In practice, a sensitivity analysis is conducted by determining the value of financial indicators at varying levels of change. For example, if it is anticipated that interest rates might change, it would be a good idea to recalculate the NPV, AEV, or BCR for a particular project using a range of discount rates. In Table 12–2, we determined NPV for a silvopasture system at a 5% discount rate. What would happen to the project's NPV if the discount rate increased? Would the investment still be acceptable? To answer these questions we will recalculate a NPV using several discount rates and try to identify one, at which the investment becomes unacceptable.

Table 12–4 shows that the silvopasture system investment is relatively robust to changes in the discount rate. Even at a discount rate as high as 15% it generates a positive NPV. Another way to conduct sensitivity analysis for this investment would be to examine how an investment's NPV responds to change in costs and expected revenues.

Agroforestry offers a unique opportunity to diversify risk associated with farm production, both through diversification of crops and distribution of income over time. When examined separately, agricultural producers and forest landowners are exposed to numerous risks that can diminish the financial viability of their production. In extreme situations, this might result in a loss. For example, agricultural producers may experience a decline in their revenues due to decreasing prices of agricultural products and increasing production costs. Therefore, focusing only on one or two agricultural crops makes agricultural producers particularly vulnerable to fluctuations in market prices.

Valuation of Nonmarket Benefits from Agroforestry

One of the key factors in determining agroforestry adoption is the profitability of the practice in comparison with other land use practices. However, profitability from a landowner's

Table 12–4. Sensitivity analysis for a southern silvopasture system based on the net present value (NPV) calculated at various discount rates, in 2006 dollars.

Discount rate, %	5	7.5	10	12.5	15
NPV, \$ ha^{-1}	3162	1855	1143	738	496

perspective, generally termed *private profitability*, can be different from that of a social perspective, often referred to as *social profitability*. The exclusion or inclusion of social benefits and costs and nonmarket goods and services (e.g., biodiversity and carbon sequestration), also known as *externalities*, largely differentiates the private and social profitability.

Research suggests that ecosystem goods and services associated with agroforestry are significant and that failure to incorporate them will result in gross undervaluation of agroforestry (Alavalapati et al., 2004). Following Alavalapati et al. (2004), we present a graphical analysis to illustrate the effect of internalizing environmental services associated with silvopasture adoption (Fig. 12–3). The horizontal axis measures the extent of trees and buffer strips on ranchlands, a proxy for silvopasture, while the vertical axis measures the costs/benefits of maintaining tree cover and buffer strips. Trees and buffer strips on ranchlands are considered beneficial to ranchers by providing shade to cattle and additional revenue from timber. These benefits to the rancher are reflected in Fig. 12–3 as private marginal benefits (MB). However, these activities also provide environmental benefits to the public by improving water quality and air quality (Zinkhan and Mercer, 1997). Consequently, maintaining trees and buffer strips on ranchlands is a cost paid by the individual ranchers, yet the benefits are enjoyed by everybody. Furthermore, the cost of fencing, tree seedlings, site preparation, and pruning is expected to increase with an increase in the tree density. These costs are also reflected in Fig. 12–3 as marginal costs (MC). In the absence of benefits from environmental services of silvopasture,

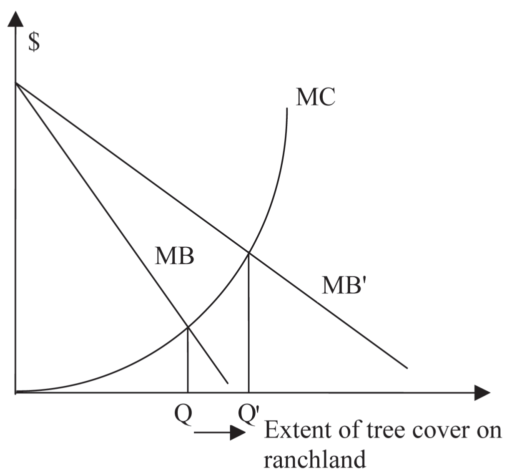

Fig. 12–3. Effect of internalizing environmental services on the extent of tree cover on ranchlands (Alavalapati et al., 2004).

ranchers will equate the private marginal cost of maintaining trees on ranchlands (MC) and private marginal benefit of trees (MB) and therefore maintain only *Q* amount of tree cover on their ranches. However, if markets exist for ecosystem services and if ranchers can capitalize on water quality improvement and carbon sequestration, the marginal benefit of trees would be higher. The marginal benefit to society is reflected in Fig. 12–3 as MB′. This increased marginal benefit motivates ranchers to maintain *Q′* amount of tree cover on their ranchlands.

In the absence of incentives for the provision of positive externalities and penalties for causing negative externalities, a rational agent is less likely to produce them at a societal optimum. Institutional economics suggests that under exclusive, transferable, and enforceable property rights, people can be rewarded for positive externalities and penalized for negative externalities. Furthermore, Coase (1960, 1992) stated that under zero transaction costs, markets allocate resources such that externalities are produced at optimum levels regardless of the initial assignment of property rights to either buyer or seller.

Consider, for example, a watershed with a group of ranchers upstream and a settlement of households downstream. Ranchers pollute a nearby stream through the application of chemical fertilizers and pesticides on pasture land. Households, who depend on the stream for clean water and other economic activities such as fishing, are affected negatively from water pollution. Ranchers, however, can reduce pollution by maintaining tree cover and buffer strips, but it would cost them. On the other hand, households would benefit if ranchers reduce pollution. In Fig. 12–4, the horizontal axis represents the quantity of tree cover and buffer strips, and the vertical axis represent costs or benefits of reducing pollution. The MC curve represents the marginal cost to ranchers, and the MB curve represents the marginal benefits to households from reducing pollution.

