

**economic analysis**  
of  
**forestry projects**

prepared by  
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## FOREWORD

This publication has been produced as part of a continuing FAO programme to help transfer skills in analysis and planning to those responsible for these activities in the forestry sector in developing countries and, thereby, to assist them in strengthening their capability to identify, prepare and implement viable and useful forestry development projects and programmes.

At an early stage in this programme, which is conducted mainly through the medium of seminars and workshops, it became clear that to be effective there would need to be a publication directed to the particular needs of forestry planners. Though the literature on cost benefit analysis is already large and still expanding, most of it is still concerned with developing methodological approaches at a rather theoretical level. Few of the existing works give much practical guidance to the analyst and planner in the field in grappling with the detailed problems of identification, measurement and valuation that constitute project planning at their level. While some guides do seek to provide help of this nature, they tend to be oriented towards sectors other than forestry.

The present publication has been developed to meet this need in forestry. As the authors explain in their preface, it is intended to be a practical document - one that does provide guidance on how to solve the pragmatic problems encountered in actual practice, but which does so in a way which helps the user understand the conceptual reasons for doing what is suggested.

It has been developed over a period of several years, the early part of which was devoted to an extensive and in-depth analysis of actual experience gained in applying economic and financial analysis to projects in the forest-based sector. In order to make this experience available as fully as possible, several case studies have been developed based upon the more important and representative of these projects. These are being published concurrently with the present publication in a companion volume. 1/ In addition, a second companion volume is being prepared which reviews, more broadly, the range of methods and approaches to analysis and decision-making available for use in forestry, in order to indicate what tools are available to supplement or complement economic analysis. 2/

This publication has been prepared within the Planning and Investment Studies Unit of the Forestry Department of FAO, under the direction of the head of that Unit, J.E.M. Arnold. It has been written by H.M. Gregersen, Professor of Forestry and Agricultural and Applied Economics at the University of Minnesota, who spent a year as consultant to FAO for this purpose, and by A.H. Contreras of FAO. In addition we have been fortunate to benefit from the advice and help of many people both within FAO and from outside the Organization, among whom I would wish in particular to acknowledge A.M. Eid, M. Gane, J. Price Gittinger, A. Grayson, I.I. Holland, T. Houghtaling, J. MacArthur, S. McGaughey, J. Spears, R. Steele, W.W. Ward and P.A. Wardle.

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1/ Economic Analysis of Forestry Projects: Case Studies, FAO Forestry Paper No. 17, Supp. 1, FAO, Rome, 1979.

2/ Economic Analysis of Forestry Projects: Readings, FAO Forestry Paper No. 17, Supp. 2, FAO, Rome, forthcoming.

I should also like to take this opportunity to record the particular contribution of the Swedish International Development Authority (SIDA). This publication and the companion case studies have been made possible through special budgetary contributions to FAO from SIDA for this purpose. This is but the most recent instance of SIDA's long and generous support and encouragement to FAO's training activities related to forestry and forest industries planning in developing countries.

In concluding, I wish to stress that, at least at present, there is no one accepted right way to carry out economic analyses of projects. Much remains to the judgement of the analyst, the planner and the decision-maker. This publication, therefore, does not pretend to present the final solution; nor does it represent FAO's view of what that solution should be. What we do hope it provides is a tool, which I think will be a powerful tool, to help those involved with forestry projects in exercising their judgement, and in moving towards a greater degree of unanimity about an acceptable methodology for project analysis. We welcome comments on this volume and the two companion volumes mentioned above.

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LIST OF ABBREVIATIONS

a	year
ACE	allowable cut effect
ARR	alternative rate of return
B/C	benefit to cost ratio
BE	breakeven
CIF	cost, insurance and freight
CRI	consumption rate of interest
EAFP	economic analysis of forestry projects
ERR	economic rate of return
FE	foreign exchange
FOB	free on board
FRR	financial rate of return
ha	hectare
IRR	kcal (page 11-16 footnote)
kcal	kilocalorie
kg	kilogram
km	kilometre
l	litre
LC	local currency
m <sup>3</sup>	cubic metre
m <sup>3</sup> (r)	cubic metre of roundwood
MRR	marginal rate of return
NPW	net present worth
OC	opportunity cost
OER	official exchange rate
PV	present value
SER	shadow exchange rate
SEV	soil (or land) expectation value
w.t.p.	willingness to pay

## PREFACE

Economic Analysis of Forestry Projects (henceforth referred to as EAFP) provides guidance and guidelines for those in public forestry agencies who are responsible for planning and appraising forestry projects.

For the forester with a background in economics and experience in applying it, or for the professional economist, some of the material covered will probably add little to what he already knows, although it may serve as a useful review. For the forester with no background in economic analysis and no experience with project appraisals, EAFP will probably not provide sufficient guidance for carrying out actual project analyses, unless it is used in conjunction with a training programme where concepts can be more fully explained. EAFP is written for those between these two extremes - those with some training in economics and/or practical experience in applying economics in the field and those who find themselves in positions where they have responsibilities for appraising projects and providing information to decision-makers on the economic values associated with alternative forestry project opportunities.

Since EAFP is written primarily for those working in forestry, it is assumed that forestry concepts and terminology are understood by the reader. For this reason technical forestry topics such as mensuration, silviculture, and engineering are not discussed. EAFP is meant to complement other works in the forestry field. Forestry involves some conditions not found in most other sectors. For example, the long time period involved in growing trees relative to production of most other goods and services makes the time factor and uncertainty in project analysis take on a greater significance. The present guide emphasizes these topics and others that are particularly relevant to forestry projects.

The purpose is to provide a practical, workable approach to economic analysis of forestry projects. Unfortunately, what can be and has been done in practice tends to differ from what ideally and theoretically should be done to make a complete economic analysis. The overall approach presented broadly reflects what is being done in actual project analyses. Some of the suggested elements have not been used in practice yet, at least not in forestry project studies.

EAFP does not contain a rigorous methodology which has to be followed step by step in order to come out with a "good" economic analysis of a project. While in some chapters specific guidelines are suggested for a particular approach to a problem, this has been done for the sake of clarification and not to suggest that the analyst follow them exactly in each appraisal. A good analysis depends greatly on the circumstances surrounding a project and the analyst's judgement based on a thorough technical understanding of the potential approaches to various problems encountered in an analysis. EAFP contributes to the latter condition. The analyst will have to decide how well the various guidelines are applicable under the particular circumstances surrounding the project being analysed.

It is well recognized that decisions on projects generally are based on a number of different criteria and considerations, some economic and financial, but others which relate entirely to social, political, organizational, and environmental considerations.

The relative weight given to any particular criterion or objective will vary with the decision-making situation. However, in most instances consideration is given to economic factors and in many cases such factors influence heavily the decisions concerning public forestry projects. Thus, economic analysis of projects deserves special attention, and it is with this in mind that EAFP has been written.

One further point needs to be made at this stage. Economic analysis should be an important component of decision-making for all forestry activities, whether or not they are described and presented as projects. The concept of a project, as an identifiable and separable set of inputs and outputs and the activities which transform inputs into outputs, is useful as a basis for investment decisions. However, in practice only relatively large and new activities usually get formally defined as projects. Much of what is undertaken in forestry is in the nature of incremental additions to continuing activities, often made up of small component parts which are repeated from year to year, which are not analyzed in any depth each time a decision is made to undertake them. Yet analytically they are no different from the larger "projects", and it is equally important to know about their economic impact and efficiency.

A full-scale economic analysis is unlikely to be either warranted or needed for each activity on each occasion that it is considered. For incremental investments in an ongoing programme rough guidelines or rules of thumb can often be developed which will suffice to indicate the economic validity of a particular action in a particular situation. However, a detailed economic analysis will be needed in order to develop the guidelines if the latter are to be useful. EAFP, therefore, is intended to help facilitate the wider application of economic analysis not just to those activities designated as "projects", but to all forestry activity planning.



## Chapter 1

### INTRODUCTION

#### 1.1 THE NATURE OF THE PROBLEM

Forestry and forest industry activities are basic to most countries. In some areas the focus is on conserving forests and building up new forest resources to meet future requirements for forest products and to protect land and environments from destruction. In other areas, the emphasis is on increased utilization of abundant forest resources to gain needed products and perhaps export revenues which can be used to purchase other goods and services. Regardless of the situation, governments are developing a greater interest in better utilization of forests, both for the production of goods and for various environmental and protection services which forests can provide. With this increasing interest in the forest has come a greater awareness that the potentials are limited in terms of satisfying all demands on the forest at one time. Increased utilization of existing forests and establishment of new forests require new investments of a nation's other limited resources - land, managerial and technical skills, and capital. There are a number of competing uses for these other resources, both within the forestry sector and in other sectors in the economy. Thus governments have to develop some means of choosing between alternative uses for the same limited resources.

The usual approach involves setting up some criteria for choice and then appraising or evaluating each proposed alternative use of resources in terms of these criteria. To aid in this process, a whole body of concepts and techniques has evolved under the heading of "project planning, evaluation and analysis", where the term "project" refers to a particular use of resources that is to be evaluated. A project involves inputs (costs) and outputs (benefits) and the measures and activities which transform the inputs into outputs. The project becomes something concrete which can be identified with specific purposes. The process of project planning involves identifying alternative means for achieving a given purpose or objective, narrowing down the alternatives to the one which seems best to meet this purpose, detailed design of that chosen alternative and then appraisal of the chosen alternative in terms of the relevant criteria for acceptance which relate to how the project affects society in terms of its objectives.

A major function of project planning, from start to finish, is to generate information on alternatives being considered in order to ascertain what their effects will be. This function is called analysis. Most project planning exercises involve a number of different types of analyses to provide different types of information on the effects of the project in terms of various specific objectives. One major objective associated with public projects is to increase the aggregate of goods and services available for society from the use of the nation's limited resources. This is the "economic efficiency" objective, and the analysis which looks at a project in terms of this objective is commonly called an "economic efficiency analysis" or an "economic analysis". This is the subject of EAFF. Specifically, EAFF attempts to explain how an economic analysis of

a forestry project is carried out and how the results are used in the various stages of the project planning process.

EAFP stops at the point where a finished appraisal of a given project is completed. How the results of final appraisals are used in decision-making - i.e., how the result of an economic analysis is weighted and considered by decision-makers in relation to all the other relevant objectives and constraints associated with project choice - is a separate matter that deserves separate treatment. Decision-making is a highly complex subject which cannot easily be covered in one chapter. Thus, all EAFP does is to point out what an economic appraisal should include in order to be considered complete, relevant and useful to decision-makers. To repeat, EAFP is primarily concerned with how economics is used in developing and appraising a particular forestry project, from the time the initial idea is put forward until a final project design is presented to decision-makers.

## 1.2 THE NATURE OF FORESTRY PROJECTS

Projects in the forest-based sector vary widely in nature, scope and size from a small fuelwood plantation to a large integrated forestry and forest industry complex including wood production, harvesting, transport, processing and marketing, and from an industry project to a national park or a watershed protection project.

The differences between forestry projects and other types of projects are more a matter of degree than uniqueness. However, there are some particular features that tend to characterize forestry projects. They are:

- (a) a long production period or period between the time an initial investment is made and output results (e.g., in the case of some plantation projects);
- (b) the tree is both the production unit and the product (both the "factory" and the output);
- (c) related to (a) and (b) is the characteristic of one-way flexibility in production. A tree can be left to grow, but once it is harvested, the "factory" is also destroyed and it can take a long time to build it back to a given level. Thus, there is great flexibility in terms of when to harvest, but little flexibility in terms of building up inventories;
- (d) in contrast with production processes involving machinery and engineering controls, biological production processes tend to be characterized by a great deal of heterogeneity within any given system. Such systems are characterized by great variation in output. Uncertainty can be substantial;
- (e) any given forest tends to have multiple uses e.g., timber production, wildlife protection, watershed and soil protection, aesthetics and recreation. Thus the problems of joint products, conflicting objectives and trade-offs between uses take on particular importance in forest project analyses.

### 1.3 OBJECTIVES, CONSTRAINTS AND PURPOSES ASSOCIATED WITH FORESTRY PROJECTS

The objectives associated with forestry projects will vary with the type of project, the nature and purpose of the institution which will carry out the project, the point of view adopted, and of course, the broader political, cultural and economic environment within which the project will function. All pulp and paper projects are not associated with the same objectives; this also applies to national park or watershed projects.

For the private entrepreneur or corporation, a forestry project is generally undertaken to make a profit or increase the chances for making future profits, or to reduce the danger that expected profits will not be forthcoming. By definition, most private projects are associated mainly with some aspect of the profit motive.

The public sector is interested in undertaking forestry projects, or supporting them in the private sector, for a variety of reasons associated with basic societal objectives. These can be many and varied and seldom is a public forestry project associated with only one of them. Common objectives are to:

- improve economic efficiency, i.e., increase the aggregate benefits (goods and services available for society) derived from the use of the nation's limited resources;
- improve conditions for the poorer members of society (or decrease the gap between rich and poor, e.g., through employment creation);
- increase social, political and economic stability (e.g., through improving the balance of payments situation, providing public services, or following sustained yield policies, etc.);
- improve environmental conditions and land use;
- generate increased revenues for government which can be used for various social needs.

Most public forestry projects involve a combination of these objectives and some may include all of them. Similarly, public support for private projects is generally based on the belief that such projects will contribute to a number of social objectives. How such multiple objectives are handled in practice in project planning and decision-making varies with the situation. Most commonly, some of them are put in the form of constraints on the project. A plantation project may be contemplated to provide fuelwood for consumption and to protect steep hillsides from erosion. Increased consumption may be taken as the main objective, with the environmental improvement objective expressed as a constraint on the way in which the project will be undertaken (e.g., related to management and harvesting options which are acceptable in terms of the protection objectives). Ultimately, public administrators or decision-makers have to provide the basis for weighing different objectives and setting constraints. ✓

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✓ One constraint which is of particular interest for foresters is that associated with a sustained yield policy for public forests. This constraint is in turn related to the basic objectives of economic and social (community) stability. It may conflict with the economic efficiency objective, and decision-makers often have a difficult task in reconciling the two. One relationship between a sustained yield policy and economic efficiency is discussed further in Section 3.3.3.3.

These concepts might seem foreign to foresters used to thinking in physical terms of growing trees, producing wood, protecting soil, etc. However, there is a direct link between these types of physical activities and the objectives mentioned. Forestry activities are not financed and carried out for the benefit of the forest. They are carried out to satisfy human wants, whether these be more housing or paper, greater enjoyment from looking at better forests, or protection of soils and watersheds to prevent decreases in production of food, fibre or water or deterioration of water quality. The stated objectives reflect that forestry investments are ultimately made to increase human satisfaction.

Thus, when the purpose of a particular forestry project is to grow 200 hectares (ha) of trees for fuelwood, this is one step removed from the objective of increasing the satisfaction of human wants, though it may be perfectly consistent with it. A purpose such as growing trees for fuel provides no guidance in terms of getting at a solution to the basic problem of resource allocation or economic efficiency. Thus, in terms of the economic efficiency analysis, the analyst must also identify how the increased wood will affect society and its wants. In other words, the basic question asked by the economic analyst is whether or not this use of resources (in producing fuelwood) increases aggregate benefits to the nation (the value of goods and services available for consumption) more than some alternative use of the resources involved.

In reality, the answer cannot be divorced from the other objectives which society has, nor from the various constraints which influence decisions in a country at any given time. Thus, the process of developing, analysing and evaluating project alternatives becomes something much more complex and diffuse than merely looking at projects in terms of economic efficiency. The term project planning is used to describe this broader process.

#### 1.4 PROJECT PLANNING <sup>1/</sup>

A main function of project planning in the public forestry sector is to identify and design forestry projects that are workable, effective and consistent in moving the nation toward its various objectives.

In a more practical sense this function involves finding the technically feasible solution to a given situation which gives an acceptable economic return to society (i.e., is economically efficient), is adapted to the institutional and managerial situation of the country, and which can be financed with the resources available. Thus, most public forestry projects generally end up being compromises that move the nation ahead in terms of one or more dominant objective(s), while avoiding conflict with all other objectives (i.e., it meets certain constraints associated with these other objectives). The compromise solution is reached through a process of give and take,

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<sup>1/</sup> This section provides only a very brief overall view of project planning in relation to the subject of EAFP. The reader desiring a more detailed view is referred to FAO, 1974.



during which the project idea is looked at broadly from each point of view, or in terms of each objective and constraint, conflicts in views are identified, alternatives are examined and adjustments are made until finally all points of view (objectives and constraints) are satisfied at least at some minimum acceptable level, where "acceptable levels" are defined implicitly or explicitly by decision-makers and policies/laws. As the give and take process progresses, alternatives are narrowed down and the amount of detail and the level of analysis required for the project increase. Finally, a detailed design for one well-defined alternative and a plan for implementing that alternative evolve. A decision is then made whether or not to undertake the project, based on a comparison of its desirability with the desirability of other project opportunities requiring the same limited resources.

The project planning process is sometimes described as an orderly, sequential series of steps that are separable and well defined. While such a neat view is appealing, it is misleading. In reality project planning is a flexible continuing process of successive approximations and refinements as different points of view and objectives are considered, argued, and reconsidered continuously from the point in time when the initial project idea and a range of alternatives are identified, until efforts focus on one alternative, and a final decision is made on whether or not to implement that alternative. Experience shows that even after implementation, the process of give and take and change continues. There are very few projects that are implemented in exactly the way they were envisaged when the decision to go ahead with them was made. Flexibility, adjustment and readjustment characterize most real world project planning exercises. There is no one well-defined way to plan a project.

While it is unrealistic to view the overall process of project planning as a neat set of sequential steps characterized by orderliness, it is necessary to recognize the need for and existence of orderliness in the analytical efforts which provide the background information on which decisions are made as a project evolves. Indeed, the firm belief that a systematic orderly approach to analysis is possible and desirable is an underlying reason for EAFFP.

#### 1.5 USE OF ANALYSIS IN PROJECT PLANNING

The term "analysis" as used here means an examination of a project to distinguish its component parts and the relationship of those parts to the whole. During the entire process of project planning, from the time an initial project idea is identified, various types of analyses are being carried out in order better to understand the project from different points of view and to help guide the process of moving toward the best means of achieving objectives.

The types of analyses carried out vary in orientation and scope depending on the objectives and constraints associated with the project and the stage in the planning process. Most projects involve a number of objectives and constraints and, therefore, a number of different types of analyses. For example, if a pulp and paper project is being considered by the public sector, it is likely being analyzed from a technical point of view (related to the constraint that it must be technically feasible), from a budget point of view (related to the constraint that it must be consistent with existing and expected institutional conditions, availability of resources, etc.), from an environmental point of view (related to an environmental improvement objective or environmental maintenance constraint), and from an economic efficiency point of view (related to the objective of increasing the benefits which will flow from the use of the nation's limited resources). There also may be analyses associated with many other aspects of the proposed project, e.g., impacts associated with local development, balance of payments, employment, markets, etc.

Ideally, one integrated analysis would be developed to deal with all these factors and the various project objectives at the same time. In reality, all of these factors cannot be considered in one analysis, partly because some will involve different units of measurement than others, partly because the various objectives with which the analyses are associated are not complementary and there is no practical, realistic way of combining or weighting the various objectives in quantitative terms, and partly because different analyses are required at different times in the planning process. Generally different analyses (related to the different objectives and constraints) are carried out independently or separately by specialists, or by one or a few general foresters in the case of smaller less complex forest-based projects or activities. At best, these specialists are interacting throughout the process of planning and developing the project. More often, some analyses follow others and interaction takes place after initial results have been obtained.

Economic analysis is just one of the inputs into this process. Its importance depends on the importance given to the economic efficiency objective and the way in which this type of analysis is introduced or used in the planning process.

#### 1.6 ORGANIZATION OF EAFF

At an early stage in the project planning process, when alternatives for achieving a given purpose are being identified, a number of alternatives will be analysed in a partial fashion to throw light on which alternatives should be considered further and which should be rejected, i.e., how the project should be designed. The analysis may only be concerned with alternative costs, or whether a specific technology is preferable to another, etc. At a later stage, when interest focuses on one specific alternative design for achieving the project purpose, the required level of analysis is generally more comprehensive in scope. The type and level of analysis thus varies with the intended use of the results, but the basic steps and techniques are the same. With this in mind, EAFF has been divided into two main parts.

Part I deals with the steps and techniques involved in an economic analysis. Chapter 2 presents an overall view of the process together with some comments on the relationships between economic analysis and other important types of project analyses which are generally associated with the economic analysis. Chapter 3 presents a discussion on how

to define project context and the scope of the analysis. Chapter 4 discusses identification of costs and benefits. In Chapter 5 the basic principles of valuation are discussed. Chapter 6 discusses valuation of costs and benefits when market prices are considered acceptable measures of value for an economic analysis. Chapters 7 and 8 discuss valuation of outputs and inputs when market prices are not acceptable, or when inputs and outputs are involved for which no market prices exist (i.e., inputs and outputs not traded in the market). Chapter 9 presents a discussion of measures of project worth, or how costs and benefits can be compared in an economic efficiency context. Recognizing that most projects involve uncertainty, Chapter 10 provides practical guidelines for considering uncertainty in an economic analysis.

The use of economic analysis in project planning varies by the stage in the planning process, and Part II explores in some detail the uses in (a) design and preparation, and (b) final appraisal.

It is in the early stages of project planning that economic analysis can have its greatest impact. "If economic analysis is to make a maximum contribution to the attempt to ensure that scarce resources are used to best advantage for the country, it should be used from the earliest phases of this process of successive sifting and narrowing down of options that are open to the country."<sup>1/</sup> While an economic analysis at the final appraisal stage provides useful information for decision-making, by that time the main choices related to technology, size, location, and scope have already been made. Most developments in the forestry sector in most countries take place in an incremental fashion through gradual changes in orientations, policies regarding conservation, forest exploitation, etc. and corresponding gradual modifications in the ways in which forestry activities are carried out. Economic analysis, by providing information which can be used in project identification and design, can help shape such gradual changes. If economic analysis does not enter the project planning process until a well-defined project with a detailed design is presented for final appraisal and decision, then its only contribution will be to help shape the decision as to whether or not to undertake the project. At this stage it is generally too late to have any influence on all the incremental decisions concerning project dimensions which, when added up, could amount to a significant impact on development and increased efficiency in the use of the nation's resources.