First, let's assume that ranchers are not required to maintain tree cover and buffer strips—ranchers have a right to pollute. However, most ranchers would be willing to maintain tree cover and buffer strips if the public would cover the costs. In this scenario, the public would have to pay ranchers an amount equal to area AED, the entire area under the MC curve, to maintain maximum tree cover for reducing water pollution. Since the amount that the public must pay ranchers to plant more trees than C is higher than the benefits they derive, the public would

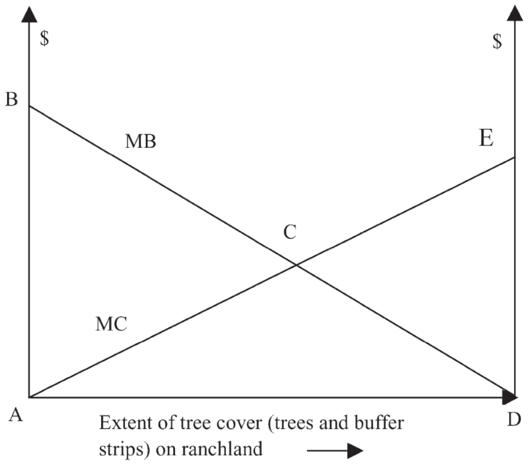

Fig. 12–4. An illustration of optimal silvopasture adoption with zero transaction costs (Alavalapati et al., 2004).

not want to pay for tree cover and buffer strips beyond C. Alternatively, if the public has a right to clean water, then ranchers would have to pay an amount equal to area ABD, the entire area under the MB curve to put up with water pollution. Given that the amount ranchers must pay households is initially much higher than the cost of withholding pollution, ranchers would want to maintain tree cover and buffer strips up to C. At this point the amount that ranchers must pay equals the marginal cost of withholding pollution. The Coase (1960, 1992) theorem suggests that if property rights are defined, the parties will negotiate according to their benefits and costs and reach an optimal solution. Regardless of which one has the property rights, with zero transaction costs, the solution is reached at C.

To realize optimum policy solutions to the above problem, a variety of information is needed, including the environmental benefits and costs of silvopasture, respectively, from households' and ranchers' perspectives. In the recent past, advancements in environmental economics have produced a range of economic tools to generate information for policy making.

Economic Case Studies

Valuing environmental services from producers' and consumers' view points is critical for policy development. Two case studies illustrate this. Shrestha and Alavalapati (2004a) recently assessed the value of environmental services associated with silvopasture in Florida using a choice experiment. Assuming that silvopasture has the potential to reduce phosphorus runoff, sequester additional carbon dioxide, and improve the habitat for wildlife in the Lake Okeechobee watershed, Shrestha and Alavalapati tested whether the public would be willing to pay (WTP) to realize those benefits. They found that the average household would be willing to pay \$137.97 yr^{-1} for 5 yr for a moderate level of improvement in all three environmental attributes. With 1.34 million households in the watershed, the total WTP for environmental services would be \$924.40 million. This value reflects the total demand for the environmental services associated with silvopasture in the Lake Okeechobee Watershed.

As indicated earlier, environmental services associated with silvopasture are external to cattle ranchers. As such they may have little or no motivation to adopt silvopasture unless they are compensated for those environmental services. Shrestha and Alavalapati (2004b) assessed ranchers' willingness to accept (WTA) to produce the above environmental services by adopting silvopasture practices. In particular, they assessed the effect of a premium on beef prices and a direct payment on the adoption of silvopasture using a contingent valuation approach. It was found that on average, a price premium of \$0.07 kg^{-1} of beef or a direct payment of \$23.03 ha^{-1} was required for ranchers to adopt silvopasture practices. With approximately 2.4 million ha of pasture and ranchlands and at the rate of \$23.03 ha^{-1}, the direct payment policy would cost about \$66 million annually.

Valuing Ranchland Attributes

Ranchers in Florida are increasingly managing their lands for recreational hunting. This is a supplemental economic activity for many ranchers, wherein they sign a lease with hunting clubs or other interested parties to hunt on their lands. Land attributes, such as the distance to urban centers, scenic view, and nature of habitat, influence hunter preferences and thus the lease price. Therefore, ranchers may be interested to know the effect of their land attributes on lease price. Shrestha and Alavalapati (2004c) estimated the effect of ranchland attributes on recreational hunting in Florida using a hedonic price analysis (a revealed preference approach). They found that trees and vegetation cover on ranchlands have a positive impact on hunting revenues, indicating opportunities for silvopasture. In particular, ranchers in Florida who maintain about 22% trees and other vegetation cover on ranchlands could charge \$39.91 ha^{-1} yr^{-1} for hunting.

Policy Implications

The success of federal cost-share programs promoting tree planting and forest management by nonindustrial forest landowners is evidence of the potential of federal land-use policy in promoting agroforestry. For example, 70% of all pine regeneration investment between 1971 and 81 was influenced by cost-share programs. A wide array of federal, state, and private programs have recently begun to provide financial incentives to landowners for adopting agroforestry. Federal funding for agroforestry is administered by the USDA Forest Service, Farm Service Agency, Natural Resource Conservation Service, and U.S. Fish and Wildlife Service.

Most federal programs providing incentives to landowners to manage forests and trees to produce environmental benefits have been authorized under the Farm Bill, the primary federal tool for developing US policies and programs affecting agriculture, rural lands, and food consumers. The first Farm Bill, developed in the 1920s, focused primarily on agricultural commodity programs such as price supports, agricultural exports, farm credit, and agricultural research. The Farm Bill is reviewed and amended every 6 yr by the U.S. Congress. Reacting to concerns regarding the environmental impacts of rural land use, Congress first introduced resource conservation policies and programs in the 1985 Farm Bill. A forestry title (Title XII, The Forest Stewardship Assistance Act) was first included in the 1990 Farm Bill and authorized the Forest Legacy Program, Forest Stewardship Program, Forestry Incentives Program (FIP), and the Stewardship Incentives Program (SIP). Several tree-planting initiatives were also included in the Conservation Title (Title XIV) of the 1990 Farm Bill. Since then, forestry stakeholders have used the Farm Bill as the primary avenue for renewing or promoting new forestry incentive programs. The 2002 Farm Bill (officially titled the Farm Security and Rural Investment Act of 2002), modified or created a number of forestry-related programs that include agroforestry options.[1]

USDA Farm Service Agency (FSA). FSA provides incentives for adopting agroforestry practices on private lands through the Conservation Reserve Program (CRP), the Continuous Conservation Reserve Program (CCRP), and the Conservation Reserve Enhancement Program (CREP). These programs provide soil rental payments, cost shares, and other financial incentives to land owners who agree to retire or convert agricultural lands to alternative uses including riparian buffers, windbreaks, and tree planting.

Natural Resource Conservation Service (NRCS). In addition to providing technical assistance to landowners interested in agroforestry and other conservation practices, the NRCS provides funding for tree planting (including agroforestry) through the Environmental Quality Incentives Program (EQIP), the Wetland Reserve Program (WRP), Conservation Security Program (CSP), and the Wildlife Habitat Incentives Program (WHIP). EQIP provides incentive payments for alley cropping, riparian buffers, and windbreaks, as well as cost shares for tree planting. Cost shares are also provided by WHIP for timber stand improvement. Both the Wetland Reserve Program (WRP) and Conservation Security Program (CSP) encourage agroforestry adoption through cost shares and conservation easement payments for riparian buffers and tree planting, while the CSP also provides cost shares and easement payments for alley cropping and silvopasture.

USDA Forest Service. The Forest Service encourages agroforestry adoption through the Forest Land Enhancement Program (FLEP). FLEP replaced the Forestry Incentives Program (FIP) and the Stewardship Incentives Program (SIP), which were eliminated in the 2002 Farm Bill. FLEP, however, allows states to continue FIP and SIP efforts initiated before 2002. FIP was originally authorized in 1978 to provide nonindustrial private landowners with up to 65% of the costs of tree planting, timber stand improvements, and related forest management practices. Between 1974 and 1994, more than $200 million in FIP cost shares were provided for 1.34 million ha of tree planting, 0.59 million ha of timber stand improvement, and 0.11 million ha of site preparation to regenerate nonindustrial private forest lands. The 1990 Farm Bill provided sunset provisions to replace FIP by 1995 with the broader-purpose Stewardship Incentive Program (SIP). Between 1991 and 2002, SIP provided $73 million in cost shares to 45,102 landowners who treated 1.78 million ha to produce a variety of environmental services such as reduced soil erosion, enhanced water quality, increased wildlife habitat, tree planting, and timber stand improvement, which help to sequester greenhouse gases.

FLEP provides cost-share assistance (up to 75%) to owners of nonindustrial private forestlands

[1] The Farm Bill was not modified until 2008. Changes to the Farm Bill will be published in the Federal Register in early 2009.

(NIPF) to implement a management plan to produce sustainable public environmental benefits including water from forests. Acceptable practices include: afforestation and reforestation, agroforestry, water quality improvement and watershed protection, fish and wildlife habitat protection, control of invasive species, reduction of risk of wildfire and restoration from wildfire events, and forest management to improve forest health and growth. Agroforestry practices include alley cropping, riparian buffers, shelterbelt and windbreak establishment, and tree/shrub planting and pruning. Each landowner is restricted to 404.6 ha, which may be increased to 2023 ha if significant public benefits are produced. Specific objectives and practices are determined at the state level through partnerships between the U.S. Forest Service, the State Foresters, State Forest Stewardship Coordinating Committees, and other interested stakeholders.

Program Effectiveness and Barriers

A number of studies have examined the social and economic efficiency of public financial incentive programs for private forest investments such as agroforestry. One hypothesis has been that these programs substitute government payments for private capital investments. Several studies have shown that cost-share assistance programs are effective in improving forest land productivity (Royer and Moulton, 1987; Mills, 1976). Baughman (2002), however, found that many owners who participated in an incentive program would have done the supported practice anyway, although Royer (1987) and Bliss and Martin (1990) found that the incentives enabled owners to treat additional hectares.

An important aspect of cost-share and management assistance programs is the interaction between landowners and land managers. Generally, landowners are required to develop management plans before receiving cost-share or lease payments. Plans are generally developed by public or private professionals, often with the participation of the landowner. Direct contact with professional land managers has been identified as a leading factor in landowners' decisions to adopt conservation practices such as agroforestry. Several studies have found that programs that put landowners in direct contact with a forester or other natural resource professional are most influential in encouraging landowners to adopt sustainable forestry practices (Kilgore and Blinn, 2004; Greene et al., 2005; Kilgore et al., 2007).