Chapter 11 concentrates on the use of economic analysis in project identification and design, i.e., in helping to shape decisions concerning project scope (components to include and exclude), project size (in relation to economies of size associated with various activities and requirements for project output), project technology (in relation to factor scarcity and availability), and project location (in relation to regional needs and opportunities).

Chapter 12 explores the need for and usefulness of economic analysis in the final appraisal stage. It includes a description of the overall economic appraisal process for projects and gives one example from an actual project.

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<sup>1/</sup> Squire and van der Tak, 1975.



PART I

APPROACHES TO ECONOMIC ANALYSIS



## Chapter 2

### FINANCIAL AND ECONOMIC ANALYSES

#### AN OVERALL VIEW

##### 2.1 INTRODUCTION

Resources are controlled by many different entities - individuals, private or public corporations, government agencies etc. Each of these allocates the resources it controls on the basis of how the returns from a project contribute to its objectives.

Private entities generally have an objective related to monetary profits, or the difference between what they have to spend or give up and what they expect to receive in money receipts from a project. The term "commercial profitability" is used to describe the relationship between outflow and inflow of funds for goods and services.

The term "financial analysis" is used to describe the type of analysis that develops an estimate of commercial profitability for a project. A financial analysis is carried out from the point of view of specific entities involved in a project. It considers the monetary returns expected by such entities from investment of their funds (resources) in a project. A financial analysis also provides information on when funds will be required (outflows) and when receipts (inflows) can be expected. This latter type of information is essential for budget planning. As such, financial analyses are also relevant for public projects.

An 'economic efficiency' analysis is in a sense merely an extension of the financial analysis concept, where the entity from whose point of view the analysis is being carried out now becomes society as an undifferentiated whole rather than a specific entity (or entities) within the society. As such, the economic efficiency analysis is also concerned with "profitability", but in this case it is the profitability from society's point of view, which is related to the return to society as a whole which can be obtained with a given use of its limited resources. This is called "economic profitability" to distinguish it from commercial profitability. Economic profitability relates directly to the economic efficiency objective defined in the previous chapter. The relationship can be characterized as follows:

Resources have value to society because there are not enough of them at a given time to satisfy all society's wants. Society desires to allocate its limited resources so that they make the greatest possible contribution to satisfying its wants for goods and services. This desire is expressed through what was earlier called the economic efficiency objective. If the existing allocation of resources can be improved, in the sense that more goods and services can be produced with given resources, then there is an improvement in economic efficiency. A use of resources (a project) which improves economic efficiency is an economically profitable project.

Just as the concept of economic profitability parallels the concept of commercial profitability, so the economic efficiency analysis parallels the financial analysis in terms of procedure. However, they differ in terms of what is included as costs and benefits and

how costs and benefits are valued. In the financial analysis, benefits are defined in terms of actual monetary returns to a specific entity (or group of entities) in society from whose point of view the analysis is being carried out. These returns result from the sale or rental of goods and services in a market, and thus returns are measured in terms of market prices. Costs in the financial analysis are represented by outflows of money from the entity (ies), mainly paid out for goods and services purchased in the market. In the economic analysis, on the other hand, the concern is with what society gives up and what society gains from a project. Costs are thus defined in terms of value of opportunities foregone by society because resources are used in the project rather than in their best alternative use. Thus, costs in an economic analysis are referred to as "opportunity costs". Project benefits are defined in terms of increases in goods and services available to society as a whole due to the project. As discussed later in this chapter, these two different concepts of costs and benefits (or the differences between commercial and economic profitability) give rise to some specific differences in the ways in which costs and benefits are identified and valued in the two types of analyses.

Both economic and financial analyses are needed for public projects or private or mixed projects for which the public sector is considering support. The economic analysis is needed to provide information on whether or not the project would provide an economically efficient use of the resources available to society. The financial analysis is needed to provide information on actual amounts and timing of inflows and outflows of funds needed to undertake the project. As mentioned, this latter information is essential for budget planning and control.

Further, for a mixed public-private project or a private project being considered for public support (special permissions, subsidies, etc.), the results of financial analyses undertaken from the viewpoints of the different entities involved in the project also provide useful information on whether or not these different entities will have the incentive and the funds to undertake a project which is economically efficient.

This point goes back to the comment made earlier that specific entities control resources and make decisions on whether they want to commit the resources they control to a given project. A project can be extremely attractive from a national economic efficiency point of view, but if it is not also financially attractive to all private entities which have to commit resources to it, then it will not be undertaken as planned. A financially unattractive project can be made financially attractive if the government (the public) provides subsidies (incentives). Whether or not such subsidies are considered justifiable in a social economic context depends directly on their required magnitude in relation to the economic surplus associated with the project (economic benefits minus economic costs, appropriately adjusted to take time into account). Similarly, analyses which show that a project appears to be more attractive financially than economically may provide some indication of the desirability to tax the financial entity(ies) involved.

Since both financial and economic analyses have much in common in terms of information requirements and procedure, they are generally carried out together. The steps in a financial analysis are more straightforward to carry out and clearer in concept. Therefore they generally precede the comparable steps in the economic efficiency analysis. In practice, a step in the financial analysis is completed and then the results of this step are used as a starting point for the parallel step in the economic analysis. This is also the approach considered in EAFFP. Actually there is no necessary reason why the economic analysis should follow the financial analysis steps; it is more a matter of



convenience. In cases where no financial analysis has been carried out, the economic analysis procedure is exactly the same as described in EAAP.

## 2.2 FINANCIAL AND ECONOMIC ANALYSES: SIMILARITIES AND DIFFERENCES

A financial analysis carried out to estimate expected commercial profitability for a project involves four major steps. First, inputs bought in the market are identified in terms of when they are needed (purchased or rented). Similarly, outputs traded in the market are identified in terms of when they are sold. This information results in a "physical flow" table. Second, market prices for the inputs and outputs are estimated for the times at which inputs will be bought and outputs sold. This information is entered into "unit value" tables. The third step involves combining the information from the two previous steps into a "cash flow" table which shows the value of total inputs and outputs at the times that such values (outflows and inflows of money) accrue to the entity from whose point of view the analysis is being undertaken. To complete the cash flow table, certain financial transactions which involve transfers of control over resources (but no use of real resources) are added to the table. These include such items as taxes and loan repayments (outflows) and subsidies and loan proceeds (inflow) plus a number of other expenses or receipts, depending on the project and the purpose for the analysis. Finally, the inflows and outflows of funds are totalled by years in which they occur to arrive at a net cash inflow (outflow) line. The fourth step then involves using these net value figures by years to derive some measure(s) of commercial profitability. <sup>1/</sup>

The economic efficiency analysis involves the same basic four steps, and each of the first three steps can start with the results of the comparable step in the financial analysis, if certain key differences are kept in mind. The differences and the adjustments needed to develop the economic analysis are outlined in Table 2.1. The following paragraphs summarize each step, and the remaining chapters in Part I discuss the steps in detail.

### 2.2.1 Physical input and output tables - identifying inputs and outputs

The physical input and output tables for the financial analysis include those inputs which have to be purchased or which are owned by the entity and have an opportunity cost and those outputs which are sold by the entity(ies) from whose point of view the analysis is being carried out.

#### 2.2.1.1 Adding indirect effects

To arrive at the appropriate physical flow tables for the economic analysis certain additional inputs and outputs may have to be added to reflect the fact that the analysis is considering all effects of the project (Item 1 in Table 2.1). Some of the relevant economic effects of the project may not have been included in the financial accounts because they occurred outside the market (i.e. they are not directly traded in a market) and do not

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<sup>1/</sup> Some examples of this process are provided by the case studies in Appendix A (from FAO, 1979). See also Chapter 12.

directly affect the project cash flow. These are commonly referred to as "indirect effects" or "externalities", i.e., effects external to the project from a financial point of view since they involve no direct monetary inflows or outflows. (They are also often referred to as "spillover effects", "non-market effects"). This concept can be illustrated with examples.

If a pulp and paper project creates pollution downstream from the mill (lowers the quality of water available to downstream users) and the entity establishing the mill does not have to pay to clean up or avoid that pollution, then this is not considered as a cost in the financial analysis undertaken from that entity's point of view. However, in the economic analysis, this is a relevant cost, since it represents a reduction in the availability of clean (or cleaner) water to members of society due to the project. In an economic analysis, a cost is any reduction in the availability of resources or goods and services (quantity or quality) due to the project, regardless of who is affected by the reduction. Similarly, if a project produces a pleasing environment (which people value), then this is a benefit in the economic analysis, but not in the financial analysis, unless consumers pay for it to the entity carrying out the project. Benefits in an economic analysis are represented by increases in goods and services available to society due to the project regardless of who actually receives them and who pays for them.

In cases where a number of indirect effects are identified, or where it is difficult to quantify and/or value them, the analyst may want to develop a separate table which lists these indirect effects for the years in which they are expected to be relevant. Even if they cannot readily be quantified and valued, they should be mentioned explicitly in the analysis.

In developing the economic accounts from the financial ones, the analyst should look carefully at all the supporting infrastructure needed to make the project work. Sometimes, for a private project, such infrastructure costs are not included in the financial analysis if government has promised to provide supporting facilities - roads, power generation, water, housing, etc. with public funds. Thus, if the financial analysis has been carried out only from the point of view of a private entity involved in the project, such inputs are indirect and have been excluded, since they will not involve outflows or loss of funds from the entity. However, if they are needed due to the project (i.e. they would not have been provided in the absence of the project), then they represent a use of resources and are relevant in terms of the economic analysis undertaken from society's point of view.

Table 2.1

## RELATIONSHIP BETWEEN STEPS IN A FINANCIAL AND AN ECONOMIC ANALYSIS

Financial Analysis	Economic Analysis	Comments
	1. <u>Develop physical flow tables (inputs and outputs.)</u>	
Direct inputs provided by the financial entity and outputs for which the entity is paid are included.	In addition to direct inputs and outputs, indirect effects are included, i.e., effects which are not included in the financial analysis since they are not directly traded in a market. These are effects on others in society.	See Chapter 4
	2. <u>Develop unit value tables</u>	
Market prices are used. For inputs and outputs which occur in the future, future market prices are estimated.	Consumer willingness to pay (w.t.p.) is used as the basic measure of value. In cases where market prices adequately reflect w.t.p., such prices are used. In other cases, "shadow prices" are estimated to provide the best measure of w.t.p.	See Chapters 5 - 8
	3. <u>Develop cash flow/economic value flow tables</u>	
Inputs and outputs are multiplied by market prices to arrive at total costs and returns which are then entered in the cash flow table. Transfer payments (taxes, subsidies, loan transactions, etc.) are added to the cash flow table.	Inputs and outputs are multiplied by unit economic values to arrive at total economic costs and benefits which are then entered in a total value flow table. Transfer payments are not treated separately, but included as part of economic costs or benefits as appropriate.	See Chapter 9
	4. <u>Calculate measures of project worth</u>	
Using cash flow table, calculate chosen measures of project worth or commercial profitability. Test results for uncertainty by varying values of key parameters in a sensitivity analysis.	Calculate chosen measures of economic efficiency or economic worth, using the information in the total value flow table. Test results for uncertainty by varying values of key relationships/parameters in a sensitivity analysis.	See Chapters 9 and 10

### 2.2.1.2 Using the "with and without" concept

Any effect of a project should be identified and measured on the basis of the difference in a given situation with and without the project. This "with and without" concept is basic to project analysis. It is important to keep in mind that the situation as it exists today would likely not remain the same in the absence of the project. Thus, the "before" project situation should not be taken to be the same as the "without" project situation in identifying project effects. Changes would likely take place without the project and these need to be estimated. An example will illustrate this point.

In a soil conservation project to restore fertility to a moderately eroded piece of land, the benefit is sometimes estimated as the difference between production with the present level of moderate fertility and production which will be achieved with the improved fertility associated with the project. However, assume that if the conservation project were not introduced, the situation without the project would eventually deteriorate to one of total loss of production, due to the cumulative nature of the erosion process. The correct benefit measure in this case would include the difference between no production and the level achieved with the project. (The timing of the deterioration process without the project would have to be considered in deriving the output quantities to enter into the physical flow table.) It would not be the difference between the present moderate level of production and full production. If the analyst ignored the "with and without" concept, he would understate the benefits due to the project.

In applying the 'with and without' concept to economic costs (or "opportunity costs"), particular care has to be taken to identify properly the best actual opportunity foregone, i.e., the best alternative use of an input that would actually have taken place in the absence of the project, taking into account the various institutional (social and political) constraints or policies that are expected to exist.

"The technical opportunities that cannot be made use of, given social constraints, are not real opportunities, and the identification of costs as maximum benefits sacrificed must be based on real feasibility... The starting point of all project evaluation is to ask the question: If we did not choose the project, what difference would it make? And the assessment of the differences that would result depends on a clear identification of political and social constraints that limit economic opportunities." <sup>1</sup>

When substantial change is not expected without the project during the period of the project, the analyst may be justified in saving time and money by assuming the "without" situation to hold constant over time. However, there are many forestry projects - which generally involve long time periods - where ignoring potential changes over time without the project will involve some major under - or over-estimation of costs and benefits due to the project.

The above provides a summary of the main differences between the physical flow accounts for the financial and economic analyses. Details are provided in Chapter 4, which deals with identification of costs and benefits in an economic analysis.

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<sup>1</sup> UNIDO. 1972, p. 53.

## 2.2.2 Unit value tables - valuing inputs and outputs

The next step in both the financial and economic analyses is to develop unit value tables for the inputs and outputs with due consideration given to trends in prices and forecasts or projections of future prices. <sup>1/</sup> (Item 2 in Table 2.1) When inputs and outputs have been identified for the economic analysis, a large overlap will likely remain with the financial analysis, i.e., most of the input and output items included in the financial analysis will also be represented by similar ones in the economic accounts. However, there can be differences in the values attached to such common inputs and outputs and these have to be considered in deriving the economic unit value tables.

Unit values used in the financial analysis are market prices. In the economic analysis, outputs are valued on the basis of consumers' willingness to pay (w.t.p.) for them. Market prices may or may not adequately reflect w.t.p. Similarly, inputs in the economic analysis are valued on the basis of consumers' w.t.p. for the benefits (goods and services) foregone by using resources in the project rather than in their best alternative use, i.e., their "opportunity costs" or maximum benefits foregone. Market prices for inputs may or may not provide an adequate measure of opportunity cost in a given project environment. Chapter 5 provides some guidelines on how to determine whether or not to use a market price for an input or output in the economic analysis. It is not an easy task nor one that is amenable to precise rules. Much depends on what information is available and what it will cost in time and money to obtain additional information on which to base a revaluation of an input or output.

If it is decided that a market price provides an adequate reflection of economic value for an input or output, then it also can be entered in the economic unit value table. Chapter 6 provides some guidelines for proper estimation of market prices.

### 2.2.2.1 Shadow prices

If it is decided that a market price does not provide an adequate reflection of economic value, then a more appropriate value (related to the definitions above) has to be derived. This process of revaluation is called "shadow pricing" and the resulting values are called "shadow prices". Detailed guidelines for shadow pricing inputs and outputs are presented in Chapters 7 and 8, together with the appropriate concepts of value on which the guidelines are based.

Indirect effects, or those costs and benefits entered in the economic analysis which were not included in the financial analysis will obviously have to be shadow priced, since by the previous definition (see Section 2.2.1) they are not directly traded in a market. In some cases, market prices can be used as shadow prices for indirect effects.

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<sup>1/</sup> See Chapter 6 for discussion of forecasting future values.

### 2.2.2.2 Income distribution and economic value measures

A major assumption underlying this approach to valuation of benefits and costs for the economic analysis is that the willingness to pay one dollar (or monetary unit) by one individual is as valuable to society as the willingness of any other individual to pay one dollar for the same good or service or a different good or service. In contrast with the financial analysis, the economic efficiency analysis does not distinguish between who loses and who specifically gains consumption benefits due to the project. The analysis is essentially neutral in terms of the distribution of benefits and costs among members of society.

The implicit assumption is that the existing distribution of income (and therefore purchasing power) is correct from society's point of view. Increasingly, this assumption is being questioned and projects are being designed with the explicit objective of redistributing income (consumption opportunities) from the richer to the poorer members of society. This objective can be considered in the economic analysis by attaching higher weights to benefits received and costs incurred by the poorer members of society.

Recently, attempts have been made to combine efficiency and redistribution considerations into one integrated system of social economic analysis.<sup>1/</sup> While such systems are conceptually sound, they are not at a stage where they can be applied realistically in practice in most cases, mainly due to the lack of generally acceptable income weights for different groups in society. EAFP follows the practice of analysing a project in economic efficiency terms first (i.e., assuming equal weights). A redistribution analysis can be undertaken separately as warranted by the circumstances. Henceforth, the term "economic analysis" is used as meaning the same as an "economic efficiency analysis", the separate analysis of income redistribution as an "income redistribution analysis", and the combined analysis as a "social economic analysis".

To summarize, derivation of unit values for the economic analysis involves a two stage process. First, for inputs and outputs traded in a market, a judgement is made on the adequacy of market prices used in the financial analysis as measures of economic value. This is discussed in Chapter 5. If they are judged to be adequate, they are entered in a table showing unit economic values. Chapter 6 provides a discussion on use of market prices. If they are judged to be inadequate, then they are treated in the second stage just like indirect effects for which no market prices exist. This second stage involves a judgement on whether or not an acceptable shadow price can be developed. If the judgement is negative, then it is better to treat the effect in a qualitative or physical quantitative fashion, by making explicit mention of the effect in the economic analysis report. The analyst should not try to develop some spurious value measure which will merely serve to confuse and mislead decision-makers. If the judgement is that a shadow price can be developed, then the analyst proceeds to do so and the resulting values are entered in the unit value table. This second stage in valuation is detailed in Chapters 7 and 8.

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<sup>1/</sup> Cf. IDB 1977, UNIDO 1972, Little and Mirrlees 1974, Squire and van der Tak 1975.

### 2.2.3 Total value flow tables

Once market prices have been estimated in the financial analysis, they are multiplied by the quantities of inputs and outputs from the physical flow table(s) and entered in a "cash flow" table in the financial analysis (Item 3. in Table 2.1). The cash flow table provides a picture of the inflows and outflows of cash expected for a given project alternative by years or other time intervals (see Chapter 9).

In order to arrive at a picture of the total financial cash flow from a particular entity's point of view, it is also necessary to add any direct subsidies received or loan proceeds as receipts in the table and any direct taxes, other government payments, and loan repayments as costs or expenditures in the cash flow table. These are all called "transfer payments", since they involve transfers of control over resources but do not involve any direct changes in the use of real resources in the project as defined.

Since the economic analysis is concerned only with real resource flows (and real output flows), transfer payments should not be shown separately in the total value flow tables for the economic analysis. This point is explained further in Chapter 9, together with some examples and guidelines for treatment of transfer payments.

To summarize, in moving from the financial cash flow table (either for a commercial profitability analysis or an analysis of return on a particular entity's equity capital) to an economic value flow table for a project, adjustments for direct transfer payments associated with the project have to be made in the economic value flow table, since they do not represent any change in real resource use or project output for a given project alternative. There are some exceptions in cases where taxes, royalty payments, loans, etc., involve foreign exchange or payments outside the country. These are discussed further in Chapter 9. They are relevant for forestry projects in some cases.

### 2.2.4 Economic profitability or efficiency

Once inputs and outputs have been properly identified and valued for the economic analysis, there is no further advantage to be gained from using the results of the financial analysis in completing the economic analysis. As indicated in Item 4 of Table 2.1, the financial analysis involves calculation of one or more measures of commercial profitability. Parallel, but completely independent calculations are made to determine the economic efficiency or economic profitability of a project.

A given project (use of resources) is considered efficient in economic terms if:

- its benefits are equal to or greater than its costs;
- benefits are at least equal to costs for each separable component of the project; <sup>1/</sup>
- there is no known lower cost means actually available (given existing constraints) to achieve the same project effects (or benefits).

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<sup>1/</sup> Separable in the sense that a project can exist (technically) with or without the component. For example, a plantation project can exist with or without a fertilizer component. Thus, the fertilizer component is separable in terms of the above definition (see Chapter 3).



In the case of all three conditions, appropriate adjustments have to be made to take timing of costs and benefits into account (see Chapter 9). If any of the three conditions or criteria are not met, then the project alternative does not represent an economically efficient use of resources, and it should be rejected or revised in terms of the economic efficiency objective. As mentioned a number of other objectives will likely influence the final decision on a project, but these are not considered in the economic efficiency analysis.

The rationale for the first condition is the easiest to grasp. If the costs for a project exceed the benefits that will flow from it, then this means that society will have a net loss in value of goods and services available for consumption if the project is undertaken.

The rationale for the second condition concerning separable components of a given project can be illustrated with an example. Assume a project designed to produce sawnwood and plywood (the two have been included in the same project for administrative or other reasons). It may be that one of these separable components - say sawnwood production - has costs higher than benefits if considered alone. The plywood component returns may be high enough to carry this loss and still make the overall project acceptable. However if the sawnwood component were removed from the project, then the total net return would increase and the benefits to society would be greater per unit of resources committed. If the components are not analysed separately, then this information will never come to light and the second condition for economic efficiency cannot be tested.

Commercial profitability of a project also could be improved if unprofitable separable components were eliminated from the project. Although the overall project might be able to carry the unprofitable component, this would certainly not make financial sense, if the component could be eliminated without making the rest of the project unfeasible. Thus, since there is a parallel condition related to financial profitability, it is likely that separable components have also been treated separately in the financial analysis. In that case, the economic analysis and the identification of direct inputs and outputs by components can proceed using the results of the financial analysis. Otherwise, the analyst will have to go back to the basic project technical studies to determine the interrelationships between components and the separability of components in terms of their costs and benefits.