Esseks and Moulton (2000) found that two-thirds of Forest Stewardship Program (FSP) participants had never had contact with a professional forester before developing the required management plan. A similar number began managing their land for multiple purposes and using new practices due to the FSP. In addition, participation in FSP prompted owners to spend an average of $2,767 of their own funds for forest management activities. Interestingly, without their involvement in FSP and receiving cost-share assistance, nearly two-thirds of participating owners said they would not have made the expenditures.

Funding has been established as a crucial barrier in promoting sustainable land use practices such as agroforestry. In a Congressional hearing reviewing the FLEP before the House Committee on Agriculture in July 2004, Charles W. Stenholm, a representative from Texas lamented that "states are facing requests for assistance that far exceeds the funding that is available." This concern is consistent with evidence from Florida: in 2003, 150 of 206 applications for FLEP funding were denied; in 2004 (a small amount of money was left over from 2003), 231 of 347 applications were denied; and in 2005, 187 of 429 applications were denied. Conversely, incentive programs may have the unintended effect of discouraging timely investments. In some instances, landowners have delayed investments until cost-share program funding was available (Haines, 1995).

Summary

Agroforestry is a way for landowners to manage scarce natural resources that balances environmental stewardship, financial feasibility, and social responsibility. Because it is a balance of these three objectives, it requires the landowner to make complex decisions. Economic analysis uses a set of tools that can identify the tradeoffs that are made in the decision process. This chapter gave a broad overview of the decision tools that economists use, including budgeting methods, financial methods, and nonmarket valuation methods. Real-world applications of these methods illustrate the applicability and importance to the decision process.

Governmental policies have an impact on land management decisions. Management of privately owned natural resources can have an impact on society in both positive and negative ways. Therefore, land management policies have been developed that provide financial incentives for land use practices, such as agroforestry, that protect, conserve, and improve the natural resource base.

Appendix 12–1

Interest Rates

You have probably heard the term *interest rate* many times. When you step into a bank to open a new savings account, certificate of deposit, or take out a loan, you are informed about current interest rates. So, what does it mean? When you open a savings account or purchase a certificate of deposit at your local bank, you are the lender and the bank is the borrower. The bank borrows money from you for a specified length of time and promises to pay you back more than it borrowed at the end of that period. The interest rate tells you how much the bank will pay you for using your money. If you are taking out a loan, the term interest rate is used to indicate the price paid by borrowers to lenders for borrowing their money and is expressed as a percentage (expressed as a decimal for financial analyses) (Gunter and Haney, 1984).

Consider a simple situation in which you invest in a 12-mo certificate of deposit paying a 5% annual interest rate. A 5% interest rate means that at the end of 1 yr, a bank will pay you $0.05 on each dollar deposited. If you make a deposit of $3,000.00, the bank will pay you $150.00 in interest ($3,000.00 × 0.05). After 1 yr, the bank will pay you $3,150.00, which includes your original deposit (principal) of $3,000.00 and an interest payment of $150.00.

Various terms are used to indicate the interest rate depending on the context; sometimes they are used interchangeably. In this textbook we use three of them: interest rate, discount rate, and minimum acceptable rate of return (MARR). The interest rate is used to calculate the future value of cash flows as well as return on financial instruments, such as savings accounts and certificates of deposit. The discount rate is used to calculate present value of future cash flows, whereas MARR indicates a minimum rate of return required on a specific agroforestry investment (Klemperer, 2003).

An interest rate has three unique components: time preference, risk, and inflation (Gunter and Haney, 1984). *Time preference* refers to an individual's preference for current rather than future consumption (Price 1993). Gunter and Haney (1984) described this as "increased future gratification" that will make current and future consumption equivalent. So, how does it work? Suppose you deposit money into a bank account for 1 yr; during that period you cannot use your money to buy items you might need. Essentially, you have agreed to postpone your current consumption in exchange for a certain amount of money (interest) that will be paid to you by your bank at a future date. With the extra money (after taxes) you will be able buy more of the items you desire, buy items you couldn't previously afford, or reinvest this money. People have different time preferences. To some, a 5% interest rate might be acceptable, but to others such an interest rate might be too low to induce them to save their money. For these individuals, the extra 5% is not worth waiting 1 yr, and they would prefer to use their money now. They value current consumption more than those accepting a 5% interest rate and thus require larger compensation (i.e., a higher interest rate) to postpone current consumption. A higher time preference indicates a higher preference for current consumption (Gunter and Haney, 1984) and results in a higher interest rate required to induce further savings.

Most investments are associated with some risk (Peterson and Fabozzi, 2002). If you were wondering how to invest some money, you would find that there are numerous options available, each offering a different rate of return. It seems that selecting an option with the highest return would be the most reasonable action. However, when you look at how others invest their money; you will see that they don't always select the opportunity with the highest possible return. This is because each investment bears a different level of risk. Some investments, such as a savings account or a certificate of deposit, are relatively safe investments (Gunter and Haney, 1984). People are pretty sure that when they come to the bank the next day, their money will be there and they will be able collect it. Other investments are considered more risky, yet people are still willing to engage in these investments if a rate of return is high enough to compensate them for the risk involved. To account for risk, the discount rate is adjusted by adding a risk premium and is called a *risk-adjusted discount rate* (Peterson and Fabozzi, 2002). The amount of risk premium indicates an additional return required due to risk and depends on the riskiness of the investment, investor aversion toward risk, and the duration of the investment (Klemperer, 2003).

The term *inflation* refers to an overall increase in prices of goods and services over time (Price, 1993; Gunter and Haney, 1984). It means that with a specified amount of money today you will be able to buy less in the future. While the price difference might not be that apparent over a short period of time, it might be significant when you examine longer periods. If you ask your parents how much they could purchase with $10.00

when they were younger, you will notice that their list of items is much longer than yours would be today.

Similar to decreasing your purchasing power, inflation decreases a real return on agroforestry as well as other investments. Imagine a situation where the value of an agroforestry plantation increased at a rate of 7% yr^{-1} during the last 10 yr. This might seem like a good rate of return if you don't account for inflation. However, if you include in your calculations the fact that the average inflation rate over that period was 3%, you will quickly realize the real appreciation on the plantation was roughly 4%. A precise real rate of return can be calculated by using the formula:

$$r = \left[\frac{1+i}{1+f}\right] - 1$$

where r is an annual real rate of return, i is an annual nominal rate of return, and f is an annual inflation rate (Klemperer, 2003). A significant portion of the gain was consumed by inflation. In nominal terms, the landowner does receive more money, but this money now buys less than it did in the past. This situation is often referred to as the *money illusion* (Klemperer, 2003).

Appendix 12–2

Compounding versus Discounting

Proper evaluation of agroforestry investments requires that all cash flows (i.e., costs and revenues) are brought to the same point in time. The reason is that costs and revenues typically occur at different times (Godsey, 2000). As a result, the value of such cash flows cannot be compared directly because each cash flow has a different "time value." Most often the financial analysis of an investment is expressed in terms of the starting year of the project [net present value (NPV)] through the process of discounting. The analysis can be conducted also in terms of the project's end year [net future value (NFV)] through the process of compounding. An analysis in terms of any intermediate year in the duration of an agroforestry project is also possible; however, this would require both compounding and discounting.

Compounding

Most of us have been exposed directly or indirectly to the process of compounding. For example, when you deposit money into a savings account or purchase a certificate of deposit, this is the process that will be used to determine how much money will accumulate in that account after a specified time period. Several formulas are used to calculate future values depending on the frequency of the specific cash flow (Klemperer, 2003; Bullard and Straka, 1998; Gunter and Haney, 1984) and can be easily applied to agroforestry practices.

Future value of a single sum is used to calculate the future value of a single cash flow (cost or revenue that occurs only once in the duration of the investment). For example, suppose the current land rent for agricultural land under agroforestry production is \$370.00 ha^{-1} yr^{-1} and it is expected that it will be increasing at 3% yr^{-1} over the next 10 yr. How much will it cost to rent the same piece of land for 1 yr 10 yr from now? To solve this problem, the following formula is used:

$$V_n = V_0 \times (1+i)^n$$

where V_n is the future value of the cash flow in n years (i.e., land rent rate 10 yr from now), V_0 is the present value of the cash flow (current land rent is \$370.00 ha^{-1}), i is an annual interest rate (3%, which is equivalent to 0.03), and n is number of years under consideration (i.e., 10 yr). Based on the above, we can then calculate the expected annual land rent 10 yr from now which will be \$497.25 ha^{-1}:

$$\begin{aligned} V_{10} &= \$370.00\ \text{ha}^{-1} \times (1+0.03)^{10} \\ &= \$370.00\ \text{ha}^{-1} \times (1.03)^{10} \\ &= \$497.25\ \text{ha}^{-1} \end{aligned}$$

Returning to the example of the savings account described in the previous section, this formula can be used to determine that \$2,433.31 would accumulate in this account after 5 yr if you initially deposited \$2,000.00 and the account paid a 4% interest rate:

$$\begin{aligned} V_5 &= \$2{,}000.00 \times (1+0.04)^5 \\ &= \$2{,}000.00 \times (1.04)^5 \\ &= \$2{,}433.31 \end{aligned}$$

Future value of a terminating annual series allows for the calculation of the future value of a stream of cash flows that occur every year. Instead of using a single sum formula and calculating the future value of each cash flow separately, you can use this formula and complete the calculations in one step. However, to use this formula, cash flows have to start at the end of the first year and stop at some point in time. In addition, they have to occur each year in the same amount and be of the same type (i.e., either cost or revenue but not both). The formula is:

$$V_n = a\left[\frac{(1+i)^n - 1}{i}\right]$$

A new symbol a is introduced in this formula to indicate the value of an annual cash flow. This formula can be used to calculate the future value of a herbicide treatment at \$52.00 ha^{-1} applied every year during a period of 7 yr. By using this formula and a 5% interest rate, it can be calculated that the future value of this series of annual costs will accumulate after 7 yr to \$423.38 ha^{-1}:

$$\begin{aligned} V_7 &= \$52.00\ \text{ha}^{-1} \times \left[\frac{(1+0.05)^7 - 1}{0.05}\right] \\ &= \$52.00\ \text{ha}^{-1} \times \left[\frac{(1.05)^7 - 1}{0.05}\right] \\ &= \$423.38\ \text{ha}^{-1} \end{aligned}$$

Future value of a terminating periodic series is used to calculate the future value of a series of cash flows that start and stop at some point in time but occur in intervals longer than 1 yr. To use this formula, cash flows have to be of the same type (i.e., cost or revenue) and magnitude. There are two new symbols that appear in this formula: p which stands for periodic cash flow and t that indicates the interval between cash flows. A notation n also has a new meaning in this formula and indicates the total number of intervals.

$$V_n = p\left[\frac{(1+i)^{nt} - 1}{(1+i)^t - 1}\right]$$

A good example of a periodic series is the pruning of black walnut at a cost of \$6.00 ha^{-1} performed every 3 yr during a 15-yr period. To calculate the future value of these payments at a 5% interest rate, we use this formula as follows:

$$\begin{aligned} V_{15} &= \$6.00\ \text{ha}^{-1} \times \left[\frac{(1+0.05)^{5\times 3} - 1}{(1+0.05)^3 - 1}\right] \\ &= \$6.00\ \text{ha}^{-1} \times \left[\frac{(1.05)^{15} - 1}{(1.05)^3 - 1}\right] \\ &= \$41.07\ \text{ha}^{-1} \end{aligned}$$

After 15 yr, the cost of periodic pruning will accumulate to \$41.07 ha^{-1}.