The third condition makes intuitive sense. If there is a known cheaper way of achieving a given purpose than the alternative being analysed, then it would make little sense not to use that cheaper way provided it achieves exactly the same benefits of effects. Thus, in comparing the costs of alternatives, adjustments may have to be made in the benefit rows of the value flow table as well as in the cost rows. For example, clearing land in the tropics for plantations may be accomplished at lower economic cost using heavy machinery rather than labour, but there can be some negative indirect effects (costs) associated with the heavy machinery in terms of environmental deterioration. These costs also have to be considered in the economic analysis.

How the economic analyst deals with the three conditions or criteria in an analysis depends on which of the following two situations is relevant:

The first situation or possibility is one where the project purpose is not now being met and no decision has been made at the time of analysis as to whether or not the



project output should be produced and added to the supply available to society. In this case, the analyst has to look at the project in terms of all three conditions for economic efficiency. In other words, in this case the decision-maker not only is interested in knowing whether the proposed project is the lowest cost means of achieving the project purpose, but also whether benefits exceed costs by a great enough margin to make the project worth undertaking, i.e., whether it is worthwhile to add the project output to the goods and/or services available to society. This first situation is the one commonly discussed under the heading of "cost-benefit" analysis.

The second situation is one where the decision has already been made that the project purpose will be achieved or will continue to be achieved. For political or other reasons the project benefits are desired and will be produced, perhaps because they traditionally have been provided or because society (through its government) feels that the benefits should be provided (for example a minimum level of fuel for poor members of society who cannot afford to pay for it). Benefits with or without the project will be the same. Thus, in terms of the economic efficiency analysis, the main task is to concentrate on the third condition, or a comparison of the costs of alternative means of achieving the project purpose, but taking different indirect effects into account. To make this comparison the analyst uses what is called a "least cost analysis" or a "cost-effectiveness analysis", which simply means that costs of known feasible alternatives are compared to find the lowest cost means of achieving the project purpose of effects. The lowest cost alternative is the most economically efficient alternative.

In this second situation, the project could involve production of an output that will substitute for a good or service that is already being consumed (and produced by alternative means, either domestic production or imports). If the consumption from the existing source is expected to continue in the absence of the project, then the relevant task of the economist is to focus on a comparison of the opportunity costs of the existing source of supply with those associated with the proposed project source of supply. If the project costs are lower than those for any known, feasible alternative, then it should be accepted in terms of the economic efficiency objective.

The point to stress in terms of the two situations is that all projects should be subjected to least-cost analysis (consideration of the third condition for economic efficiency), while only some involve full scale cost-benefit analyses. The differences will become clearer later in Part I and in the discussion in Part II of the appropriate treatment of the two types of situations in project planning.

#### 2.2.5 Dealing with uncertainty

One additional point needs to be mentioned in connection with estimating the economic efficiency of a project. This is the question of how uncertainty is treated in the analysis. So far costs and benefits and their appropriate measure of value have been defined and how they are used in determining efficiency. Little has been said about the empirical problems associated with identifying, valuing and comparing costs and benefits. As techniques and empirical questions are discussed in the remainder of Part I, it will become evident that a great deal of uncertainty surrounds most empirical analyses of economic efficiency. A major function of the economic analysis should be to explore the implications of uncertainty surrounding the values of project parameters for the measures

of economic efficiency derived. This function is usually incorporated into what is called a "sensitivity analysis", or an analysis of the sensitivity of a chosen measure of project worth to changes in the assumptions concerning inputs and outputs and the values attached to them. The concepts and techniques are explored in detail in Chapter 10.

### 2.3 ECONOMIC ANALYSIS OF PROJECTS VERSUS POLICIES

Before getting into a detailed discussion of the four major steps in an economic efficiency analysis and particularly into the details on valuation, it is necessary to point out the difference between the interpretation used here for an economic efficiency analysis for a project which will exist in a given political and social environment, and an economic analysis of the policies which shape that environment (i.e., an analysis of the costs and benefits to the nation in efficiency terms associated with the existence of a policy). The two are considered here to be quite separate.

In an economic efficiency analysis for a project, costs and benefits are defined and valued in terms of the actual conditions which are expected to exist in the project environment. These conditions are influenced by government policies. Some of these policies are aimed at supporting objectives other than increasing economic efficiency. For this reason some of the policies can lead the economy away from maximum possible economic efficiency. If they were eliminated, the allocation of resources could be improved in terms of the economic efficiency objective. Some argue that only in a distortion-free environment (i.e., in the absence of all policies restricting economic efficiency) can the conditions be found which are adequate for identifying and valuing costs and benefits for an economic analysis.

While these arguments have merit, it is felt that the worthiness of a project should be estimated in terms of the difference it makes to society, given expected actual conditions and the actual available opportunities which will exist given such conditions. As mentioned in Section 2.2.2, a project that is technically feasible but cannot be implemented because of some policy restriction is not a real opportunity and should not be considered as being feasible. To do so might result in even worse distortions in resource allocation when all objectives and constraints are considered. Thus, the recommendation made here and the approach followed in EAFFP is to take into account all policies which are expected to exist during the life of the project when calculating opportunity costs for inputs and valuing project outputs.

Under certain circumstances, it may also be desirable to examine the efficiency conditions that would exist without a given policy. This should be done separately. This type of analysis is called a "policy efficiency analysis". Such an analysis can be useful in two main ways:

- it allows an examination of the changes that would occur in the economic profitability associated with a given project if the policy were changed. Since the permanence of a given policy over the life of a project is not certain, this analysis is really aimed at exploring one area of project uncertainty by testing the sensitivity of the project to changes in policies;
- it can generate information on the general effect of a policy on resource allocation in a given total economic setting. (Most changes in policies

will have impacts reaching far beyond the confines of a specific project.) Such information provides the basis for assessing the overall desirability of a policy in terms of the national efficiency objective and provides background information for making the future policy decisions.

The main elements involved in an economic analysis and the relationship between economic and financial analyses have been discussed. In the following chapters details are given on how to carry out an economic analysis (i.e. techniques) and where and when to apply economic analysis (i.e., uses for economic analysis in project planning) but first there is a brief discussion on how the financial and economic analyses provide (or do not provide) information related to other objectives which are commonly of concern to decision-makers.

#### 2.4 ECONOMIC AND FINANCIAL ANALYSES AND OTHER OBJECTIVES

As stated before, decisions are not based on financial and economic criteria alone. Decision makers are concerned with effects of projects which are related to other objectives. Some of the main ones of concern include (a) income redistribution effects, (b) balance of payments effects, (c) employment effects and (d) environmental effects.

It was pointed out in Section 2.2.2.2 that the economic analysis tells the user nothing about income redistribution effects, although it is possible to weigh the costs and benefits used in the economic analysis to reflect income redistribution objectives. The financial analysis does tell something about the incidence of expenditures and receipts associated with a project, but weights are not attached to expenditures and receipts associated with different income groups. Thus, if there is an objective to redistribute income to the poorer members of society through projects, a separate analysis will have to be undertaken which appropriately weights costs and benefits.

With regard to the employment objective, shadow prices for labour used in the economic analysis should reflect conditions of unemployment and thus favour use of labour in cases where there is substantial unemployment. In addition, the physical flow tables provide an indication of the impact of the project in terms of numbers of persons employed.

In some situations balance of payments effects are of primary concern. The financial and economic analyses can be set up in such a way that costs and benefits (expenditures and receipts) are listed by foreign and domestic sources. A summary can then be prepared to indicate the net effect of the project in terms of foreign exchange or balance of payments. The shadow price used for foreign exchange is a means of directly incorporating the balance of payments objective in the economic analysis. Other approaches are also possible.<sup>1</sup>

The economic and financial analyses tell nothing directly about environmental impacts related to environmental improvement or maintenance objectives. A separate environmental impact analysis will have to be undertaken for this purpose. Similarly, there may be other social and political objectives which are relevant in particular cases. The impacts of a project in terms of such other objectives will also have to be analysed separately.

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<sup>1</sup> See paper by McGaughey, in FAO, forthcoming.



## Chapter 3

### PROJECT CONTEXT

#### 3.1 INTRODUCTION

As mentioned in Chapter 1, in the process of shaping a project idea into a well-defined project to meet an objective, a number of alternatives are likely to be considered and compared. Before alternatives can be analysed in an economic framework and compared, it is necessary to know in each case the context of the analysis and the dimensions of the alternatives being considered. First, the level of detail required, the relevant time frame for the analysis, and the constraints on the analysis, have to be defined in terms of the purpose for the analysis. Second, the scope of the project alternative in terms of its components (and their separability and interdependencies) has to be determined, at least on a preliminary basis.

The first consideration is needed in order to allocate the time and budget available for analysis to the various tasks involved and to the alternatives being considered; the second is needed so that inputs and outputs of separable project components can be properly identified and valued in order to evaluate alternatives in terms of the second condition for economic efficiency mentioned in Chapter 2, namely that each separable component should have benefits at least equal to costs.

#### 3.2 LEVEL OF DETAIL AND RELEVANT TIME FRAME FOR THE ANALYSIS

An economic analysis takes time and costs money. In most cases both are limited for any given project. Thus, the time and funds available have to be allocated to the various tasks involved in the analysis. The appropriate allocation of time to input and output identification and valuation will depend on the nature of the alternative being analysed and the purpose for the analysis. If the analyst is involved in the early stages in project planning, where an idea exists and the task is to sift through a large number of alternative means for implementing the idea, then he will likely want to concentrate on looking at the alternatives in a very general (as opposed to detailed) fashion in order to eliminate the obviously unacceptable ones. As the planning process progresses, the number of alternatives will be narrowed down through successive eliminations and more time and effort will be devoted to detailed analysis of a few alternatives. Finally, once one alternative is settled on and detailed design of that alternative takes place, a comprehensive economic appraisal will be required. These various uses for economic analysis are discussed in more detail in Part II. For the present it is enough to point out that before any given economic analysis proceeds it is necessary to have in mind the level of detail required for the particular purpose and the level of detail possible, given time and funding limitations and existing data.

A time frame needs to be established for the project idea being considered, i.e., the analyst has to settle on a relevant project time span, or how far into the future effects should be considered. Similarly, the time interval to use in identifying effects needs to be established. In reality, effects take place on a continuous basis and may change constantly over the life of a project. It is obviously impractical to consider and identify effects on a daily basis, so what other basis should be used for identifying and listing inputs and outputs and values?

With regard to the appropriate project time span, a general recommendation is to consider a time period that is long enough to include all the major effects of the project that can be foreseen. For example, a project which involves growing trees on a fifty year rotation should have a defined time span of at least fifty years. Some complications can arise in terms of input and output identification if a project only involves a part of an on-going programme. These problems and how to handle them are discussed under the heading of "time-slice" projects in Section 3.3.3.1.

With regard to the appropriate time interval to consider in identifying inputs and outputs, the usual procedure - and the one followed here - is to consider one year intervals, i.e., to list inputs and outputs on a yearly basis. A year can be defined to begin on any date, e.g., January 1, June 1, etc. For forestry projects, a "year" is often taken to begin on the day of planting or some other major initial investment in the project (e.g., site preparation). However it does not matter when the year is defined to start, so long as the same date each year is assumed in the physical flow table ( and in the subsequent value flow tables). Similarly, there is no convention regarding how a given input or output is allocated to a given year when it occurs sometime in between the chosen date for the beginning of a "year" and the beginning of the next year. A convenient procedure is to assign any input or output that occurs within six months of the beginning date of a given year to that year and any effect which occurs more than six months after that beginning date to the next year in the physical flow table. The main point is that once a rule is set up for assigning inputs and outputs to a particular year, it should be followed uniformly throughout the analysis.

It is only by convention that the period of one year is chosen for use in investment projects. If a very short project and/or a very high discount rate is being dealt with, then a shorter time interval (say 3 months or even one month) can be used. The procedure is exactly the same, although the data requirements and calculations usually become more cumbersome.

### 3.3 ANALYSING INTERDEPENDENCE AND SEPARABILITY OF PROJECT COMPONENTS.

By its very nature, a project consists of interrelated components. Indeed, diverse activities or components are combined into one "project" because they are inter-related in some way. However often some of the components of a project can be defined separately in the sense that most of their costs and benefits are independent from the rest of the project and the components can be added to (eliminated from) the project without affecting its technical feasibility, although they may obviously affect its overall profitability or economic efficiency.

If such separable components can be identified, then inputs and outputs should be allocated to them and they should be analysed separately, since as explained in Chapter

2, each separable project component should have benefits at least equal to costs in order for the total project to be considered an economically efficient use of resources.

When looking at component separability there are two relevant questions. First, does it make sense in the context of the purpose for the analysis to separate components, and if so, which components? Second, can components reasonably be separated for analytical purposes, i.e., can the inputs required for each component meaningfully be separated from each other?

With regard to the first question, the answer depends very much on the viewpoint of the institution for which the analysis is being carried out. If the institution does not want to change a given project scope, or if it has already decided on the size of the project, then it makes little sense to waste valuable analytical time and effort on detailed separation of components. The answer also depends to some extent on the stage in the project planning process. At the early stages, when alternative combinations of components and project sizes are being explored, it makes sense to separate out components and to analyse them individually and in combinations. This is indeed one of the main functions of the project identification and preparation stages in the planning process, and one of the main uses for economic analysis at these stages (see Chapter 11). However once a project alternative has been shaped and designed in detail, it may make little sense to spend much time on detailed analysis of components that have already been analysed and accepted in the earlier stages of planning. This is the case, for example, in the final project appraisal stage. The question at this stage is whether or not in fact alternatives were looked at at an earlier stage. If not, then there may be some justification for separate analysis of components even at the final appraisal stage, if such is not ruled out by the relevant decision-makers or the institution undertaking the analysis.

For the present, let it be assumed that there is a need and desire to look at separable project components in economic efficiency terms. The second question then arises, namely, what are the considerations that are relevant in determining whether or not components can be reasonably separated for analysis?

There are at least four types of interrelationships between project components and between a project and other projects or activities which have to be considered in looking at the question of separability. These are:

- horizontal interrelationships, i.e., interrelationships between components at the same level in the production process (see Section 3.3.1);
- vertical interrelationships, i.e., interrelationships between project components at different levels in the production process, i.e., where the output from one is an input into the next (see Section 3.3.2);
- interrelationships through time, i.e., the problem of identifying costs and benefits in a "time-slice" project, or a project that only involves one time segment of an on-going activity or programme (Section 3.3.3.1);
- interrelationships between a given project and other activities which should be considered within the project scope if a meaningful economic analysis is to be carried out. This relates to the problems associated with identifying and valuing indirect effects. (Section 3.3.3.2).

### 3.3.1 Horizontal project components

Forestry projects may involve two types of horizontal project components. One type is found in projects that are designed to produce several different outputs, for example sawnwood and plywood, or joint products such as timber, watershed or soil protection, and wildlife habitat. The other type is related to project scale, i.e., where a number of relatively independent production units producing the same output(s) are combined for administrative or other reasons into one "project". Examples would be a community fuelwood plantation project that includes sub-units or components in a number of independent communities, or a smallholder farm forestry project that involves support for establishment of numerous small independent plantations on private farms in a given region. <sup>1/</sup>

For both types — several outputs or several producers of the same output(s) — there will always be some inputs which are jointly required by all components. If nothing else, since they are encompassed in one project, they will have project administration inputs in common. But quite often they will also have other inputs in common, e.g., infrastructure, marketing services, etc.

A typical situation where separate analyses can be undertaken is where several parallel processing activities are included within the scope of the same project. For example, in a project designed to produce both plywood and sawnwood, the major input items can generally be assigned separately to the two activities (although they also will likely have some inputs in common, e.g., administration, some infrastructure, etc.). <sup>2/</sup>

In many other types of forestry projects with joint outputs, there is little scope for separate analyses of components, since most of the inputs required to produce the outputs are common to all of them. For example, a plantation project may produce wood, provide soil protection and wildlife habitat. All three outputs ("multiple use" of the plantation) result from the same production system and inputs and are thus difficult, if not impossible, to separate from each other in terms of inputs.

In this latter case the cost of adding on one purpose or output could be analysed. For example, the extra cost of management and harvesting associated with improvement in the soil protection function of a plantation on a hillside aimed primarily at producing wood and wildlife habitat could be analysed. But this would not be the same as analysing the soil protection output as a separate horizontal component, since the additional costs required to obtain the soil protection would not be the same as the total costs for it if taken in isolation. This type of analysis of the cost of adding on an additional purpose to the main project purpose is relevant in some cases, as will be discussed in Part II.

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<sup>1/</sup> For examples see the Case Studies outlined in Appendix A.

<sup>2/</sup> The question of allocating a fixed and limited wood supply (input) to alternative processing activities is a separate question and is treated in Chapter 11.



For a type of project that involves a number of relatively independent units producing the same outputs, (such as the fuelwood plantation or small-holder agro-forestry examples cited above), there is a different set of questions which is relevant in determining the value of looking at separable units. First and foremost is the question of data and information on which to base such separation. If, as is often the case, estimates of "average" or "typical" conditions are used for all the components because of lack of more detailed information, then separate analyses make little sense, since all components will have the same assumed conditions and thus the analysis of each will produce the same results. For example, for an agro-forestry project in the Philippines involving subsidization of several hundreds of smallholder farmers, the data base was such that the best the analyst could do, given limitations on time and funds, was to use estimates of "typical" input requirements and "typical" yields for the area in which the farmers were located. <sup>1/</sup> Information was not available on which to base a disaggregated analysis of the relative profitability of different types of farms or different sites. Thus, components were not separated out for separate analyses. Instead, an "average" farm was analysed and the results extrapolated to take into account all the expected participants in the project.

Even if more detailed data had been available, it would hardly have been worth the analyst's time and effort to analyse each potential participant separately. However, separate analyses might have been made for several broad productivity and/or location classes to provide some indication of the relative profitability of different groups within the total project scope. Such information would be useful for establishing priorities in cases where there were more potential participants than funds to support them.

Whether or not separation of such components makes sense, even if the information on which to base separation is available, depends on the nature of the particular project situation, the time and funds available for analysis, and the objectives and constraints faced by the relevant institutions involved in the project. It is seldom worthwhile to separate out all such components. But it is generally worthwhile to look at some major classes of components in these types of projects. Once the relevant separation has been determined (agreed upon) then the analyst can proceed to identify inputs and outputs by such categories, developing separate physical flow and unit value tables for each.

However in these cases or the ones previously cited which involved joint outputs, the analyst still faces the problem of allocating some inputs which are jointly required by several or all components. As mentioned, even in the clearest of cases, there will always be some joint inputs (costs).

Some argue that as long as all inputs cannot be separately assigned to specific components there is little justification for separate analyses of components. The argument is that arbitrary assignment of joint costs is artificial and may lead to wrong decisions. The question is really one of degree. In cases where joint costs are significant in relation to separable costs (say around 25 percent or more of the total costs) separate analyses of components might lead to problems.

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<sup>1/</sup> See Case Study No. 1, FAO, 1979.

In cases where the estimated joint costs are relatively insignificant, or where the analyst is asked or required to undertake separate analyses of components, the analyst has to resort to judgement in allocating joint costs in a systematic, albeit arbitrary fashion.

To summarize, for horizontally related project components, the analyst should explore the extent to which inputs and outputs (costs and benefits) can be separated in a meaningful way. If three-quarters or more of the costs required for a given component can be separated out, then it is probably worthwhile to analyse the component separately, using whatever information and judgements are available to allocate joint costs. If none of the project components appear to be reasonably separable in terms of their inputs, then inputs should merely be identified for the project as a whole.

The above relates to analysis of a given project which is already defined in scope. If the economic analysis is being used to help determine an appropriate project scope and content (i.e., in the early stages of project planning), then horizontal components and alternative combinations of components can be looked at in more detail. This is discussed in Chapter 11, under the uses of economic analysis in project design.

### 3.3.2 Vertical project components

Most forestry and forest industry projects also involve distinguishable vertical components or activities, where the output or result from one component is an input into another component in the project. For example, wood produced in plantations is an input into a processing activity, with both being part of a defined integrated forestry and forest industry project. The wood production and the processing are quite well-defined separate activities, if the wood has alternative uses or value other than in the project processing activities. (If it does not have other uses, then it cannot be analysed separately. See section 3.3.3.2).

The main point to keep in mind when dealing with vertically related components is the concept of one-way dependence. This concept can be illustrated with a parallel. If a column is being built out of bricks, the bricks on the top depend directly on the bricks below; building cannot start from the top down. Each successive brick placed on the column depends directly on all those below it. On the other hand, the top brick can be eliminated then the next one and so forth down the column without affecting the bricks below. Similarly with a project (if the bricks are considered as being vertically related project components), components at the bottom can be undertaken without undertaking those at the top, but a component at the top cannot be undertaken without also undertaking all those that lie below it. Thus, it makes sense to analyse lower components separately from those above, but it makes little sense to analyse a higher component separately without considering all those that lie below it and on which it depends.

For example, assume a plantation project for which fertilization is being considered. Applying the 'with and without' concept, the one-way dependence involved between the plantation and the fertilization can be seen. Without the plantation project, the fertilizer obviously would not be applied. Therefore, if it is applied with the project, the total costs and benefits involved are properly of concern in the analysis. The plantation project can be undertaken without the fertilization (it is independent of the fertilization), while the fertilization cannot be undertaken without the plantation

(it is dependent on the plantation). Thus the two can be logically separated in terms of analysing the profitability of the plantation without the fertilization, but it would be meaningless to analyse fertilization without also considering the plantation in this particular case.

At the same time, it should be emphasized that it makes sense to analyse the incremental costs and benefits associated with adding on a component (adding a "brick" to the column). Thus, for vertical components, the analyst should attempt to separate out inputs and outputs, so an analysis can be made of whether or not adding the next higher component involves an addition to the present value of total net benefits of the project. To take again the example of a project that envisages possible application of fertilizer to a plantation, assume that the overall return of the project, including the fertilization component, is \$1 500 and the total cost is \$1 200, both adjusted to take timing into account. If the project is looked at as a whole, the net benefits would be \$300 and the project would be considered economically profitable. However, looking at the fertilizer component in terms of additional costs and benefits, the added value yield (benefit) due to the fertilizer is \$100, while the cost of fertilizer and its application is \$150. Therefore the fertilizer component involves a net cost of \$50 (i.e., \$150 minus \$100). Total net benefits would be \$50 higher, or \$350, if the fertilizer component were excluded. According to the second condition for economic efficiency, the project would not be considered economically efficient unless the fertilizer component was eliminated. Only by analysing the incremental costs and benefits involved can it be seen whether or not a dependent component should be included in the project.

Two points should be emphasized. First in this example, it was assumed that both establishment of the plantation and fertilization were being considered as components of a project proposal. If the plantation were already established, then the fertilization component would be considered as a separate project and only the incremental costs and benefits involved in fertilization would be analysed. The same conclusion as above would be reached, namely that the fertilization costs would exceed the benefits.

Second is the assumption that the wood produced in the plantation without fertilization would have an economic use. The assumption would likely be true in this case. However, in some cases this assumption might not hold; then non-separable components would have to be dealt with. For example, if the wood to be produced as part of an integrated project has no value other than in the particular processing activity being considered as a project component, then the wood growing separately from the processing activity cannot be meaningfully evaluated. (The two components are not separable.) Section 3.3.3.2 discusses this point further.

Most forestry projects involve a number of vertical components. Some can be meaningfully separated as discussed above; others cannot. For example, in a project involving land clearing and planting of trees, the clearing component and the planting component need not be separated, since the value of the wood output is dependent on both clearing and planting and it is not possible to derive a meaningful output value for the land clearing in isolation from what will be done on the land after it is cleared.

To summarize, inputs and outputs should be listed by separable vertical components so an analysis can be made of whether or not it makes economic sense to add successive components to the overall project (such as in the example of adding fertilizer to a plantation project).

From these comments on horizontal and vertical components, it can be seen that for most projects there will be a number of intermediate physical flow tables needed and not just one. Thus, if a project has two horizontally separable components and three vertically separable components for each of the two, it could have six separate flow tables, or one for each of the two horizontal components with three vertical components separated within each horizontal component. A total flow table would also be prepared, once the separable components have been analysed.

### 3.3.3 Interdependencies with other projects

The above two types of relationships refer to interdependencies and separability of components within a given, defined project. Two additional types of relationships also have to be analysed in order properly to identify inputs and outputs. The first relates to interdependencies between the project and other projects over time, i.e., in the case where the project merely represents a part of an on-going activity or programme. This type of project is called a "time-slice" project. The second is the type of interdependency which exists when the output of a given defined project only has one use and there is no practical way of estimating the value of the benefits of the project other than as an input into that use. These two types of interdependencies and their implications for input and output identification are discussed below, together with a special case of interdependency found in forestry, namely, the case of the "allowable cut effect".

#### 3.3.3.1 "Time-slice" projects and interdependencies over time

It is quite common to find projects which include only a given part of an ongoing programme. These are called "time-slice" projects. <sup>1/</sup> Identification of costs and benefits in this type of project can be tricky, since care is needed to identify carry-over values from previous activities (projects) which should be entered as costs in the new project and residual values associated with the new project which should be entered as benefits at the end of the new project. This task involves, among other things, distinguishing between sunk and nonsunk or recoverable costs. A sunk cost is one which has already been committed and which cannot be recovered and thus should not enter into consideration in an analysis of appraisal of a project involving decisions about future expenditure or use of resources. With or without the project, the resources are committed in the case of sunk costs. Thus, they involve no change in the project. These types of values are treated as follows:

Initial carryover or "inherited" costs and treatment of sunk costs. In a time-slice project, i.e., an investment in continuation or expansion of an on-going operation, resources used in the present operation which will also be used in the continuation or time-slice project should be treated as follows (this guide relates to the general rule that analysis should be based on the difference "with and without" the project):

- if the resource would actually have been used in some other productive use in the absence of the proposed continuation project, then it must be included as an input in the economic appraisal of the continuation project and given some positive value;

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<sup>1/</sup> FAO, 1979. Case studies nos. 2, 4 and 5 deal with projects which represent plantation activities for a certain number of years of ongoing forest plantation programmes. (See also Appendix A.)

- if the resource that will be used in the continuation project has no use other than for the proposed continuation project, then it should be included as an input but valued at zero in the economic analysis.

Residual value at the end of a project.<sup>1/</sup> Most projects have capital assets (land, buildings, equipment, etc.) which have differing lives. If some capital asset has a life that is longer than the project period chosen, i.e., the asset has some other use at the end of the project, then the value in that other use should be entered as a "residual value" or benefit at the end of the project. The argument is exactly the same as in the case of carryover or inherited costs, except residual values are entered as benefits instead of costs, since when the project is terminated, it releases resources (or goods and services) which can be used in producing other consumption goods and services.

Residual values are common in financial analyses, since most often a purchase cost of an asset is entered into the accounts at the time it is paid for, and this purchase cost takes into account the expected stream of benefits foregone during the entire life of the asset, not merely for the time during which the asset will be used in the project. Thus, when a land purchase cost is entered in the financial analysis, it theoretically takes into account the value of the alternative benefits which the land could produce forever, not merely during the project time span. Thus, if the land has a use beyond the time span of the project (as it normally does) then a residual value should be entered at the end of the project to take into account the fact that the land will be sold or put into some other use when it is released from the project.

In an economic analysis, the theoretically correct way to enter the opportunity cost of land is to enter each year an annual value foregone by using it in the project in that year. In this case, since only the opportunity cost of the land during the time in which it is used in the project is entered into the accounts, there is no residual value to account for in the economic analysis. The same goes for other capital assets, again, however only in a theoretical sense. In reality it is difficult to allow for annual values foregone or opportunity costs for most capital assets. Thus, commonly they are entered at full value at the time they are first committed to the project and thus a residual value is relevant. In terms of input identification, this means that an asset is entered once in the analysis as a cost in the year in which it is first committed to the project and then it is entered at the end of the project as a benefit and assigned a residual value which reflects the initial real cost for it plus the value of any improvements resulting from the project which have raised its real opportunity cost.

Residual value should not reflect any real value increase that would have taken place without the project. At the same time, if the real opportunity cost of an asset is increasing over the life of the project, then this should be reflected as a cost to the project in the unit value tables (see Chapter 8).

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<sup>1/</sup> Residual value is often referred to as "salvage" value. However, in the case of land, it seems awkward to refer to value of land at the end of a project as "salvage" value. Thus the more general term, "residual" value is used.

Time-slice projects can involve some serious problems in terms of identification and valuation of inputs and outputs. Such complications can be avoided by combining all directly interdependent activities (time-slices) and appraising them as one project. (The time-slice component of relevance can at the same time be analysed separately in terms of its incremental costs and benefits, such as discussed earlier).

There are often time-slice projects that involve expenditure of funds for a few years of an on-going programme, with benefits occurring many years after the "project" is finished in an administrative sense. The question arises as to how to handle such projects. The answer is clear. All costs up to the point at which the output from the project occurs must be included in the economic analysis and the outputs must also be included, even if they occur a number of years after the administrative life of the project has terminated. In other words, the economic analysis deals with a project as including all the inter-related costs and benefits associated with achieving a given purpose or output.

### 3.3.3.2 Vertical interdependencies between separate projects

In some cases, meaningful decisions about one project cannot be made separately from decisions regarding other projects. Thus, they need to be combined as components of one project. Specifically, the output of one project cannot be valued properly if it only has one use and that is as an input into one other specific project or activity. This case relates closely to that discussed in Section 3.3.2, except here a "project" has been proposed which is in fact not separable from certain other activities. In other words, in defining a project all elements (or components) needed to make the project feasible have to be included. This problem can be illustrated with a simple example.

A country is contemplating establishment of a pulp and paper mill to produce for the local market. There is no current pulp and paper production in the country. All consumption is based on imported paper. As a start, the country planners propose establishment of a pulpwood plantation project. The pulp and paper mill will come "later". This plantation project has to be analysed. A problem then arises since decisions on the plantation project can be made only in terms of decisions concerning the size and type of pulp and paper mill that will be constructed (and when it will be constructed and come on stream to consume the pulpwood output). Further, since there is no market for pulpwood in the country, there is no practical way to value the pulpwood output from the project.

The best way to get around this problem would be to take one step back and redefine the "project" to include both the plantation activities and the pulp and paper processing activities. If this were done, then the dimensions of the plantation component could be better defined in the context of the intended use for the wood output, and the wood could be treated as an input into the processing activities rather than as a project output that is difficult to value as such. The output of the project in this case would be paper.

If the analyst runs up against this type of situation, the best he can do is to suggest that the separate projects be combined into one, or if that is impossible, then merely look at the cost side of the wood production. Of course, if there is an alternative use for the wood from the plantations, then a measure of value could be derived on the basis of the willingness to pay for the wood in that other use. However, in many cases,



particularly in developing countries where totally new activities are being introduced, such alternative uses do not exist.

Since this problem really relates centrally to the problem of output valuation, it is discussed further in Chapter 7. Here the subject is raised as a point to watch in defining the scope of a project.

There are other interrelationships between various activities which are relevant in defining the best project scope to meet a given objective or purpose. For example, several activities which have initially been defined as independent projects may be complementary in one of several ways. It may be that to take full advantage of such complementarities these activities should be combined into one project. For example, if the residues from a sawmilling project could be used in particleboard production, then consideration should be given to designing a project that includes both. These types of questions and others related to project identification and design are discussed in Part II.

### 3.3.3.3 The special case of the "allowable cut effect" (ACE)

Increasingly, foresters are being introduced to the concept of the ACE and its potential for raising rates of return from plantation projects. The basic concept is that if a country has a non-declining even flow sustained yield policy and has a lot of old growth or mature forest that is not adding any appreciable net increment, then by establishing a plantation, the allowable cut of the old growth can immediately be increased under the assumption that the plantation volume will become available to meet the even-flow constraint in the future. The value of the increased volume of old growth harvested immediately is then attributed to the plantation project as a benefit. Since this benefit occurs immediately, rather than in the future when the plantation wood is merchantable, it tends to increase the present value of the net benefits of the project.

Whether or not this is an appropriate approach to benefit identification depends directly on the assumptions made with regard to policies. If it is assumed that the even-flow sustained yield policy will remain in effect, then the allowable cut effect would appear to be appropriate. This follows from application of the "with and without" concept. Without the plantation project, the additional wood would not be harvested now due to the even flow sustained yield policy constraint. If the allowable cut is an actual constraint (i.e., if there is demand at prevailing prices for more wood than is allowed each year), then with the project the additional old growth will be harvested. Thus, due to the project (and how it relates to policy) the additional wood is made available to society now and this is identified as the benefit due to the project. (Of course, in this case the actual wood output from the plantation in the future is not considered as a benefit due to the project).

A commonly heard argument is the following: Since the wood could be obtained by merely changing the policy, how can the benefits be attributed to the project? The answer goes back to the basic assumptions underlying the measures of value used in the type of economic analysis discussed in EAFF. (See Sections 2.2.1.2 and 2.3). Opportunity costs as defined here relate to opportunities that are actually feasible, given the expected political and social environment which is expected to exist. Any policy could be changed. But the relevant question is: Will it be changed? If the sustained yield even

flow policy is expected to remain in effect, then the ACE is a legitimate approach to benefit valuation, and the appropriate output to identify and enter into the physical flow table is the volume of old growth timber that will be harvested immediately due to the project. In a sense the ACE becomes a way of modifying or circumventing the sustained yield even flow policy impacts.

Another criticism of the allowable cut effect is the fact that certain present wood supply is being substituted for uncertain future wood supply, i.e., what happens if the plantation burns sometime in the future, or if for some other reason all or part of the new plantation wood does not actually become available when planned? These questions have to be considered by decision makers in each case. Application of the allowable cut effect in project analyses is in fact a matter of policy choice, and one which is quite separate from the decision regarding sustained yield policies. If a government has decided to use the allowable cut effect and if the conditions are such that it matters (i.e., if there is a large enough volume of old growth timber to which the ACE can be applied), then it legitimately can be used in economic analyses of projects.

In applying the ACE in identifying outputs, care is needed to analyse the assumption that the quality and use for the plantation grown wood will be the same as the quality and use for the old growth timber which is attributed to the project as an "output". This becomes a judgmental factor. For example, if a fast-growing, low density species is planted and then under the ACE a long fibre, dense species with high use value for structural products is harvested, it becomes highly questionable whether this higher valued present harvest should be attributed to a plantation project that will involve production of wood with a different use and use value. It is because of these types of questions that ACE depends on government policy concerning its use. Some countries use it; others do not. The project analyst generally follows accepted practice in his country, although he can at the same time try to argue for changes in the practice.

The sustained yield/even flow policy and the associated ACE policy are two classic examples of policies that are not designed with maximum economic efficiency in mind. They are, therefore, prime candidates for a policy efficiency analysis, which was discussed in Section 2.3. However regardless of what such an analysis might indicate in terms of the cost in economic efficiency terms associated with policies, they should be considered as given and taken into account when identifying and valuing inputs and outputs in an economic analysis of a project, if they are expected to remain in effect over the life of a given project.



## Chapter 4

### INPUT AND OUTPUT IDENTIFICATION

#### 4.1 INTRODUCTION

After the context of a project alternative has been defined and the scope of the analysis determined, the next step is to identify the effects (or the inputs and outputs) associated with the project. In the economic analysis, any effect which results in an increase in desired goods and services available for society is a "positive" effect (output) and any effect which results in a reduction of goods and services available is a "negative" effect (input). Increases or decreases can relate to either or both quantity and quality of goods and services. The theoretical goal at this stage is to identify all the effects of the project on society. In practice, it is only possible to identify some of them due to lack of available information and lack of time and funds to generate additional information.

For the purposes of identification, a distinction is made between direct inputs and outputs and indirect effects. This is done more for convenience than for any conceptual or theoretical reasons. The terms are defined in relation to the financial analysis and the physical flow tables derived for use in estimating commercial profitability. In this context, direct inputs and outputs are those which enter into the financial analysis (i.e., are directly traded for money in a market) and indirect effects are all those other (often non-market) effects which are not considered in the financial analysis). <sup>1/</sup>

A point to note is that a given effect may be direct or indirect, depending on whether or not it is traded directly in the market in a particular project situation and environment. For example, in one case, fuelwood may be traded in the market, while in another case it is produced and distributed "free" using some quota or other allocation mechanism. In the latter case, it would not have entered into financial accounts as a revenue (receipt). In the former it would have been considered in a financial analysis.

Similarly on the input side, a given input can be direct or indirect in the context of the definitions, depending on whether or not it is paid for by the entity for which the financial analysis is carried out. For example, if the government provides and pays for certain roads required for a private plantation project, then the cost of such would not enter the financial analysis for the private entity for which the analysis is being done. It would still be an input into the project from the economic point of view and should be identified as such. If the private project built the road, even though it was fully paid for (subsidized) by the government, then it would have appeared in the financial analysis. (See Chapter 9 where treatment of subsidies in the economic analysis is discussed.)

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<sup>1/</sup> Indirect effects are often referred to as "externalities" or "spillover" effects.

It does not matter whether an effect is labelled as direct or indirect. The distinction is made for convenience and to remind the analyst that he has to look beyond the financial analysis for effects associated with a project.

With this in mind, the identification procedure suggested here, and discussed in the remainder of the chapter, is as follows:

First, using the physical flow table(s) developed for the financial analysis and/or the various technical studies available for the project, identify direct inputs and outputs. To the extent that separable project components have been identified, divide up the direct inputs and outputs by components. These can be listed in separate physical flow tables for components and added together at a later, summary stage in the analysis (see Section 4.2).

Second, identify the indirect effects due to the project. List these by separable components if possible, as indirect positive effects, if they add to the aggregate quantity/quality of goods and services available for consumption, or as indirect negative effects if they involve reductions in the quantity/quality of goods and services available. Such efforts can again be associated with both quality and quantity changes (see Section 4.3).

In identifying both direct and indirect effects, it is important to distinguish them on the basis of what the resulting information will be used for in succeeding stages in the analysis. Thus, they should be divided and distinguished in categories which make sense from the point of view of valuation and in terms of the types of sensitivity tests which will be included in the analysis. Generally, project activities should not be listed as "inputs", since values will normally be attached to the inputs required to carry out the activities and not the activities themselves. <sup>1/</sup> For example, it is not enough to identify "land clearing" as an input in a plantation project analysis. Rather, "land clearing" can be a heading in the physical flow table, but under it should be listed requirements for various types of labour and supervision, machinery, tools, etc. Similarly, if at all possible, structures that will be constructed as part of the project should be broken down by the component inputs required to build them, and roads should be broken down by labour, machinery, and various materials required instead of just listed as "roads". If this is not done, it becomes difficult at later stages to develop proper values, since it is the inputs which are required to build the roads which are shadow priced or valued.

#### 4.2 IDENTIFYING DIRECT INPUTS AND OUTPUTS

The direct inputs and outputs are generally the most important in terms of total project costs and benefits and are central to the economic as well as the financial analyses of a project. In most analyses of forestry projects, they are the only effects which have been given explicit consideration in terms of monetary values.

Most of the direct inputs and outputs which are relevant for the financial analysis are also relevant for the economic analysis. Commonly, the identification of such effects is done at the same time for both analyses.

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<sup>1/</sup> Summary tables may present costs by activities, but these summaries can only be derived by estimating the inputs actually required to implement them.

#### 4.2.1 Direct Inputs

The main source of information on direct inputs will be the engineering and other technical studies available at the time of the economic analysis. The various input categories for the project and its separable components are defined and the relevant quantities are then entered in physical flow tables by each category and for the year(s) in which they are needed. The listing of inputs is done in a form that will facilitate valuation at a later stage. The types of main input categories which are relevant for most projects are shown in Table 4.1. The table provides only a convenient checklist which will have to be expanded both in breadth and detail for particular cases. <sup>1</sup>

Input categories shown in Table 4.1 can be listed in a number of different ways by subcategories related to (a) phases of the project, (b) activities or components within phases, and (c) by foreign and domestic sources for each phase and activity. There may be three major phases:

- project planning (preinvestment phase);
- investment phase (construction i.e., fixed investment and preproduction capital costs);
- production phase.

Activities within each phase will differ with the project being analysed. Production activities (or components) will often include raw material production, processing activities, storage, sales and distribution. In many types of forestry projects it makes little sense to separate the investment phase from the production phase for the economic analysis. It is often preferable to treat the two together and distinguish activities such as site preparation, planting, crop maintenance and management inputs during the growing period and harvest and transport. The only general rule for establishing appropriate categories is that the analyst classify inputs in a way that makes sense in terms of the objective of the analysis, i.e., the derivation of the total value flow table and the measures of project worth. Some examples for specific projects are given later.

If balance of payments effects are of particular concern to decision-makers, then all inputs can be listed separately by domestic and foreign sources.

The amount of detail required for the tables depends on the stage in the planning process. During initial phases, when project identification, preparation and design is the main focus, the analyst may start with very general, rough estimates which can be used to make initial comparisons between alternative technologies, scales, locations, etc. As attention focuses on one alternative design, the detail required increases. When the alternative has been designed and prepared, the analyst may wish merely to summarize inputs by categories and activities or components with headings such as shown in Table 4.1. The final appraisal document should not contain excessive details. Rather, reference can be made to the supporting studies, so the decision-maker can find details if so desired. He should not be forced to wade through them to put the logic of the project and its appraisal clearly in perspective.

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<sup>1</sup> cf. FAO 1973, UNIDO 1978, OECD 1968.

Table 4.1

CATEGORIES OF DIRECT INPUTS<sup>1/</sup>

Inputs Category	Comments
1. Manpower	A distinction should be made between unskilled and skilled labour, staff, consultants, etc.
2. Land	Land can be further broken down into categories to reflect different uses and values.
3. Equipment	Working tables will be needed with detailed listings of equipment required and timing of such requirements. In the final tables, some major subcategories can be used as derived from the detailed tables. Replacement requirements have to be included.
4. Raw materials	Such items as utilities (energy, fuels, etc.), wood raw material, if purchased, chemicals and other purchased inputs, and water can be listed separately. <sup>2/</sup>
5. Structures and civil works	If structures and civil works (housing, roads, other facilities such as dock and harbour services) are purchased or rented outright, then they would appear as separate inputs. However, if the project itself involves construction of such works, then they should not be listed as inputs as such. Rather, the component labour, land, equipment and raw material requirements for constructing them are listed.

Note: See text for further discussion of how these inputs should be listed by subcategories related to (a) phases of the project, (b) activities or separable components, and (c) foreign and domestic sources.