Discounting

Discounting is the process of calculating the present value of project cash flows. By using a discounting factor (Price, 1993), a present value equivalent is calculated for cash flows that are expected to occur in the future. As the term suggests, this process decreases the value of future cash flows and, as a result, the present value is always smaller than a future value. The further in the future a cash flow is expected to occur, the smaller its present value will be. An increase in the interest rate will also result in a smaller present value. There are several formulas used to calculate present value (Klemperer, 2003; Bullard and Straka, 1998; Gunter and Haney, 1984). Again, the choice of a proper formula depends on the frequency of cash flows.

Present value of a single sum is used to calculate the present value equivalent of a cash flow that occurs only once in the life of a project. The formula is:

$$V_0 = \frac{V_n}{(1+i)^n}$$

This formula can be used to calculate the present value equivalent for an expected income of \$1,480.00 ha^{-1} that will be obtained from harvesting pine trees in 15 yr, assuming a 6% discount rate. By inserting this information into the formula we obtain:

$$\begin{aligned} V_0 &= \frac{\$1,480.00\ \text{ha}^{-1}}{(1+0.06)^{15}} \\ &= \frac{\$1,480.00\ \text{ha}^{-1}}{(1.06)^{15}} \\ &= \$617.52\ \text{ha}^{-1} \end{aligned}$$

Notice that the income of \$1,480 ha^{-1} expected in 15 yr is worth only \$617.52 ha^{-1} now.

Present value of a terminating annual series is used to calculate the present value of a series of cash flows occurring every year, starting at the end of the first year, and ending at some point in time in the future. Each year, these cash flows have to be of the same value and type:

$$V_0 = a\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$

An example of this type of cash flow is an annual hunting lease income of \$25.00 ha^{-1} yr^{-1}. What will be the present value equivalent of an annual hunting lease income if the lease was signed for 5 yr and the discount rate was 7%? By using this formula, we determined that the present value of a hunting lease income for a 5-yr time period was \$102.50 ha^{-1}:

$$V_0 = \$25.00 \text{ ha}^{-1} \times \left[\frac{(1+0.07)^5 - 1}{0.07 \times (1+0.07)^5}\right]$$
$$= \$25.00 \text{ ha}^{-1} \times \left[\frac{(1.07)^5 - 1}{0.07 \times (1.07)^5}\right]$$
$$= \$102.50 \text{ ha}^{-1}$$

Present value of a terminating periodic series is used to calculate the present value of periodic cash flows, starting at the end of the first period, and stopping at some future point in time. Similar to annual cash flows, periodic cash flows also have to have the same value at each occurrence and be of the same type:

$$V_0 = p\left\{\frac{(1+i)^{nt} - 1}{\left[(1+i)^t - 1\right](1+i)^{nt}}\right\}$$

For example, to calculate a present value of periodic maintenance costs of \$124.00 ha^{-1} occurring every 5 yr during a period of 20 yr (i.e., four intervals of 5 yr each) at an 8% discount rate, we calculate:

$$V_0 = \$124.00 \text{ ha}^{-1} \times \left\{\frac{(1+0.08)^{4\times5} - 1}{\left[(1+0.08)^5 - 1\right] \times (1+0.08)^{4\times5}}\right\}$$
$$= \$124.00 \text{ ha}^{-1} \times \left\{\frac{(1.08)^{20} - 1}{\left[(1.08)^5 - 1\right] \times (1.08)^{20}}\right\}$$
$$= \$207.52 \text{ ha}^{-1}$$

The present value of four periodic payments accumulates to \$207.52 ha^{-1}.

Present value of a perpetual annual series allows for calculating the present value equivalent of cash flows that start at the end of the first year and continue on an annual basis forever. The formula is:

$$V_0 = \frac{a}{i}$$

To calculate the present value of annual tax payments of \$4,000.00 that will be paid every year into the future, and assuming an annual discount rate of 4%, we apply the formula as follows:

$$V_0 = \frac{\$4{,}000.00}{0.04} = \$100{,}000.00$$

The present value of an annual tax liability of \$4,000.00 that will continue forever is \$100,000.00. Sometimes, it may be difficult to understand what this value means and it is useful to look at it from a different perspective. Basically, you would need to deposit \$100,000.00 into an account that pays a 4% annual interest rate to withdraw \$4,000.00 every year into the future to cover your annual taxes.