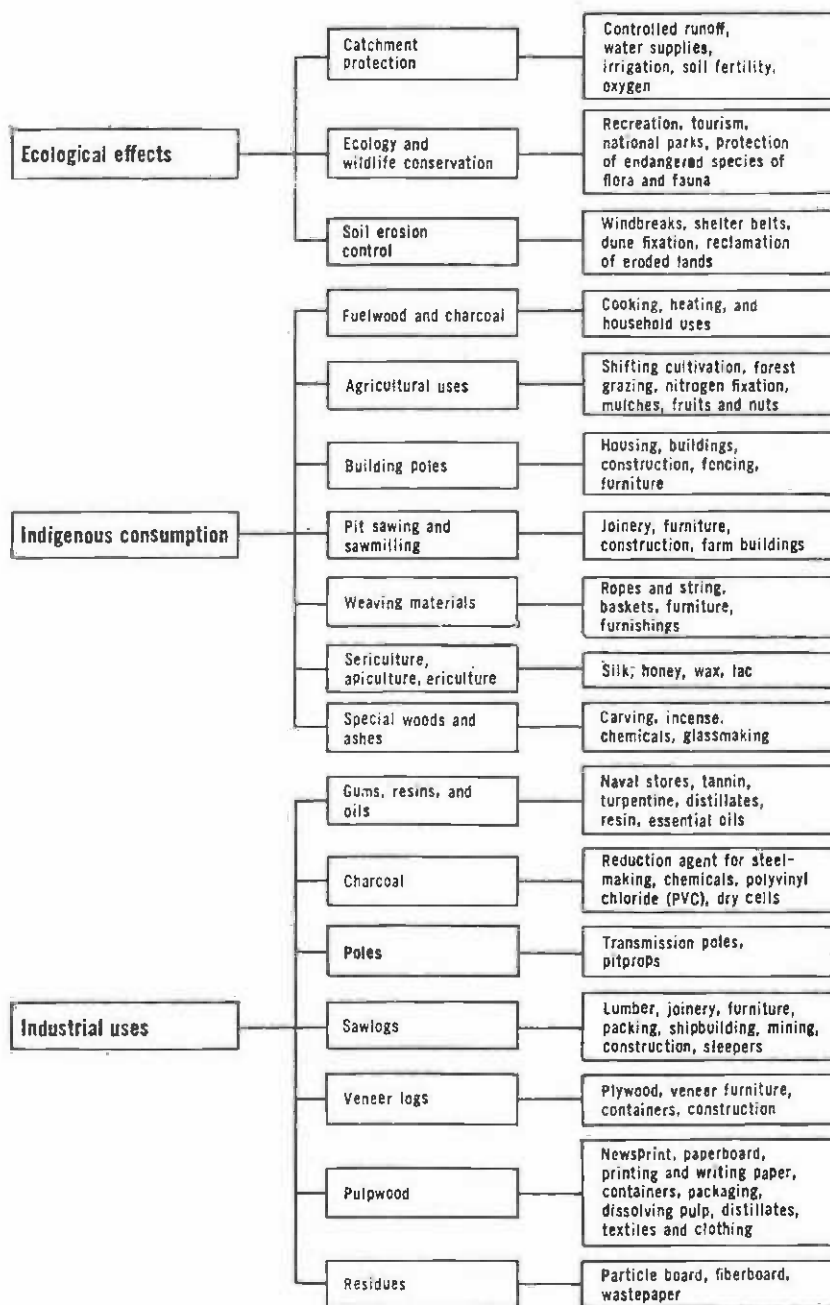
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<sup>1/</sup> As mentioned in the text, depending on the situation some of the listed inputs may be indirect instead of direct, e.g., in the case of infrastructure such as roads, community facilities, etc. It all depends on whether or not they are directly paid for by the project entity for which the financial analysis is being done.

<sup>2/</sup> If raw materials, such as wood, are produced as part of the project itself, then the component input requirements are listed rather than the raw materials such as round-wood. See text.

Table 4.2

POSSIBLE DIRECT OUTPUTS FROM FORESTRY PROJECTS



Source: World Bank, Feb. 1978.

#### 4.2.2 Direct Outputs

Direct outputs can also be derived from the basic technical studies and from market studies which are a basic element for projects involving direct outputs. Some main categories of direct output types which can be associated with forestry projects are shown in Table 4.2. Depending on the project circumstances, some of these may be indirect instead of direct outputs, particularly in the case of "ecological effects".

There are two types of potentially direct project outputs which are not shown in Table 4.2 and which sometimes become difficult to identify properly. These can be labelled as "cost savings" and "losses avoided". Some examples will illustrate them. Assume a project designed to reduce log hauling costs by improving a logging road. This is a cost savings type of project and the benefit from the project is the difference in hauling costs with and without the project, i.e., the cost savings. The "output" can be specified initially in terms of resources saved, i.e., reduced requirements for trucks, maintenance labour and spare parts, etc. These physical measures are then transformed at the valuation stage to monetary measures of costs saved. Similarly, a watershed protection project may be contemplated to reduce the cost of dredging of a reservoir that provides flood protection and regulates water flows for dry season use. The reductions in dredging equipment, labour, etc., required are identified as the physical measures of "output" or resources saved. (They are then valued in the next stage on the basis of what these released resources can produce elsewhere, i.e., the willingness to pay for the additional goods and services which these released resources can now produce in alternative uses). In both cases, the relevant final comparison is between costs of alternatives, i.e., "cost savings" projects are considered in terms of the third condition for efficiency or by applying a least cost analysis such as explained in Section 2.2.4.

It should be noted that cost savings projects can also be oriented toward preventing future cost increases. For example, the relative price for labour may be increasing and a project could be proposed gradually to reduce the labour input into a particular activity so that total unit costs can be maintained at present levels or at least prevented from increasing at a rate that would occur if the project were not undertaken. This type of project is closely related to projects designed to prevent losses.

In the case of projects that are aimed at preventing losses, the relevant comparison is between the value of the losses avoided and the costs of avoiding the losses through the project measures. Thus, at the identification stage, outputs are identified in terms of physical losses avoided. The approach is illustrated in a FAO document for a watershed protection project which involves land use improvements to reduce siltation in a reservoir. <sup>1/</sup>

Reduced siltation results in reducing the loss of storage capacity, which in turn results in reducing the downstream losses which are caused by the decreasing water availability from the reservoir. The losses avoided or benefits in this case are identified in terms of such downstream uses (since these are what society values, not the capacity of the reservoir itself).

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<sup>1/</sup> Example no. 2 in Gregersen and Brooks paper in FAO, forthcoming.

Similarly, forest protection projects are aimed at reducing the risk of loss due to fire, insects, disease, etc. In these cases the probability of loss without the project and the reduced probability of loss with the project have to be estimated. The difference is the "output" or benefit due to the project. This task is appropriately done by the technical experts. Once such information is available, the task of the economist is to take the appropriate estimates of physical losses avoided and attempt to value them in a time context. Since the estimates of physical losses avoided will be subject to probabilities so will be the values of these losses avoided. At the input and output identification stage, there are no particularly unique problems involved, although analyses involving probabilities are always more complicated to carry out (and require more data) than those involving the assumption of certainty.<sup>1/</sup>

Finally, there is the situation mentioned earlier where a project involves both losses avoided and production (output) increases over present levels. For example, assume a situation where an area of hill land is deteriorating due to erosion taking away the productive top soil. It has been estimated that the production from the land will decrease over a 20-year period from level A to zero (point B) in figure 4.1. Now a project is proposed to build up production to level C in ten years. The appropriate measure of output is area ACDE, plus the loss avoided, or area AEB. If only the production increase over present level were included, it would understate the output or benefits of the project.

If production is expected to continue at level C beyond the 20 year life of the project, then the benefits or output of the land beyond that period should also be included in the project calculations net of any additional costs required to maintain production at that level. In other words, at the end of the project period, there is a residual value (such as explained in Chapter 3) that can be attributed to the project. It can be seen that application of the 'with and without' concept is critical to proper benefit identification in these cases.

Table 4.3 provides an example of a physical flow table for a forestry project, showing how direct inputs and outputs are organized and how inputs are listed in the year(s) in which they are used and outputs by the year(s) in which they occur. An additional example is provided in Chapter 12.

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<sup>1/</sup> The assumed probabilities can be tested in the sensitivity analysis (see Section 2.2.5 and Chapter 10).

Figure 4.1

SOIL PROTECTION BENEFITS

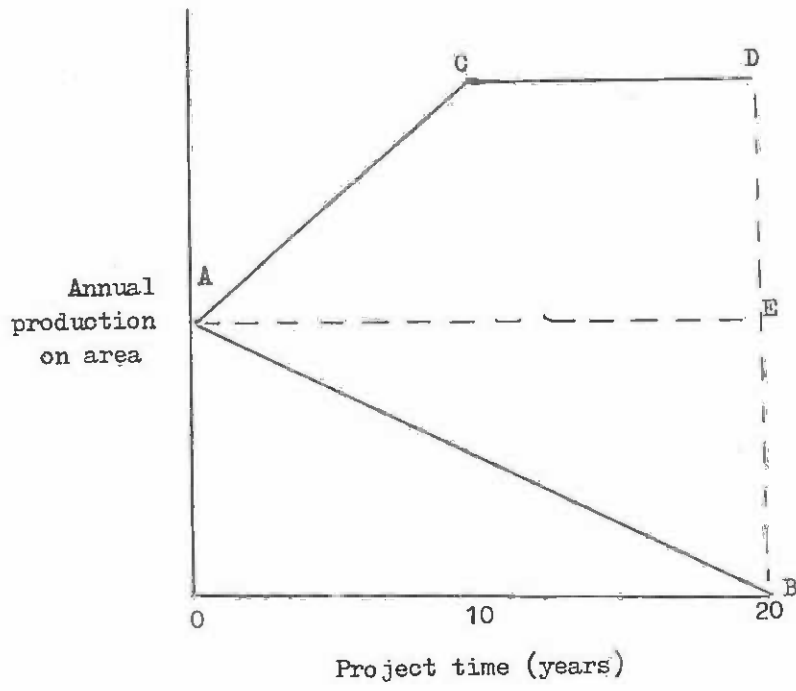




Table 4.3

## TIMING AND MAGNITUDES OF PHYSICAL INPUTS AND OUTPUTS

for Assumed "Average" 10 ha Farm <sup>1/</sup>

Item	Units	Years															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<u>Inputs</u>		<sup>2/</sup>															
Land preparation lining, digging and planting	m.d.	74	74	74	74												
labour	m.d.	38	38	38	38												
seedlings	no.	1200	1200	1200	1200												
Replanting																	
labour	m.d.	16	16	16	16												
seedlings <sup>3/</sup>	no.	300	300	300	300												
Fertilization																	
labour	m.d.	25	25	25	25												
fertilizer	kg.	4	4	4	4												
Weeding	m.d.	68	68	68	68			34	34	34	34	34	34	34	34	34	34
Singling	m.d.							25	25	25	25	25	25	25	25	25	25
<u>Output</u>																	
Pulpwood stumpage m <sup>3</sup> (r)								184.1	205.8	205.8	227.0	227.0	247.8	247.8	268.2	205.8	

<sup>1/</sup>From Case Study No. 1. See FAO 1979.<sup>2/</sup>man days<sup>3/</sup>Assumed that 25 percent would have to be replanted on the average.

#### 4.3 IDENTIFYING INDIRECT EFFECTS

An indirect effect was defined earlier as any change in the quantity or quality of goods and services available to society due to the project which does not enter into the accounts for the financial analysis, since it is not directly bought or sold in a market by the financial entity for which the financial analysis was done.

A first point to note about indirect effects is that many of them cannot be meaningfully valued in monetary terms. However they should still be identified in quantitative physical terms, if possible, and otherwise at least specified in descriptive terms. Regardless of whether or not they have an identifiable monetary value, they may be important in the broader context of decision-making, where many considerations other than monetary values are important.

A second point is that whenever an indirect positive effect is identified, the analyst should be careful to search for any corresponding indirect negative effect (cost) required to bring about the positive one. It is only the net indirect effect that can be attributed to the project. The following discussion will illustrate this point.

##### 4.3.1 Indirect positive effects

The following are the main indirect positive effects of concern in forestry projects:

- soil and watershed protection and wildlife and recreation habitat improvements which are not directly traded in a market and thus are not accounted for in the financial analysis;
- benefits accruing to society due to the fact that the project has trained persons to be more productive or has demonstrated the viability of some activity which is then undertaken by entities outside the project boundaries;
- cost savings which result in output expansion and increased use of excess capacity outside the project, but due to the project activities.

Some examples of each type follow -

Soil and watershed protection and wildlife recreation habitat improvements. Many projects involving establishment and/or management of forests for wood production also produce certain indirect effects in the form of improvements in soil or watershed protection "services" from the land (forest) and, possibly, improvements in wildlife habitats and recreation opportunities. In rare instances, these services are paid for directly to the project and thus enter the financial analysis as direct outputs. (See Section 4.2.2). However in most cases they are not directly priced in a market.

Quantification of such indirect effects depends on the availability of input/output information which describes the changes in output that will take place with a given

forestry activity. In the absence of such information, there is little that the economic analyst can do to quantify them. He can describe them to the extent possible and point out that they will likely result.

There are some studies which have been carried out for specific regions which link various forestry activities to watershed protection changes and further link these changes to consumption changes downstream. <sup>1/</sup> The transferability of such specific results to a broad range of project situations may be possible. The best that can be done is to rely on the judgments and figures provided by the technical experts. If such effects have been identified in quantitative terms, they enter the analysis in exactly the same way as any other quantified input or output.

Training and demonstration effects. A project may involve training of labour to increase its productivity. The training expenses are likely to be direct inputs into the project; however, the indirect effects due to the training are not accounted for in the financial analysis, since the project financial entity does not collect the increased revenues made possible by use of this better trained labour in other projects when the project is terminated or the labour leaves the project for other employment. It is very difficult to quantify this benefit and particularly to value it. Thus, it is generally included in the analysis in a descriptive fashion, for example, "100 labourers will be trained to operate power saws and this will increase their productivity in future years". The training expenditure also results in benefits in the form of increased output per unit of input in the project itself. These should be accounted for in the direct output measures for the project.

Similarly, in many forestry project situations, there can be significant demonstration effects. For example, a public project may involve support for establishing fuelwood plantations in selected communities. Once surrounding communities see the benefits to be derived from such plantations, they may on their own undertake to establish such plantations to meet their increasing requirements for fuel and/or to reduce the increases they are experiencing in fuel costs. The net benefits resulting from this type of demonstration effect can appropriately be attributed to the project being analysed (even though the additional plantations resulting due to the demonstration effect are totally outside the project scope). The 'with and without' concept can be applied to see which net benefits would not have been expected to result without the project. They can legitimately be attributed to the project. It should be emphasized though that it is only the net benefits that can be attributed to the project. If the additional outputs are to be attributed to the project, then care should be taken to attribute as inputs the resources and goods and services needed to bring about the additional output.

Cost savings and increased use of excess capacity in other sectors. If a forestry project results in production of lower cost wood than previously (i.e., more efficient wood production) there may be an increase in the use of wood in existing idle processing capacity outside the project boundaries. (The increases will be due to the fact that the price of the final product can be lowered since costs are lowered; demand for such products will increase because of the lower price, and therefore processing can increase to meet this demand.) The indirect benefits in this case will be the increased output resulting outside the project less the costs (the inputs) required to bring about

<sup>1/</sup> FAO, forthcoming. Paper by Gregersen and Brooks.

this new production.

Similarly, a road project designed to reduce the cost of delivered wood (i.e., increase efficiency in wood delivery) may have indirect effects beyond the project. Such improved roads may be used by farmers who can lower their effective costs of delivery, thereby lowering farm product prices, which can result in increased demand and expansion of production (i.e., goods available for society to consume). Such increases can be attributed to the project in question (the road project) net of any increases in costs (use of resources) required to bring about these production increases. The appropriateness of attributing these net benefits can again be ascertained by applying the 'with and without' concept.

This type of indirect positive effect should be distinguished from what is generally called a "multiplier effect", i.e., a short run increase in income generated outside the project when surplus capacity in an economy is activated by additional rounds of spending resulting from investment in the project. Forest recreation projects are often justified in terms of the additional expenditures which will occur in the communities adjacent to the recreation project. From a national point of view, such "benefits" need to be questioned. In most cases they are merely transfer payments in the sense that the expenditures would occur elsewhere in the absence of the project. Again, application of the 'with and without' concept is critical in identifying true net indirect positive effects associated with such additional expenditures. They generally can be justified only in cases where the funds available for the project could only be used for the project being analysed and not for any other project in the economy. This would be the case for tied grants and loans which could not be used for anything other than the project in question. In this case, it still only is the net effect which should be included, i.e., there may be additional non-tied expenditures - outside the project boundaries - which are required to achieve the benefits or indirect positive effects in question.

#### 4.3.2 Indirect negative effects

There are also certain indirect negative effects which may be associated with forestry projects. The main categories are:

- pollution or negative environmental effects not accounted for by direct costs to the financial entities involved;
- increases in costs outside the project boundaries which influence production (cause decreases) elsewhere in the economy;
- infrastructure costs not included as direct costs, but required for the project.

Pollution and negative environmental effects. The common example given is a pulp mill that pollutes water that is put back into rivers, thereby reducing the quality of water downstream and consumption benefits of downstream water users. Similarly, such a project may reduce air quality. Often a measure can be derived of the amount of pollutants which the mill discharges into a river or lake. In some instances such increased pollution levels can be associated with losses in consumption benefits (e.g., loss of fish catch, increased health problems, etc.). Quite often, however, this type of indirect negative effect is merely described in the project document without making any attempt to value it since the necessary data on input-output relationships are not

available. Increasingly, pollution is being internalized in projects through the use of effluent charges or requirements for pollution control equipment or project water purification expenses. In these cases, such effects enter the project analysis as direct effects or inputs, since they involve financial costs and enter the financial analysis.

A similar situation exists with most other types of indirect negative effects involving deterioration of the environment, for example, soil deterioration and watershed benefits foregone due to a project that involves manipulation of vegetation upstream. Considerable research and study has been devoted to watershed problems and potentials for improving watersheds through forestry activities. There are some estimates of quantitative relationships available which may be usefully transferred from one situation to another. The judgment on transferability should be made by the technical personnel familiar with watershed management and the project.

Cost increases affecting production of non-project output. In some instances, a forestry project may result in the prices for certain inputs being increased. Such increases will affect other producers who have to curtail production. Reduction of their production releases resources, some of which may not be usable in producing other goods and services. If there is a net loss in the value of goods and services available to society due to such a project effect on prices, then this is legitimately attributed to the project as an indirect negative effect. Such a net loss would result if some of the resources released had no alternative uses and thus remained idle when the project-caused cost increases put them out of work. For example, if the project demand for imported machinery results in the price for such machinery increasing to the point where certain other activities cannot afford it and they have to shut down, then they release labour and other resources that may not be able to find alternative employment. The reduced output value from the activities that shut down, less the new value produced by those released resources which find alternative uses, would be a measure of the indirect cost of the project being analysed.

Infrastructure costs. As mentioned earlier, it is common that some of the infrastructure - roads, community facilities, power generation and communication facilities - which have to be produced for the project are not paid for directly by the financial entity for which the financial analysis is being undertaken. In such cases, the costs associated with such infrastructure have to be included in the economic analysis as indirect negative effects of the project, to the extent that their provision involves use of resources that could have been used in the absence of the project to produce other goods and services valued by society. Both capital and operating costs associated with such infrastructure have to be considered. At the same time if certain infrastructure items will be used outside the project boundaries, then allowance should be made for such use as an indirect positive effect. Again, the "with and without" test is applied to infrastructure.

If infrastructure is produced and operated directly by the project entity or entities for which the financial analysis is undertaken, then it should have been included in the financial analysis, even if it is entirely subsidized by the government or some other entity not considered in the financial analysis. The exception is if the financial analysis netted the project expenditure against the subsidy. In this case the cost to the financial project entity would not appear in the financial accounts. In such cases, the cost should still be included in the economic analysis. The cost of the infrastructure is real. It is impossible to generalize on how such subsidies and infrastructure expenditures are handled in the financial analysis. In each case the analyst preparing the economic analysis has to look at the project's financial accounts and make sure that costs to society are included

and subsidies are appropriately treated as "transfer payments" as suggested in Chapter 9.

Common categories of infrastructure which the analyst should examine critically include those shown in Table 4.4.

#### 4.3.3 Additional points: indirect effects

What is to be done in terms of identification of indirect effects? There is no one best way to proceed, since there are few ready and available sources of information on most of such effects. Success in identifying indirect effects depends a great deal on experience and knowledge of relevant interrelationships based on study of other projects and technical literature. Interaction between various technical experts is essential, since identification of most indirect effects depends on information related to technical relationships.

Given some general ideas on potential indirect effects of given types of activities the analyst can proceed to estimate whether any given type will be relevant for the particular project he is analysing. If he decides that it is likely to be relevant, then he can discuss with technical experts the likely physical magnitudes of the effects (both positive and negative) and list these in a separate table (or tables). Where it does not appear possible to estimate magnitudes (quantities involved) the analyst should still develop a statement describing the nature of the effect expected in as specific terms as possible.

Some indirect effects will be accounted for in the economic analysis through shadow pricing of direct inputs and outputs and will, therefore, not appear as separate cost or benefit items (see Chapter 5). For example, if water used in a pulp mill is shadow priced to reflect its true opportunity cost, then this shadow price (cost) should incorporate the value of opportunities for using clean water downstream that are foregone due to the project polluting downstream water. Since identification and valuation are closely inter-related, in practice the two steps are often carried out simultaneously, i.e., a given effect is identified and then valued at the same time. The distinction between identification and valuation in EAAP is made for clarity of exposition and to emphasize the point that even though a given effect cannot be valued in monetary terms, it should still be identified and specified as explicitly as possible.

Table 4.4

INFRASTRUCTURE CATEGORIES CHECKLIST FOR ECONOMIC ANALYSIS

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Rail (track and rolling stock)  
Road (highways and vehicles)  
Port  
Shipping  
Logging facilities (vehicles, equipment, roads)  
Power (generation, distribution)  
Telephone  
Freshwater supply  
Stormwater drainage  
Sewerage (drains and treatment)  
Housing  
Education (schools)  
Health (hospitals)  
Government Agencies (post office, tax department, justice, etc.)  
Churches  
Recreation facilities (sporting and cultural)  
Commercial facilities (shops, banks, hotels, etc.)

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Source: R.G. Steele, FAO internal working paper (restricted), 1979.

#### 4.4 LOCATION RELATED INPUTS AND OUTPUTS (EFFECTS)

As mentioned earlier, inputs and outputs or effects associated with a project should be identified in such a way that the process of valuation is facilitated. Since many inputs and outputs will be valued directly or indirectly on the basis of (market) prices that are established in locations other than those where projects produce outputs or use inputs, it is important to pay special attention to the handling, marketing and transport functions and properly to identify the inputs used in these functions due to the project or saved by producing an output in the project rather than importing it or producing it somewhere else in the domestic economy. This category of effects relates closely to infrastructure inputs discussed in Section 4.3.2.

As in the case of infrastructure (and other inputs and outputs), location related effects can be identified as direct inputs and outputs or as indirect effects depending on the nature of the project and the financial analysis being carried out. The important point is that they be included in the analysis and not that they are classified correctly as direct or indirect.

Location related effects which need to be considered can be divided into general ones, i.e., relevant for all types of projects and specific ones, i.e., specific to certain types of projects which involve substitutions (as explained below). In both cases, they only arise when (a) the value measure (price) which is to be used for a direct project input is established in a market, or at a point which is different from the point of use of the input in the project, and (b) the value measure (price) to be used in valuing a project output is established in a market or a location that is different from the point of use of the output and/or different from the point of production of the output. Thus, this type of effect is one that can only be identified properly in the context of the valuation system which will be used. This emphasizes the point made earlier that in practice identification and valuation often have to be carried out simultaneously for some types of project effects.

##### 4.4.1 General effects

(a) For all direct project outputs the analyst needs to identify inputs required to handle project outputs and move them to their intended point(s) of consumption (or export) at which their values are determined. For example, in the case of an export output, it will be valued on the basis of its export price, generally determined at the port of export. (This will be discussed in the following chapters). In this case, the inputs - handling and transport - associated with getting the output from the project point of production to the port in which the export price is determined should be included as inputs in the project accounts (the physical flow table and, later, the value flow table).

(b) In the case of all direct inputs used in a project, the additional inputs required to handle and to move such direct project inputs (resources, goods or services) from their point(s) of origin (or the location(s) at which their prices are determined) to the point(s) of use in the project need to be included in the project accounts. For example, in the case of imported inputs, which will be valued on the basis of an import price established at the port of import, the handling and transport inputs from that port to the point(s) of use in the project need to be included.



4.4.2 Specific effects

In addition to these two general considerations (which should be considered for all inputs and outputs) there are two special cases where a project can result in positive effects (cost or resource savings) which must be considered and identified where relevant.

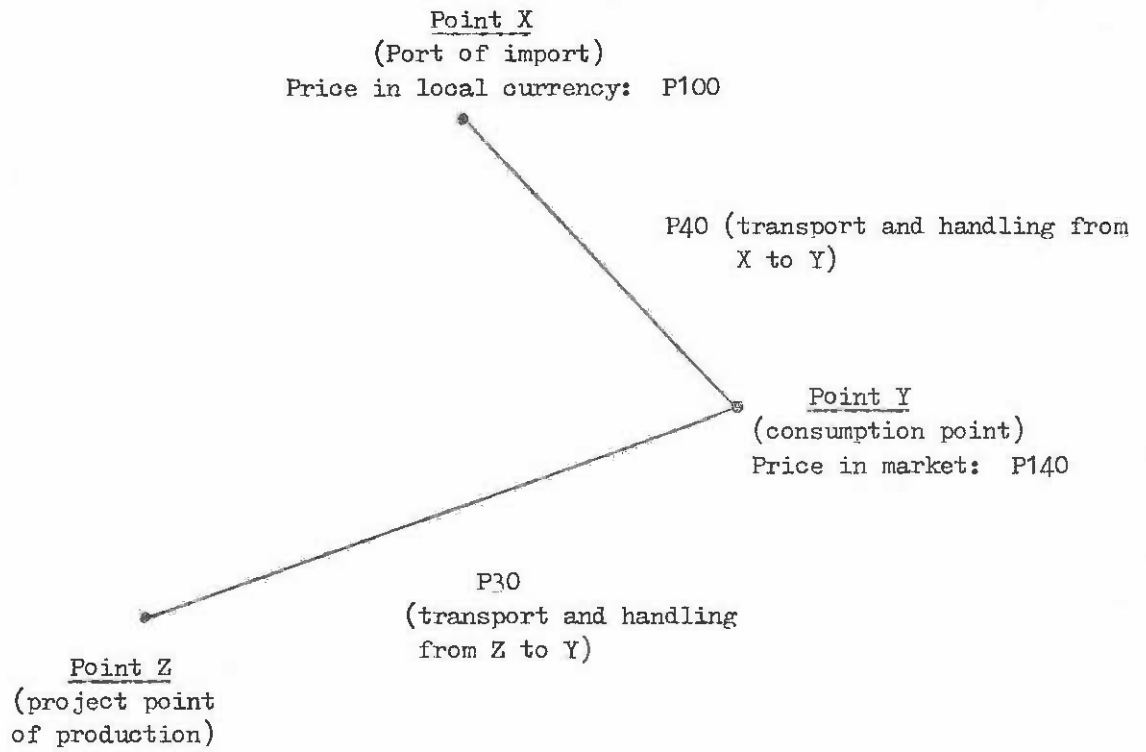
(a) In the case of a project output which substitutes for an import or a domestically produced output, the project will often result in a savings of handling and transport inputs which would have been incurred in the absence of the project. These inputs are saved because the good or service being substituted by the project output will not have to be handled and transported from its point of origin (e.g., port of import) to the market(s) or point(s) of consumption in which its local market price (or w.t.p. for it) is determined. For example, in the case of import substitutes which will be consumed in market A, it will no longer be necessary to handle and transport the import from the port of import to market A. The resources saved due to the substitution are a positive effect of the project, if they have productive uses elsewhere in the economy. This will be determined in the valuation stages. At the identification stage such resources saved due to the project should always be included. (Of course, the effects described under (a) in Section 4.4.1 would also be included).

An example will illustrate this point. Assume that an import price of a good at the point of import (converted to local currency equivalent) will be used to value the output of a project that will substitute for the import. The local currency equivalent at port of import (point X in Figure 4.2) is P100. Adding on marketing costs (transport and handling, etc.) to the point of consumption (point Y in Figure 4.2) a local price of P140 is arrived at (which is here assumed to equal the w.t.p. for the output at the point of consumption). It can be seen that in addition to saving the local currency equivalent of the import price, the additional handling and transport costs of P40 from the port of import (point X) to the market or consumption point (Y) is also saved. This can be legitimately attributed to the project as a separate positive effect (resource savings) in addition to the direct import cost savings which will be used to value the direct project output. Of course, by producing the output at project location X, the transport and handling costs of P30 between point Z and the market (point Y) are also incurred. This additional requirement for transport and handling services is taken care of under (a) in Section 4.4.1 as an additional cost (or input requirement) due to the project.

(b) In the case of a project which uses as an input a local resource or locally produced good or service which would have been exported in the absence of the project, use of the input in the project will result in savings in additional resources which would have been required to handle and move the particular project input in question from its point of origin to the port of export to point(s) of use in which its price is determined. These savings of additional inputs are legitimately identified as positive indirect effects due to the project in the stage being discussed here.

Figure 4.2

IDENTIFYING LOCATION EFFECTS: IMPORT SUBSTITUTES



An example will illustrate this point. Assume conditions as shown in Figure 4.3. The local currency equivalent of the export price which would have been received for the input if it were not used in the project is P200 at the port of export (point M in Figure 4.3). <sup>1/</sup> This value is used as the basis for valuing the opportunity cost of the input being used in the project. However, by using the input in the project rather than exporting it, the P50 worth of transport and handling resources which would have been required to get the resource, good or service in question from its point of origin (point N in Figure 4.3) to the port of export (the point at which the P200 is determined) is saved. This can legitimately be attributed to the project as an indirect positive effect. Of course, the additional cost of P30 required to get the input from its point of origin (point N) to the project point of use would also be included as additional direct inputs due to the project. (This follows from application of the 'with and without' concept and is taken into account under (b) in Section 4.4.1.

It should be noted that the P50 of resources saved by not having to move the input (resource, good or service) from its point of origin to the port of export from which it would have been exported could also have been netted out of the P200 to arrive at the net opportunity cost associated with using the input in the project rather than exporting it. Both approaches, treating the transport and handling resources (valued at P50) as separate project effects, or netting them out of the P200 - would give exactly the same result. Thus, the question is really which of the two approaches provides the best information for decision makers or causes the least confusion. It is felt that the former approach causes the least confusion and the least chance for making errors in arriving at the final picture of direct and indirect costs and benefits associated with a project. The recommended approach results in a more systematic process of identification and valuation of all project effects.

In both cases (a) and (b) in Section 4.4.2 the need to include the effects mentioned arises from the nature of the measures of value which are commonly used and the fact that such measures are determined in locations which are different from either the project location or the point(s) of consumption (or export in the case of (b)). In all cases, whether or not the identified additional inputs or indirect positive effects will be assigned a positive or zero value depends on whether or not the additional inputs used or saved have any alternative productive uses (i.e., opportunity costs). This is determined in the valuation stage.

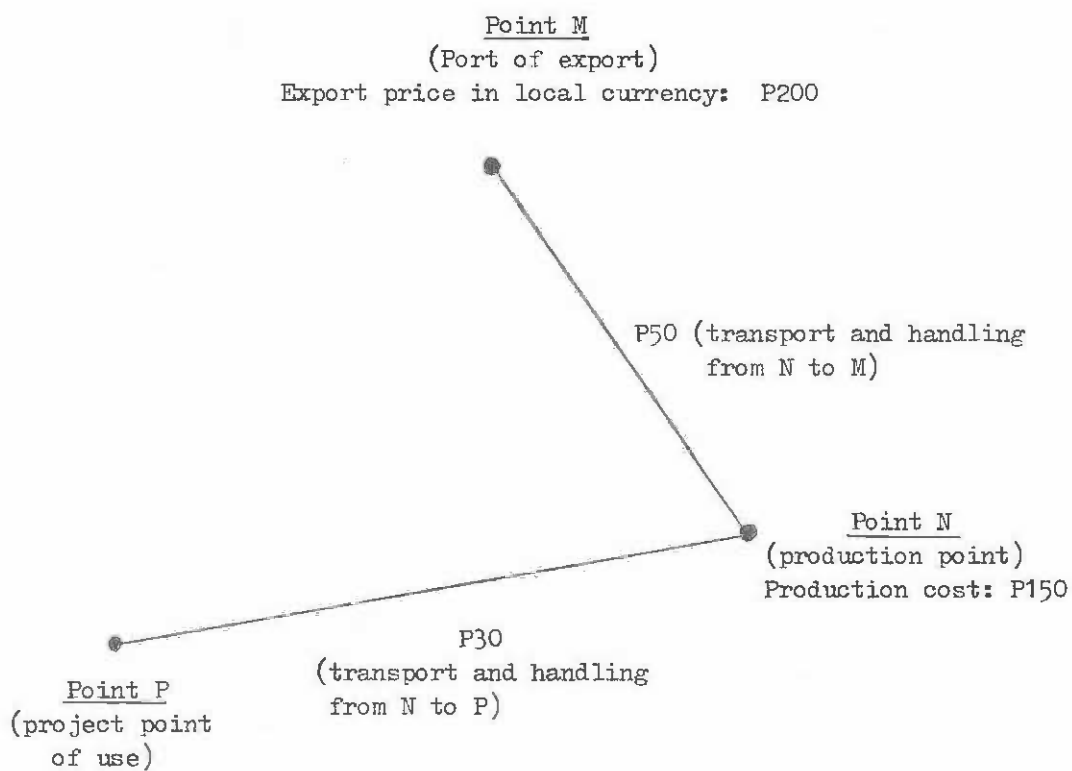
In the chapters that follow, which deal with valuing inputs and outputs, it will be assumed that location related project effects have been explicitly recognized and identified in this earlier stage in the analysis and thus will be valued independently of values assigned to direct project inputs and outputs. This approach has the advantage of clearly pointing out handling and transport inputs and not confusing decision-makers by netting out transport and handling costs from established prices used to value direct project outputs or inputs.

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<sup>1/</sup> Derivation of the local currency equivalent will be discussed in Chapters 5 and 8.

Figure 4.3

IDENTIFYING LOCATION EFFECTS: PROJECT INPUTS WHICH WOULD HAVE BEEN EXPORTED



## Chapter 5

### VALUING INPUTS AND OUTPUTS

#### 5.1 INTRODUCTION - THE APPROACH

Once inputs and outputs have been identified, the next step is to develop values for them. Chapters 5-8 are concerned with the process of determining appropriate values to use in an economic analysis.

In a financial analysis, the valuation process is fairly straightforward and market prices are used for all inputs and outputs. Non-market effects (externalities or indirect effects) are not valued in the financial analysis, since they do not enter into the physical or cash flow tables of the financial entity.

The valuation process is more complex for an economic analysis, first, because some market prices for direct inputs and outputs may not be appropriate measures of economic value as defined in Chapter 2; and, second, because indirect effects are considered to the extent possible.

Market prices should be used in the economic analysis to the extent that they reflect economic values. Therefore, the first logical step is to separate out all those inputs and outputs which are associated with market prices and then to determine whether existing market prices provide appropriate measures of economic value for those inputs and outputs. The remainder of this chapter discusses this step. In those cases where market prices are acceptable, the next step is to project them into the future (since a project involves future periods) and to make adjustments in prices for market location relative to the project and for inflation. These points are covered in Chapter 6. In the case of market priced inputs and outputs for which market prices do not provide acceptable measures of economic value, shadow prices have to be developed. Also, an attempt has to be made to derive shadow prices for the indirect effects associated with the project. Shadow pricing is discussed in Chapter 7 (for outputs or benefits) and in Chapter 8 (for inputs or costs).

Before the adequacy of existing market prices as measures of economic value can be usefully discussed, it is necessary to have clearly in mind the meaning of the terms "market prices" and "economic values". These are defined in the following section.

#### 5.2 MARKET PRICES AND ECONOMIC VALUES - SOME DEFINITIONS

A market price is the amount of money which a buyer (consumer) has to pay at a given time in a given market for a good or service, or the amount of money which the seller of a good or service receives in the market. A market price is determined by the interaction of (a) consumers' willingness to pay for a good or service (demand), (b) suppliers' costs and willingness to sell it (supply), and (c) policies which constrain the free interaction of supply and demand. Regardless of how policies, market conditions, and other

considerations affect the final magnitude of the market price, the basic point is that it becomes a fact once a transaction has taken place.

"World market prices" are particularly useful in an economic analysis as a basis for valuing inputs and outputs that are traded in international markets. There are two main types, namely, export prices (FOB prices) and import prices (CIF prices).

Export or FOB price. The term "FOB" means "free on board" and includes all costs to get goods on board the ship in the harbour of the exporting country, that is, project gate price, local marketing and transport costs, local port charges and export tariffs and subsidies.

Import or CIF price. The term "CIF" means "cost, insurance, and freight" included. It is defined as the price of the good delivered on the importing country's dock and includes the cost of the good at point of export (i.e., FOB price) freight charges to point of import, insurance charges and in some cases the cost of unloading from ship to pier at the port of the importing country. It excludes import duties and subsidies, port charges at point of entry (e.g., taxes, handling other than unloading, storage and agent fees), and local marketing and transport costs.

As indicated in these definitions, there is a direct relationship for a given good between FOB price in an exporting country and the CIF price in the importing country. Sometimes the analyst is dealing with a situation where a project output is intended for export, but it is not yet being exported from the project country. The analyst must then determine the most likely port of import for the project output, find the CIF price at that port and work backwards to estimate a FOB price in the project country. At the same time, there is no necessary direct relationship between the CIF price (import price) and the FOB price (export price) for a given product in a given country. Further, in a competitive world market situation, it is never possible for the FOB price in a given country to be higher than the CIF price for the same good in that same country, if both are adjusted to a common border point in the country. It is possible for the FOB price at a port on one side of the country to be higher than the CIF price at a point of entry on the other side of the country. But when adjusted to a common location and in a competitive situation, FOB can never be higher than CIF.

The basic measure of economic value adopted here is consumers' w.t.p. for goods and services, given existing policies which affect w.t.p. In the case of inputs or costs, the term "opportunity cost" (OC) is often used. As discussed in Chapter 2, the cost of using an input in the project being analysed is the value foregone by not being able to use it in its next best alternative use, i.e., its OC. However the value foregone is measured in terms of consumers' w.t.p. for the goods and/or services foregone. Thus, both in the case of benefits (outputs) and in the case of costs (inputs) w.t.p. is used as the basis for valuation in the economic analysis.

While this provides an adequate conceptual definition of economic value, it is necessary to be more specific when it comes to applying the concept in practice and deciding on exactly what measure of w.t.p. or OC, must be estimated when valuing different types of inputs and outputs. For this purpose, five categories of outputs and five categories of inputs can be defined, each of which is associated with a different measure of w.t.p. or OC. These categories are discussed below, first for outputs and then for inputs.

### 5.2.1 Appropriate economic value measures for different types of outputs

For analytical purposes, three types of effects which project outputs can have can be distinguished (See Figure 5.1). First, a project output can increase the total supply of a good or service available to society. Two categories of outputs related to this effect can be distinguished for the purpose of valuation. The first is consumer goods or services and the second is intermediate or producer goods or services (i.e., project outputs which will serve as inputs in other production processes which produce consumer goods). In the former case, the appropriate measure of value is the consumers' w.t.p. for the output of the project itself. In the latter case, the appropriate value measure is producers' w.t.p. for the project output, which in turn is based on consumers' w.t.p. for the other goods and services which will be produced with the output from the project being analysed. (See I and II in Figure 5.1)

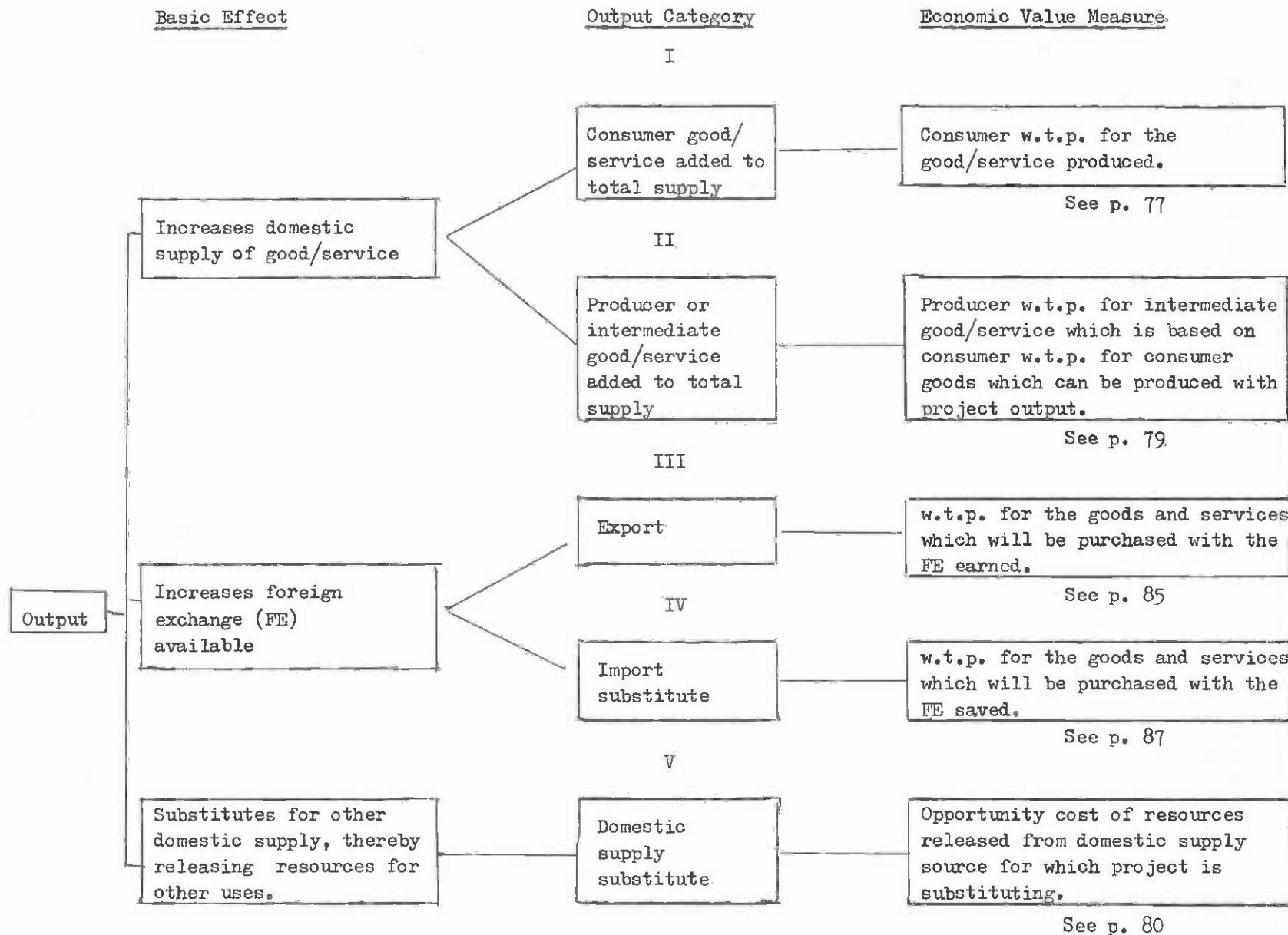
As a second effect, a project can increase the availability of foreign exchange to the economy. There are two categories of outputs which fit in here. The first is exports and the second is import substitutes. The value of these types of outputs (of the project) are measured in terms of the local w.t.p. for the goods and services which can be purchased with the foreign exchange earned (in the case of exports), or the foreign exchange saved (in the case of import substitutes). Since it is necessary to measure economic values in terms of local consumers' w.t.p. for goods and services expressed in local currency, the foreign currency earned or saved has to be converted to local currency, and government policies which make local w.t.p. differ from what the country actually has to pay for imported goods and services in terms of foreign currency have to be taken into account. Unadjusted CIF and FOB values (converted to local currency) will not provide adequate measures of economic values (nor of local market prices) in cases where a government imposes tariffs or provides subsidies for exports and imports. (See Categories III and IV in Figure 5.1).

The third effect which a project output can have in terms of contribution to real national income occurs when the project output substitutes for other domestic supply, thereby releasing resources from these other domestic supply sources for use elsewhere in the economy. (See Category V in Figure 5.1). The relevant measure of economic value of the benefits due to the project in this case is the opportunity cost of the released resources, which is based on the w.t.p. for the goods and services which will be produced with the released resources.

Section 5.5 discusses how to determine the appropriateness of market prices and the factors which are likely to cause a discrepancy between the local market price and the economic value for these five categories of outputs.