Present value of a perpetual periodic series calculates the present value of cash flows that occur in intervals longer than 1 yr and continue into the future.

$$V_0 = \frac{p}{(1+i)^t - 1}$$

By using this formula to calculate the present value of a \$4,000.00 income from pine straw production that occurs every 4 yr in perpetuity, and assuming a 7% discount rate, we find that it is worth \$12,870.18:

$$V_0 = \frac{\$4{,}000.00}{(1+0.07)^4 - 1}$$
$$= \frac{\$4{,}000.00}{(1.07)^4 - 1}$$
$$= \$12{,}870.18$$

Appendix 12–3

Inflation

Inflation exists in almost every economy and has a significant effect on the economic viability of investments (Price, 1993), including agroforestry alternatives. If inflation is not accounted for in financial analyses when evaluating agroforestry investments, this might lead to an incorrect decision about accepting or rejecting a particular investment opportunity. For example, it might result in acceptance of an alternative that seems financially viable in nominal terms; however, when inflation is accounted for, it might generate a smaller monetary return or even a loss.

Inflation is measured using a specially constructed index that expresses prices in relation to a base year for which the value of 100 is assigned (Klemperer, 2003; Gunter and Haney, 1984). There are two types of indexes: the Consumer Price Index (CPI) indicates an increase in prices of goods and services consumed by consumers, whereas the Producer Price Index (PPI) measures an increase in the costs of wholesale or producer inputs. Both indices can be used to calculate an inflation rate. In both cases, you need to know the start and end value of the index to calculate inflation for a specific period. For example, to calculate inflation for 2000 through 2006 using the CPI index, you would need to obtain the CPI values for years 2000 and 2006. They can be obtained from numerous sources available online, such as the Bureau of Labor Statistics, U.S. Department of Labor. Assuming that the CPI is 172.2 and 201.6 for 2000 and 2006, respectively, the annual inflation rate can be calculated using the formula:

$$f = n\sqrt{\frac{\mathrm{CPI}_n}{\mathrm{CPI}_0}} - 1$$

where f is annual inflation rate, CPI_0 and CPI_n are CPI values for the start and end year, respectively, and n is the number of years in the period for which inflation is calculated. By inserting the CPI values and number of years into the formula, we can calculate that the annual inflation rate during 2000–2006 averaged 2.66%:

$$\begin{aligned} f &= n\sqrt{\frac{\mathrm{CPI}_{2006}}{\mathrm{CPI}_{2000}}} - 1 \\ &= 6\sqrt{\frac{201.6}{172.2}} - 1 \\ &= 0.0266, \text{ equivalent to } 2.66\% \end{aligned}$$

Calculated inflation rate indicates only an average price increase for goods and services included in a market basket used to measure inflation. For some goods and services, the rate of price increase will be high, while other goods and services might have a decrease in price (Gunter and Haney, 1984). Similarly, inflation also will differ each year depending on economic conditions.

It is important to understand the concepts of current and real dollar values when inflation is discussed. Current dollar values include values of prices and costs reported as they occur in a given year and, hence, they include inflation. For example, prices that you pay in the store are current values. Likewise, your salary is also a current value. On the other hand, a real dollar value is a value that doesn't include inflation (Klemperer, 2003). The process of removing the effect of inflation from current value is called deflating and works exactly as when you are calculating present value except that current value is discounted at the inflation rate instead of discount rate (Klemperer, 2003).

A simple example using an agricultural land purchase and resale will help illustrate this process. The property was purchased in 1996 for $200,000 and sold in 2006 for $300,000. The inflation rate during that period averaged 2.53%. When we compare the nominal values of the purchase and sale, it seems that there is a $100,000 profit. However, we need to account for the inflation that consumed part of that profit. To compare these two values we need to express them in terms of the same base year. Consequently, the 2006 sale value of $300,000 needs to be deflated to 1996 and will be comparable with the purchase price of $200,000. The formula for calculating deflated value is (Klemperer, 2003):

$$V_n = \frac{I_n}{(1+f)^n}$$

where I_n is the inflated (current) value (in this case, $300,000), f is the annual inflation rate, and n is the number of years in the period being analyzed.

By inserting information referring to the agricultural land sale into the formula, we obtain the following result:

$$\begin{aligned} V_n &= \frac{\$300,000}{(1+0.0253)^{10}} \\ &= \frac{\$300,000}{(1.0253)^{10}} \\ &= \$233,675 \end{aligned}$$

The nominal sale price deflated to 1996 is only $233,675 and can now be compared with the purchase price of $200,000. The real gain on this investment is $33,675. We can see that of the $100,000 that constituted a nominal gain, $66,325 was due to inflation. This means that even though the sales price increased by $100,000, the purchasing power of the sales price increased by only $33,675. Of note, although inflation eroded profit, we need to realize that one benefit of this investment was that it more than kept pace with the rate of inflation.

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Study Questions

1. A farmer considers planting a shelterbelt around the farmstead to decrease heating and cooling costs. A projected total cost of planting the shelterbelt is $10,000, whereas expected average savings are estimated to be $1,800 yr^{-1} during a 30-yr shelterbelt lifespan. Is this investment financially justifiable if the farmer's minimum acceptable rate of return is 10%?

2. Historical data show that an average return on an alley cropping system was 12% during a 10-yr period, whereas inflation during that time averaged 3%. What was the real rate of return on the alley cropping system? Should a farmer engage in this investment if it requires a real minimum acceptable rate of return of 10%?

3. A landowner considers introducing mushroom production into their forest farming operations and would like to know what rate of return can be expected on this investment. The landowner was able to collect accurate information on costs associated with mushroom production but was unsure about the revenues because it was expected that the price of mushrooms will vary significantly. How can the landowner decide if mushroom production is a worthwhile investment?