Figure 5.1

OUTPUTS: MEASURES OF ECONOMIC VALUE





### 5.2.2 Appropriate economic value measures for different types of inputs.

Two types of effects can be associated with using inputs in a project. The appropriate measures of opportunity cost or economic value are directly related to these two effects. First, an input into a project can result in a reduction of foreign exchange available for the rest of the economy. There are two categories of inputs which have this effect, namely, imported inputs when no quota exists and locally produced inputs which would have been exported in the absence of the project (see A and B in Figure 5.2). In the case of imported inputs, the appropriate measure of opportunity cost is based on the w.t.p. for the goods and services which would have been bought with the foreign currency or foreign exchange which will be spent on the imported inputs for the project. This category also includes the case where the project uses a locally produced input in short supply and forces a previous user of the input to import the input. In either case - direct use of imported input or forcing someone else to import it - the effect is the same and so is the value measure that is appropriate.

For locally produced inputs which would have been exported if they were not used in the project, the appropriate measure of opportunity cost is based on the w.t.p. for the goods and services which would have been purchased with the foreign exchange which would have been earned from exporting the inputs if they were not used in the project.

The second effect associated with inputs is a reduction in domestic real resources or inputs available to the rest of the economy when an input is diverted from other domestic use to the project. Here three categories of inputs can be distinguished (see C, D and E in Figure 5.2). The first is the locally produced input which does not reduce exports or induce new imports. The second is the imported input when a quota exists, i.e., a quantitative restriction exists on imports of the input. The third includes local resources, primarily land and labour, which are not "produced" as such.

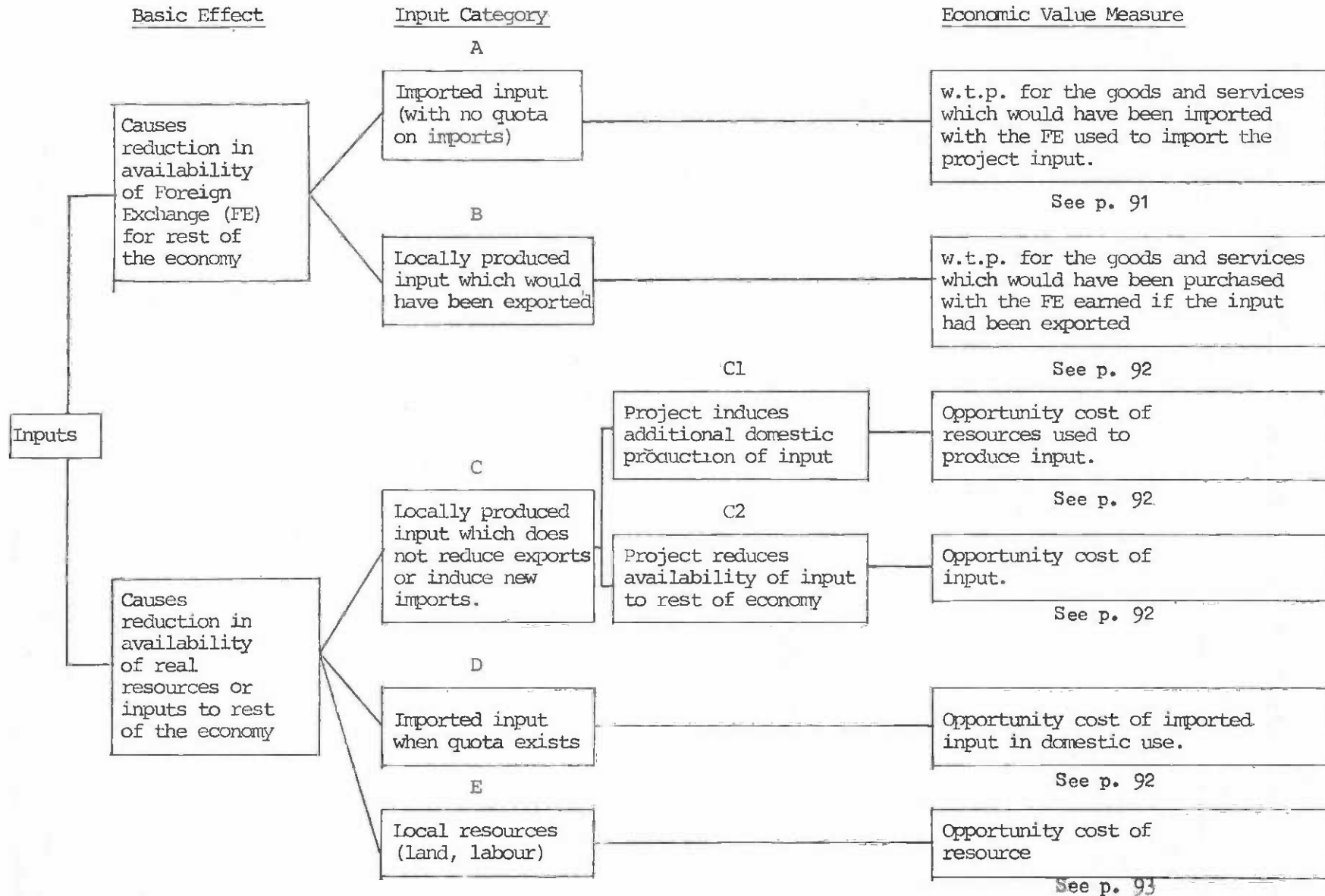
In the case of the first category, a further distinction can be made for valuation purposes between the situation where the project induces additional domestic production of the input and the situation where the project reduces the availability of the input to the rest of the economy. In the former case, the appropriate measure of economic value is the opportunity cost of the resources used to produce the input. In the latter case, it is the opportunity cost of the input itself, i.e., the value foregone by using it in the project rather than in its next best alternative use. (Note that if other users now import the input, then it fits into Category A.)

In the case of imported inputs when a quota exists, the reasoning is that there is no additional outflow of foreign currency, since the total amount of the input imported into the country remains the same (at the level of the quota). Thus, the relevant opportunity cost is the value foregone from shifting the imported input from some other domestic use to the project. Naturally, if the quota is not being met, i.e., imports of the input without the project are below the level of the quota, then the quota is not effective and from an analytical point of view the input is reclassified as an imported input with no quota (see item A in Figure 5.2).

In the case of local resource, the appropriate measure of value is simply the opportunity cost of the resource or the value foregone by using the resource in the project rather than in its best alternative use.

Figure 5.2

INPUTS: MEASURES OF ECONOMIC VALUE



Means for deriving these measures of economic value for inputs are discussed in Chapter 8 for cases where market prices are not considered as appropriate approximations of economic values. The following section discusses some of the factors to be considered in determining the appropriateness of market prices.

### 5.3 DETERMINING ADEQUACY OF EXISTING MARKET PRICES AS MEASURES OF ECONOMIC VALUE

In practice most analysts tend to accept market prices as proxies for the measures of economic values and then search for reasons why they are not acceptable. This contrasts with the theoretician's approach, which starts with the assumption that all inputs and outputs should be shadow priced, even though some shadow prices and market prices may end up being similar. Since the latter, more conceptually correct approach will involve considerably more time and funds. In practice, the analyst will generally have to use the first approach and only attempt to shadow price major inputs and outputs for which the market price is not considered to be an "adequate" measure of economic value. It should be up to the analyst to show convincing evidence that the magnitude and importance of the difference between a market price and the w.t.p. is great enough to justify the extra effort involved in shadow pricing an input or output. Quite apart from the additional time and funds required to develop shadow prices, there is the danger that inappropriate shadow prices will lead to decisions that, taken in the context of the actual workings of the economy, will be worse for the country than if market prices had been used (which take into account the influences of policies, customs, attitudes, and non-economic objectives which actually direct the economy).

"Adequacy" or "acceptability" of a given market price as a measure of w.t.p. or OC thus is a relative concept which depends on the situation. For any given situation, acceptability of a market price for an input or output depends on (a) the importance of the input or output in the overall project, (b) the estimated degree of discrepancy between market price and w.t.p. or OC for the input or output, and (c) the practicability of developing an acceptable shadow price (which relates centrally to the time and budget available for the economic analysis in each case, and the purpose for the analysis). Each of these three factors is discussed in the following sections.

### 5.4 ESTIMATING THE IMPORTANCE OF INPUTS OR OUTPUTS

Most market priced forestry project outputs will be important in terms of their values relative to total project benefits. Thus, most direct outputs are potential candidates for shadow pricing.

With regard to inputs, there will likely be many items which are relatively insignificant in terms of total costs measured in market price terms. Every project involves purchases of a myriad of small items - office supplies, hand tools, etc. Such items generally need not be shadow priced. However, one word of caution is needed here. A project may involve a number of different inputs that individually are unimportant in terms of total cost, but when they are added together, they may have a significant influence on total costs. While it may not be worth the time and effort to shadow price each item

individually, it is possible through a sensitivity analysis to test the effect on project outcome of an increase in some or all of the values of these inputs combined. (See Chapter 10).

Most forestry projects also involve major input items such as land, labour, heavy machinery, processing equipment, etc. Such items may or may not be considered for shadow pricing, depending on time and funds available and the conditions which influence the market prices which exist for them.

As a rough rule of thumb, if an input valued in market price terms represents 5 percent or more of the total present value of the cost of the project, then it is a logical candidate for shadow pricing. Whether or not it is actually worth shadow pricing the input depends on the magnitude of the estimated difference between its market price and its economic value (as discussed in the next section). For example, if an item that represents 5 percent of total cost in present value terms has an estimated shadow price that is 80 percent below the market price, then the effect of shadow pricing will be to reduce the total cost by 4 percent (80 percent of 5 percent) for the economic analysis. This could be significant in terms of a project's economic profitability. On the other hand, if such an item has an estimated difference between market and shadow prices of only 10 percent, then the difference in terms of total cost would only be one-half of one percent, which would not be as significant in terms of economic profitability.

Some types of items often listed as inputs can present problems. For example, projects generally include various physical structures, roads, etc. If these have been listed as "inputs" they are likely to be major items in terms of total costs. As pointed out in the previous chapter, such items should be broken down into their component inputs of labour, equipment, various types of materials, etc. In this case, the judgement relates to whether the component inputs are important enough to merit the extra effort involved in developing shadow prices.

#### 5.5 IDENTIFYING DISCREPANCIES BETWEEN EXISTING LOCAL MARKET PRICES AND ECONOMIC VALUES

To determine whether or not a shadow price should be developed for a given input or output which is considered important, an estimate is needed of the nature and direction of any likely discrepancy that might exist between its existing market price and its economic value.

On the surface the definitions of economic value and market price given in Section 5.2 may seem similar. In many cases the two measures will coincide. However, in some cases, what a consumer has to pay for a good or service in the market (the local market price) may not be a reflection of what he actually is willing to pay for it (its economic value). He may very well be willing to pay more than he actually has to pay, but because of various policies - e.g., a price ceiling - he does not have to pay an amount equal to his w.t.p., which was defined as the economic value of the good or service. Similarly, a producer (the project) may have to pay in the market an amount for an input which is higher or lower than the value which that input could produce in the best alternative activity, i.e., its OC. For example, a minimum wage law may be in existence which sets a wage that is higher than the OC of labour. The producer has to pay the minimum wage and this amount would be used in a financial analysis. However, in the economic analysis the lower OC of labour would be used.

### 5.5.1 Discrepancies caused by government policies

In the above examples, it is existing government policies which cause market prices to be different from economic values as defined here. However, in other cases where government policies affect market prices in the project environment there will be no discrepancy between market prices and economic values. For example, a government imposed tariff or tax on imported goods will affect the price of the good in the local market and the quantity of the good imported relative to what the price and quantity would have been in the absence of the tariff. However, in terms of the economic value definition used here, the resulting local market price with the tariff would still provide a reasonable approximation of consumers' w.t.p. for the good or service at the margin in the existing market. If the tariff were expected to remain in effect during the period of the project, then the local market price would be used in the economic analysis as well as in the financial analysis.

It can be seen that just because a government policy influences a local market price (and the quantity sold in the market), there is no reason to assume that the existing local market price for a particular good or service will differ from its economic value as defined above. It all depends on whether the policy restricts movement of the market price in a given situation, and on the type or category of input or output which is being considered. Thus, in order to develop a more systematic approach to identifying discrepancies between market prices and economic values each of these two considerations needs to be looked at.

In general, any policy which allows the free movement of prices will not cause a discrepancy to exist between market price and economic value as defined here. Such policies may have a significant effect on the size of the market, by changing supply and/or demand. However, so long as the policy does not prevent the changed demand and supply from coming into balance, then the local market price is likely to reflect w.t.p. for outputs and the OC of inputs. For example, a high tax on consumption of good X will restrict effective demand, but if the tax is not accompanied by a minimum price or price ceiling, supply and demand will come into balance at a price which reflects the "marginal" consumer's w.t.p. for good X, even though the quantity consumed will be less and the price will likely be higher than if the tax did not exist. The term "marginal consumer" is used to refer to the consumer who is just willing to pay the resulting market price, but no more. He is marginal in the sense that if the price were increased slightly, he would drop out of the market, i.e., not purchase the good or service in question. As a matter of practicality, most project analyses are undertaken with the simplifying assumption that output will be used or purchased by "marginal" consumers.

Similarly, in the case of a subsidy for consumption (or production) of good Y, the price that results in the market will reflect w.t.p. of the marginal consumer in that market, although the quantity sold will be higher and the price likely lower than in the absence of the subsidy. If a subsidy is provided to consumers it means that such consumers will be willing to buy more of a good or service at any given price or will be willing to pay a higher price for a given quantity. Similarly, a tax on producers means that they will be willing to sell less at any given price or that they will want a higher price for any given quantity of the good or service.

Governments use a great number of policy tools to guide their economies toward what are considered to be the economic and social development goals of the country. Common ones include taxes (including tariffs), subsidies, minimum price and price ceiling laws, and quantitative restrictions on market transactions.

Of those mentioned, the only ones which restrict local price movements (i.e., result in excess demand or supply) are minimum price and price ceiling laws. Even these policies will cause discrepancies between local market prices and economic values in the case of only some of the input and output categories discussed in Section 5.2 (and shown in Figures 5.1 and 5.2). The potential influence of each of these types of policies and how it is possible to identify in practice whether an existing policy is effective is examined further. This latter question is particularly important, since in many countries policies exist on the books which are, in fact, ineffective and, thus, for analytical purposes they can be disregarded. For example, a government may have placed a price ceiling on lumber for construction but, in fact, the market price for lumber is below the price ceiling. In this case, the price ceiling is ineffective in the sense that the price of lumber would be the same with or without the policy, or price ceiling. As in the case of identification of inputs and outputs, the "with and without" concept can be applied in identifying the effectiveness of policies.

Minimum price imposed by government - If a minimum price imposed by a government is effective for a given good or service, then supply would tend to exceed demand for that particular good or service at the established minimum price. If supply does not exceed demand at this price, then the minimum price is an ineffective policy tool, since the market price would settle at the same level with or without the policy (the minimum price).

In the case of an effective minimum price associated with an output - i.e., where there is excess supply of that good or service at the minimum price - it is unlikely that a project would be proposed to expand supply (or add to total supply) of that output. This follows from the fact that buyers can obtain as much as they want at the minimum price without the project, so any addition to total supply would likely remain unutilized so long as the policy remains in effect. Consumption would remain the same with or without the project and, therefore, the output of the project would be valued at zero. Of course, if the minimum price is expected to be reduced, then this would have to be taken into account.

The only type of project that would likely be proposed (or make sense) for an output for which an effective minimum price exists is one that would substitute for existing supply. In this case, as pointed out in Section 2.2.4, the appropriate measure of the value of benefits due to the project is related to the w.t.p. for the goods and services which would be produced with the resources released, i.e., the cost savings, and not the w.t.p. for the project output itself. <sup>1/</sup> Thus, a minimum price on the output itself would not be of concern in the analysis of this type of project.

In the case of inputs, where a minimum price for a project input is effective, supply of that input would exceed demand. The existing local price in the market would reflect the producers' willingness to pay for the input as long as there is competition among the producers who are buying it. However in this surplus situation, if the project employs additional units of the input out of the surplus supply, the sacrifice in terms of alternative consumption benefits foregone will be low or nil. The economic cost of using

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<sup>1/</sup> This follows from application of the "with and without" test. Consumption of the product produced by the project would not change.

an input in the project in circumstances where the input would otherwise be unemployed is then zero or at least less than the existing local price for purposes of an economic analysis. As will be pointed out in Chapter 8, there may be reasons why the shadow price in this situation will be greater than zero, e.g., in the case of labour.

Evidence of an effective minimum price policy can be observed by looking at the supply situation for goods and services. Some indications of effective minimum prices are as follows:

- accumulation of stocks when a minimum price is imposed;
- excess capacity coupled with an increase in the minimum price;
- creation of a black market (or informal labour markets where labour is hired below the minimum wage set by government);
- producers abandoning the market because of lack of sales;
- the existence of unemployment coupled with an effectively enforced minimum wage law. The minimum wage (the "market" wage) is higher than the opportunity cost of labour which should be used in the economic analysis.

Price ceiling imposed by the government - In the case of an effective price ceiling imposed by government, buyers will not be able to buy as much as they would like to at the controlled price, i.e., there will be an excess demand at the existing market price. In this situation the market price will be lower than marginal buyer's actual w.t.p. for the input or output. If there were no control on prices, buyers would bid up the market price until the available supply equaled demand at some higher price. This price would then be equal to w.t.p. for the input or output given the supply situation.

One place to look for evidence of the existence of a price ceiling is the regulatory legislation affecting the marketing of an input or output. However, the mere existence of legislation does not guarantee that price ceiling legislation will be effective. It is necessary, therefore, to look for evidence easily observable in the market that consumption is, in fact, restricted by the government control. Manifestations of an effective price ceiling policy include the existence of queues, black markets, and various forms of rationing. These are all indicators that the marginal buyer is willing to pay more than the going price for the quantity offered in the market, i.e., that the controlled market price is lower than the w.t.p. at the margin.

The nature and direction of discrepancies between local market prices and economic measures of value caused by effective government controls on local prices (minimum prices and price ceilings) are summarized in Table 5.1 for each of the output and input categories shown in Figures 5.1 and 5.2. As indicated for several categories of inputs and outputs the policies can either not be effectively applied, or if they are effectively applied, they are not applicable in terms of the measures of economic value used for the particular category of input or output being considered.



Table 5.1

DISCREPANCIES BETWEEN LOCAL MARKET PRICES AND ECONOMIC VALUES  
CAUSED BY EFFECTIVE GOVERNMENT CONTROLS ON LOCAL PRICES <sup>1/</sup>

	Controls on Local Prices	
	Minimum Prices	Price Ceilings
<u>Outputs</u> (see Figure 5.1)		
I. Consumer good/service added to total supply	NA	LP < w.t.p.
II. Producer or intermediate good/service added to total supply	NA	LP < w.t.p.
III. Export	NA	NA
IV. Import substitute	NA	NA
V. Domestic supply substitute	NA	NA
<u>Inputs</u> (see Figure 5.2)		
A. Imported input - no quota	LP > OC	NA
B. Locally produced input which would have been exported	NA	NA
C1. Locally produced non-exportable input when project induces additional supply	NA	NA
C2. Locally produced non-exportable input when project reduces availability to rest of economy	LP > OC	LP < OC
D. Imported input when quota exists	NA	LP < OC
E. Local resources	LP > OC	LP < OC

<sup>1/</sup> LP = local price; w.t.p. = willingness to pay; OC = opportunity cost; NA means "not applicable" in terms of the appropriate measure of economic value shown in Figure 5.1 (outputs) or 5.2 (inputs) or that the policy cannot be effective for the particular type of input or output being considered.



This discussion relates to discrepancies between local market prices and economic values which are due to the influence of government policies. Government policies, through the existence of an official fixed exchange rate (OER), can also cause discrepancies between the existing "market" price for foreign currency (the OER) and the real economic value of foreign currency in terms of what it actually can purchase in the local market in terms of domestic prices. Since several of the output categories (III and IV) in Figure 5.1 and input categories (A and B) in Figure 5.2 involve use of world market prices (CIF and FOB values) to derive economic values, such discrepancies need to be taken into account if they exist, and foreign currency related effects shadow priced. A "shadow exchange rate" (SER) is commonly used. Its derivation is discussed in Chapter 7.

In the case of an identified discrepancy between the OER and the real value of foreign currency in local terms, a general SER is derived and used in all calculations of economic values for inputs and outputs which involve earning, saving or using foreign exchange or foreign currencies. Thus, once the SER has been derived, it can be used for all the categories of inputs and outputs shown in Figures 5.1 and 5.2 which directly or indirectly involve foreign exchange (i.e., output categories III and IV and input categories A and B). Not only should a general SER be used to evaluate all such inputs and outputs for a specific project, but it should also be used in analysing all other projects in the country. Thus, estimation of a SER should be done at the national level and used systematically for all projects. This contrasts with the situation for many domestic (non-traded) inputs and outputs. For example, in the case of labour there will likely be shadow prices that are unique to given small areas within a country. If unemployment is high in one area (and mobility of labour is low) then a lower opportunity cost (shadow price) for labour would exist for projects in that area than would exist for labour in other areas with lower unemployment.

#### 5.5.2 Discrepancies caused by other factors.

In addition to government policies, there are other conditions which may exist in the project's economic environment which can cause discrepancies between existing local market prices and economic values for some input and output categories.<sup>1/</sup> The main ones needing consideration are:

- existence of monopoly or monopsony elements in the markets for project outputs or inputs;
- existence of speculation or status influences, particularly in the case of land prices.

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<sup>1/</sup> Note that existing market prices are emphasized. In all cases where existing market prices are used as a basis for economic values, a number of factors that will influence projected future prices and economic values have to be taken into account. This chapter attempts to identify discrepancies between existing market prices and economic values. Expected changes in conditions in the future that will affect market prices as well as economic values are discussed in Chapter 6. They should also be considered in deriving estimates of future market prices that will be used in the financial analysis.

5.5.2.1 Monopsony and monopoly

The existence of monopsony power and monopoly power is common in many countries. Government set prices are a form of monopoly exercised by the government. The distinction made here (in relation to the two categories of policy influences discussed in the previous section) is that this discussion involves monopoly and monopsony power exercised by private (non-governmental) individuals and/or groups, e.g., corporations or unions. The relationship between the existence of either of these two forms of market control and government policies is often difficult to ascertain, i.e., whether in fact a government is encouraging either or both of them, or it merely permits or condones them in the economy. In some cases, a government is against the existence of monopoly and monopsony in the private sector, but it does not have the political power to do away with them.