4. A financial analysis of a proposed agroforestry alternative generated a benefit/cost ratio (BCR) of 0.7. Should this alternative, given its B/C ratio, be accepted?

5. A landowner considers purchasing a land parcel to install a silvopastoral system. The land expectation value (LEV) calculated for this investment based on projected cash flows and a minimum acceptable rate of return (MARR) of 10% is $2,350 ha^{-1}. What is the maximum dollar amount the landowner can pay for this land and earn the required 10% rate of return on this investment? How would the rate of return be affected if the landowner paid $2,800 ha^{-1}? How would the rate of return be affected if the landowner paid less than $2,350 ha^{-1}?

6. A report indicated that the price of mushrooms increased 4% above an annual inflation rate over the last 5 yr. Calculate the inflated price at the end of this period knowing that the starting price was $8 kg^{-1} and inflation was 3% per year.

7. A financial analysis shows that an alley cropping system generates a net present value (NPV) of $750 ha^{-1} at a 12% minimum acceptable rate of return (MARR). Explain the meaning of the NPV criterion for this investment.

8. Explain why landowners whose minimum acceptable rate of return (MARR) is 9% shouldn't accept an agroforestry alternative with an internal rate of return (IRR) of 6%.

Study Question Answers

1. To answer this question we need to calculate a present value equivalent of heating and cooling cost savings and compare them with the cost of establishing a shelterbelt. Since savings are presented on an annual basis, we use the formula to calculate the present value of a terminating annual series:

$$
\begin{aligned}
V_0 &= a\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right] \\
&= \$1,800.00 \times \left[\frac{(1+0.10)^{30} - 1}{0.10 \times (1+0.10)^{30}}\right] \\
&= \$1,800.00 \times \left[\frac{(1.10)^{30} - 1}{0.10 \times (1.10)^{30}}\right] \\
&= \$16,968.45
\end{aligned}
$$

The present value equivalent of annual savings that will occur during the shelterbelt lifetime is \$16,968.45 and can be compared with the shelterbelt cost of \$10,000. You can see that the savings more than offset the cost and thus the investment is financially acceptable.

2. A real rate of return on an alley cropping system can be calculated by inserting information on nominal return and inflation into the following formula:

$$
\begin{aligned}
r &= \frac{1+i}{1+f} - 1 \\
&= \frac{1+0.12}{1+0.03} - 1 \\
&= \frac{1.12}{1.03} - 1 \\
&= 0.084, \text{ equivalent to 8.4\% real rate of return}
\end{aligned}
$$

After accounting for inflation, the real rate of return on the alley cropping system was 8.4% yr^{-1}. The farmer should not engage in this investment because it requires at minimum a 10% rate of return, whereas the investment earns only 8.4%.

3. This is an example of a situation in which there is uncertainty associated with the financial performance of the investment due to possible changes in the price of the product. For example, a price drop will decrease revenues and result in a lower rate of return on the investment. Conducting a financial analysis only at one price level might lead to a significant overestimation of the potential return. Therefore, it is more appropriate to calculate a rate of return on this investment at several anticipated price levels. For example, the landowner can consider 10, 20, and 30% price decreases and increases and examine how sensitive the rate of return is to these changes. In this way a landowner will have a range of possible returns on mushroom production, each representing a different price level.

4. The alternative shouldn't be accepted because the BCR ratio is smaller than one (refer to Table 12–3 for guidelines). In present value terms, this means that each dollar invested in this alternative generates only \$0.70 in return. This is not enough to offset the costs that would be incurred to implement this alternative. In other words, the alternative generates a loss of \$0.30 on each dollar invested.

5. To ensure that a 10% rate of return is earned on the silvopastoral system, the landowner can pay, at maximum, \$2,350 ha^{-1}. If a larger sum is paid (e.g., \$2,800 ha^{-1}), this would result in a rate of return lower than 10%. Conversely, if the landowner was able to purchase this land at a price lower than \$2,350 ha^{-1}, the rate of return would be higher than 10%.

6. This problem can be solved in two steps. First, a nominal rate of increase needs to be calculated utilizing the following formula:

$$\begin{aligned} i &= \left[(1+r)(1+f)\right]-1 \\ &= \left[(1+0.04)(1+0.03)\right]-1 \\ &= \left[(1.04)(1.03)\right]-1 \\ &= 0.0712,\ \text{equivalent to } 7.12\% \end{aligned}$$

Second, we can use the nominal rate of increase to calculate a nominal price:

$$\begin{aligned} I_n &= V_0\,(1+i)^n \\ &= \$8.00\ \mathrm{kg}^{-1} \times (1+0.0712)^5 \\ &= \$8.00\ \mathrm{kg}^{-1} \times (1.0712)^5 \\ &= \$11.23\ \mathrm{kg}^{-1} \end{aligned}$$

The nominal price that accounts for real price increase and an increase due to inflation is \$11.23 kg^{-1}.

7. The NPV of \$750 ha^{-1} means the landowner will not only earn a 12% rate of return on the alley cropping system but also will gain a lump sum of \$750 ha^{-1} (in present value terms). This indicates that the investment's rate of return is higher than 12%.

8. The IRR of 6% means that the net present value (NPV) calculated at a 6% rate of return will equal zero. This is a rate of return at which the investment breaks even. A rate of return higher than 6% will result in a negative NPV, indicating that the investment isn't acceptable because it will generate a financial loss (see Table 12–3 for guidelines on accepting agroforestry alternatives). Consequently, a landowner who requires at least a 9% rate of return shouldn't accept an investment with an IRR smaller than 9%.