The point here, in terms of valuation, is that if monopoly and/or monopsony exist in the project environment and are expected to persist during the period of the project, then their effect should be taken into account when looking at discrepancies between market prices and economic values. For example, if a strong union exists and is expected to persist during the period of the project, then the discrepancy between union set wages and actual opportunity cost of labour should be taken into account in the same way that the discrepancy caused by a government set minimum wage needs to be considered.

Monopsony power - If one or a few purchasers acting together can alter market prices by modifying their buying policies, then a "monopsony" condition exists.<sup>1/</sup> A buyer enjoying some degree of monopsony power will change the market price of the input or output to his advantage. If his power is effective, then the price that he will pay in the market for the input or output will be somewhat lower than what he actually would be prepared to pay if he did not have the monopsony power. The market price will reflect only partially his real willingness to pay.

If there is monopsony power associated with the product (good or service) being produced by the project, or monopsony power associated with the inputs required for the project being analysed, the same kinds of discrepancies can develop as in the case of price ceiling policies. Thus, the direction of such discrepancies for different categories of inputs and outputs can be identified in column 2 of Table 5.1.

Evidence of the existence of monopsony forces can be obtained in some cases by examining sales records. If one buyer dominates the market, then there is good reason to suspect that that buyer is influencing market prices in his favour. In the case of collusive agreements among several buyers, market influence is much more difficult to identify and to measure. Since these types of arrangements are forbidden by law in most countries, they tend to be made in secret or through informal, tacit understanding among buyers. Generally, when this type of influence is suspected to exist in the market, it can best be considered in a sensitivity analysis, since it is extremely difficult to adjust the market price for this type of effect.

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<sup>1/</sup> Strictly speaking, when there are a few purchasers rather than just one controlling a market, economists talk about "oligopsony". For convenience, the term "monopsony" is used loosely to refer to both situations.

Monopoly power - If one or a few sellers in a market have the power to influence prices by altering their selling policies, a monopoly condition exists.<sup>1/</sup> Whether this monopoly condition will cause a discrepancy between market prices and economic values depends on the type of output or input being valued.

In general discrepancies caused by the existence of monopoly power in the markets for project outputs or inputs will be the same as those shown in column 1 of Table 5.1 for government minimum price policies. In other words, monopolists will in a sense have the power to set "minimum" prices. On the output side, if a monopolist sets a higher price than previously existed in the market, it will likely influence the volume of sales since less will be consumed when the price is increased. However, consumers will adjust their purchases until the marginal consumer (or last buyer of the good or service) is just paying what he is willing to pay. If the price were raised slightly, the marginal consumer at the initial price would drop out of the market. Thus, the price set by the monopolist will reflect w.t.p. at the margin, which is the concept of relevance in terms of valuing outputs in a practical project analysis.

On the input side, discrepancies can arise between the local market price and the opportunity cost associated with an input if a monopolist sets the price. For example, in the case of an imported input when no quota on imports exist, if the monopolist controls the local price of imports, he can set it above the opportunity cost of foreign exchange used to import the input. Similarly, in the case of local resources, say labour, a monopolist (e.g., a union) can set the minimum wage level at a level above the opportunity cost of labour.

#### 5.5.2.2 Existence of speculation or status influences on market prices

Prices for land are often set in the market on the basis of speculation concerning future values of land and/or on the basis of status associated with owning land. Such influences can cause a divergence between market prices for land and the value of land in terms of its alternative productive uses (i.e., contribution to real national income). The valuation approach used in EAFP (see Chapter 8) eliminates the need to be concerned with such divergencies. It is suggested that land should always be shadow priced on the basis of its alternative productive uses over the period of the project and not on the basis of land sale prices.

#### 5.5.3 Comments on identifying discrepancies

It is clear that very often the analyst will be able to identify some of the discrepancies discussed and to estimate the direction of the divergence between market prices and economic values, i.e., whether economic values will be higher or lower than existing market prices. However, it is quite a different matter to be able to measure the magnitude of such differences. Even so, the qualitative knowledge obtained provides a very useful guide for focusing attention in those areas in which the discrepancy although not quantifiable, is judged to have a potentially important impact on project worth. Thus, this type of analysis helps to identify areas of uncertainty to be treated later in the sensitivity analysis.

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<sup>1/</sup> The term "monopoly power" is used to refer to oligopoly (several-sellers) as well as the traditional monopoly (one seller) situation.

There is one other point which should be mentioned. This relates to "second-round" effects, or discrepancies which exist between market prices and economic values one or more steps removed from the market prices for direct inputs or outputs associated with a project. The discussion of discrepancies has concentrated on only the direct or first-round discrepancies which can be identified. It is quite possible that the analyst will have information on which to judge whether there are discrepancies further down the line which should be taken into account. For example, it may be determined that there are no apparent policies or other factors which are directly affecting the price of locally produced tractors to cause a discrepancy between the local market price for a tractor and its economic value in terms of the project. However, it is known that there is a discrepancy between the local market price and the economic value for the steel used in producing the tractor. Ideally, an attempt should be made to shadow price the tractor taking into account the shadow price for steel. While in rare instances it may be possible to make such corrections, in general, from a practical point of view it will not be possible to trace through all the effects of every input that enters into the production of the inputs used in a project.

Normally, the analyst will have to be content to deal with the obvious discrepancies directly associated with the prices for project inputs and outputs. Obviously, if the analyst has the time and funds to carry the shadow pricing exercise to its logical extreme and to take into account all such second-round effects then he can proceed to do so using exactly the same concepts and techniques explained here for treating the first-round effects.

#### 5.6 EASE WITH WHICH ACCEPTABLE SHADOW PRICES CAN BE DEVELOPED

The final factor which needs to be considered in deciding whether to use the market price for an input or output or whether it should be shadow priced relates to the ease with which an acceptable shadow price can be developed. In nearly all project analyses, the analyst is faced with a time and a budget constraint. He will not have the time to spend on shadow pricing every input or output item which is important and for which a discrepancy is expected between market price and economic value. For many inputs or outputs which are difficult to shadow price, the choice will have to be made between using a rough "guesstimate" of an appropriate shadow price (that at least covers some of the estimated discrepancies between market price and economic value) or using the market price, even though it is recognized to be less than a perfect measure of economic value. (In the latter case, the discrepancy is explicitly acknowledged in the analysis report and alternative values can be tested in the sensitivity analysis.) The choice between these two alternatives will have to be made on the basis of the circumstances surrounding the analysis (its purpose) and the judgement of the analyst as to just how critical the value of the particular item is in terms of the selected measure of economic efficiency.

Finally, for most forestry projects the analyst will encounter indirect effects (externalities or non-market priced effects) for which it is difficult, if not impossible, to develop acceptable shadow prices (e.g., in valuing scenic beauty, increases in self-reliance, reduction of drudgery, etc.). In such cases, the best the analyst can do is to describe the effects in physical and/or qualitative terms and suggest how they are likely to affect the project outcome and its impact on society.

Chapters 7 and 8 discuss in more detail some of the practical considerations which influence the decision on whether or not to attempt to shadow price an input or output.

## Chapter 6

### USE OF MARKET PRICES: GENERAL CONSIDERATIONS

#### 6.1 INTRODUCTION

For most inputs and outputs, market prices are likely to be used as direct measures of economic value or indirectly in deriving shadow prices (as will be discussed in Chapters 7 and 8). There are some general considerations which need to be kept in mind when market prices are used as a basis for economic values.

Observed market prices for inputs and outputs reflect present and past conditions of supply and demand. Values used in project analyses involve consideration of future supply and demand conditions. Thus, to arrive at future value estimates for effects or inputs and outputs based on observed market prices, some adjustments in observed prices and trends in such prices may have to be made. First, it is recommended that economic analyses be carried out using price or value estimates net of the effects of inflation. This means that adjustments will have to be made to take out the likely effects of inflation on future price levels. Second, even after the expected effects of general price inflation have been eliminated, there may be changes in relative prices for certain inputs and outputs, i.e., changes in prices of specific inputs and outputs relative to general price changes due to inflation. Third, the project being analysed may itself have an influence on future relative prices, and thus on economic values. These three considerations are the subject of this chapter. They apply whether market prices are used directly or indirectly in deriving economic value measures.

The assumption stated in Section 4.4 namely that all location related effects are explicitly identified and recognized as independent project effects is stressed. This is mentioned since some manuals or guides to project analysis treat location effects in the valuation stage, by adjusting market prices for the location related effects. For example, instead of valuing an export output on the basis of its FOB value alone, the costs of transportation from the project (often called the project "gate") are subtracted from the FOB value of the output appropriately converted to local currency to arrive at what is called an "export parity price". <sup>1/</sup>

While either approach - that suggested in Chapter 4 or the above approach which involves adjustments at the valuation stage - should produce the same result if done properly, the suggestion in Chapter 4, that location effects be considered separately in the analysis is followed here.

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<sup>1/</sup> The reader interested in this approach is referred to Ward 1976.

## 6.2 ESTIMATING FUTURE PRICES

An existing or past market price is a "fact". It represents what a good or service actually is or was traded for in a given market. Existing market prices can be used directly in valuing inputs and outputs that occur today. When deciding on how to adjust existing prices so they can be used to value inputs and outputs that occur sometime in the future, the analyst has to consider two factors. The first is general price inflation and the second includes influences that are likely to affect particular prices in the future, or prices of specific inputs and outputs relative to prices for other inputs and outputs.

Inflation relates to general price increases which affect all goods and services. Inflation reflects a decline in the real value of money. In addition, there may be relative price changes for some goods or services. Some prices may be expected to change in value more or less than the general level of inflation and, therefore, change relative to other prices. In developing future value estimates for project appraisal purposes, it is important that the analyst be aware of the distinction between general inflation and relative price changes and make appropriate adjustments for both in estimating future values.

### 6.2.1 Treatment of Inflation

The general approach recommended is to work with prices net of inflation, but to include any relative price changes which are expected. Thus, if prices of all inputs and outputs for the project are expected to increase at the same rate (i.e., at the rate of general inflation), then the analyst can merely use existing prices as a measure of future prices (keeping in mind that actual money prices will increase with general inflation). If certain prices are expected to increase or decrease relative to others, (i.e., faster or slower than the rate of general inflation) then adjustments can be made in such prices according to the assumptions accepted regarding the rate and direction of relative price changes. The result will be an estimate of the expected prices in the future, taking into account relative price changes expected, but excluding the effects of inflation.

The advantages of using price estimates net of inflation, i.e., relative prices, are (a) the analyst does not have to try to estimate general price inflation over the life of the project, which is always difficult to ascertain and justify, (b) the results can be understood more easily, and (c) the analyst will be able to show more clearly the assumptions used in the analysis concerning relative price changes.<sup>1/</sup>

As an empirical point, it should be stressed that relative price changes tend to be more pronounced in situations of high inflation, as investors search for means to hedge against inflation. For example, high inflation tends to encourage investment in land and other real assets that increase in value at a rate greater than or equal to the rate of general inflation. Bank accounts and certain other fixed return investments, on the other hand, have a tendency not to keep up with inflation because the fixed return becomes less valuable in the future as inflation increases. Thus, relative prices of land and certain other assets may be bid up relative to other prices in periods of inflation as demand for such assets increases.

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<sup>1/</sup> For a more detailed discussion on the treatment of inflation and some examples of application, see H. Gregersen, 1975.

### 6.2.2 Estimating Relative Price Changes

It is quite common that some prices are increasing (or decreasing) relative to others. For example, in many countries, the price of stumpage is increasing relative to other prices, i.e., it is increasing at a rate faster than the rate of general price inflation. In cases where relative price changes are expected, the question arises as to how the analyst should attempt to estimate or forecast such changes. Forecasting is an area of specialization in and of itself and can be quite complicated to carry out in practice if it is to be done properly. Thus, no attempt is made to cover the techniques and approaches in EAFF.<sup>1/</sup>

In most circumstances the analyst dealing with forestry projects will not find himself in a position to use sophisticated forecasting techniques to estimate future prices; he will have to rely on simple approximation techniques.

If acceptable data on past prices are available, then the simplest approach is to plot prices over time on a graph. If a trend is evident, then the resulting trend line can be extended into the future. This can be done with regression analysis or simply by extending visually the historical price line on the graph into the future. In working with historical data, there are a number of ways of smoothing out variations that occur from year to year and adjusting for inflation to arrive at a long-term trend estimate which excludes cyclical influences and the effects of inflation.<sup>2/</sup>

In this type of trend projection, it is assumed that certain forces (other than the project itself) have affected prices in the past. It might not be possible to identify or define these forces with precision, nor how they are interlinked in the market. However, their combined effect on relative market price changes over time can be observed. For practical purposes, the analyst assumes that these forces will persist into the future and that the same trend can be projected over the period of the project. This simple type of projection technique is most often used in practice.

For some forest products, records on domestic prices over time may be limited. In fact this is the usual situation in countries where the contribution of the forest sector is modest and where statistical services are not well developed. In these cases, the analyst can do little more than try to obtain opinions of knowledgeable people and look at trends in relative prices in other countries and adapt these to his needs. Alternative price assumptions can be introduced in the sensitivity analysis of project results.

In other cases, accurate records exist covering extended periods, and clear trends are readily perceived. This might be the case, for example, for wages, or for some internationally-traded goods, where records can be obtained from international agencies or from the exporting/importing countries' statistical services.<sup>3/</sup>

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<sup>1/</sup> The reader can find various techniques discussed in IUFRO 1971 and in Chisholm 1971, as well as in references cited in these two documents.

<sup>2/</sup> See Chisholm, op cit. Some hand calculators are now available which will make forecasts based on various assumed relationships.

<sup>3/</sup> cf. United Nations and FAO 1977.



Some approximations of future price movements are relatively easy to imagine without having much data. For example, if a given region's forests are being rapidly depleted, and population density and the development of general economic activity show a clear trend to increase, the analyst has sufficient reasons to expect growing scarcity of forest products and rising prices if it is assumed that the trend will persist. Thus he can pick some reasonable rate of increase in prices and test others in the sensitivity analysis.

On the input side, records usually exist on prices of imported goods (in the project country or in neighbouring importing country customs files, or in the files of importers). Price trends can be derived from such records and projected into the future.

### 6.2.3 The "Big Project" effect

Naturally, a new project being analysed has not influenced the way in which prices have changed in the past relative to other prices or the rate of general price inflation. However the proposed project may be large enough in relation to input or output markets to be able to influence prices in the future. Thus, a pulp and paper project's output might add significantly to supply and result in a decrease in future prices. Or the project requirement for given inputs may be large enough to push up the price of these inputs. If information is available on which to base an estimate of how the project is likely to affect future prices, it should be taken into account. It may only be possible to state the direction of the expected influence. Even though the magnitude of the effect cannot be estimated, the analyst should still include information on the expected direction of change, so various potential prices can be tested quantitatively in the sensitivity analysis.

Treatment of project influences on future input or output prices - or what is often called the "big project" effect - can also be considered as a form of shadow pricing. It does not matter whether such adjustments are dealt with under the heading of "shadow pricing" or "use of market prices", so long as they are considered to the extent possible.



## Chapter 7

### SHADOW PRICING OUTPUTS

#### 7.1 INTRODUCTION

This chapter deals with an approach to shadow pricing outputs for an economic analysis when existing market prices are considered inadequate direct measures of economic value.

As shown in Figure 5.1, there are five basic categories of project outputs which can be distinguished for purposes of valuation. These are:

- consumer goods or services which add to total domestic supply available;
- producer or intermediate goods or services which add to total domestic supply available;
- output substituting for existing domestic supply;
- exports;
- import substitutes.

The eventual effect in all cases is an increase in the goods and services available for domestic final consumption. However, the appropriate approaches to shadow pricing such increases depend on the category of output being considered and the nature of the links from immediate or direct project output to the increase in availability of domestic consumption goods and/or services. In the case of the first two categories, the relevant measure of value is the w.t.p. for the output of the project. For the third category, the relevant measure of value is based on opportunity cost of the resources released. The last two categories of outputs involve earning or saving foreign exchange. Thus, the relevant measure of benefits is based on what the foreign exchange earned or saved can buy for domestic consumers in terms of local prices, i.e., w.t.p. for imported goods in local price terms. The remainder of this chapter discusses appropriate approaches to deriving these measures of value.

#### 7.2 CONSUMER GOODS AND SERVICES THAT ADD TO TOTAL DOMESTIC SUPPLY

This category of output is often considered to be the most difficult type to value for an economic analysis when the local market price is rejected as a measure value. Fortunately, most forestry project outputs are not final consumer goods that are added to total supply. If they are, then it is frequently found that their existing market prices provide a reasonable approximation of economic value or w.t.p. The main exception is a market priced good or service for which a price ceiling has been set (see below). As mentioned in Chapter 5, in cases where a minimum price has been set which creates a discrepancy between market price and w.t.p., it is unlikely that a project will be proposed to add to total supply. This follows from the fact that an effective minimum price is associated with excess supply, so a project would not likely be proposed that would merely increase that excess supply.

The appropriate measure of value for this first category of output is consumers' w.t.p. for the increased output. If the existing market price is judged to be inappropriate as a measure of w.t.p., then the analyst has to try to estimate an approximate schedule of w.t.p. for the output. The usual way is to conduct a survey among prospective consumers.

Two points should be kept in mind concerning consumer surveys. First, in many cases and particularly in those situations where the project affects persons outside the market economy, potential consumers often will not understand monetary values well enough to provide an accurate monetary measure of their w.t.p. for the potential output, particularly considering that the expressed w.t.p. must reflect ability to pay to be meaningful. In other words, if a community family earns a cash income of \$50 per year and says it is "willing to pay" \$60 per year for, say, fuelwood, this is a meaningless result in terms of an economic efficiency analysis.

Second, experience indicates that w.t.p. surveys sometimes produce biased values, even for consumers within the market economy. For example, even if a family could well afford to pay what it says it is willing to pay, it may not actually do so if the good becomes available. Along the same lines, questions related to how much people would consume at a given price if the output were available sometimes elicit quantity estimates that are different from the quantities that people actually are willing to purchase at that given price. However, despite these potential shortcomings such surveys may be the only, and therefore best way to get some idea of local w.t.p. Thus, they can be a useful tool.

In some cases a forestry project output will add to total supply of a group of goods which have the same end use (i.e., relate to the same consumption objective). The goods themselves may be different, but the use is the same; thus they should be considered together. For example, fuelwood and coal may be used interchangeably for fuel by local villagers. A fuelwood project may add to the total supply of fuel available. It may be substituted for coal by local villagers, but the released coal in turn will be added to the supply available for and used by urban and industrial fuel users. If there is no market price established for fuelwood which is acceptable as a measure of economic value for the additional project output, then the market price for coal may provide an acceptable measure of value when appropriately converted to some common measure of fuel/energy value (e.g., calorific value). This would be the case if the market price adequately reflects w.t.p. for coal.

In this case a first reaction might be to value the fuelwood as a substitute for coal. In fact, while the fuelwood is being substituted for coal by villagers, the coal will be used elsewhere, i.e., the total supply of "fuel" available has been increased. Thus, the appropriate measure of value is the w.t.p. for the additional fuel indirectly made available to society by the project. Section 7.4 will discuss this distinction in more detail. The point is that w.t.p. is based on use or consumption value and there may be several seemingly diverse products which have the same use value. For the purposes of the economic analysis, they are considered together when defining "supply available" and determining whether a project output adds to or substitutes for existing supply.

In the case of a project which would add to total supply of a consumer good or service for which a price ceiling exists, a situation of excess demand may be encountered, i.e., at the prevailing maximum allowable market price, consumers are willing to buy more than suppliers are willing to sell. As indicated in Chapter 5, evidence of such a situation (an effective price ceiling) includes the existence of queues, black markets, etc. The black market price can provide an upper limit on the actual w.t.p. for the good, but should generally not be used as a proxy for w.t.p., particularly if the black market is

fairly small relative to the total market. Rather, some value in between the administered price (the ceiling price) and the black market price could be used. The best approach in this case is probably to test a number of value assumptions in the sensitivity analysis. If the project produces an acceptable measure of economic profitability using the administered price, then there is less need to consider higher prices (such as the black market price) since they would merely serve to make the project even more profitable (or to increase the measure of economic efficiency).

A final comment relates to the suggestion sometimes made that world market prices can be used as proxy measures of economic value for this category of outputs. Based on the valuation system adopted in EAPP, if for policy or other reasons a market priced good or service could not, or would not be imported in the absence of the project, then its world market price (CIF value) should not be used as a measure of value for it. Similarly, if a good could have been exported, but is produced by the project for domestic consumption, then the export price should not be used as the basis of value for local w.t.p. In this latter case, it can be said that the decision-makers who decided that the good will be consumed domestically instead of being exported must consider the local consumption value to be at least as great as the export value to the nation. Thus, the export value provides an estimate of the minimum value of the output from the viewpoint of decision-makers. However actual w.t.p. by local consumers may be quite different from the decision-makers' interpretation of the minimum value of the product and it is this local w.t.p. which is relevant.

### 7.3 INTERMEDIATE GOODS WHICH ADD TO TOTAL DOMESTIC SUPPLY

Many forestry project outputs fall in this category. The appropriate measure of value should be based on the relative contribution of the project output to the value of the final consumer goods or services which will be produced with the project output, when such value is measured in terms of consumers' w.t.p. for those final goods or services. For example, lumber produced by a project should be valued on the basis of its contribution to the value of final consumer goods - housing, etc. - which will be produced with the lumber. In practice it is exceedingly difficult and time consuming to develop such a value measure, and this difficulty has led to the common practice of valuing such project outputs on the basis of producers' or "converters' " w.t.p. for them, where the "converters" are those who will take the project output and convert it into final products for consumption.

If there is a local market for such intermediate goods and it is competitive enough to make the price an acceptable reflection of w.t.p. for the output, then there are no problems of shadow pricing. However, if there are administered prices associated with the market or there is evidence of monopsony power on the part of those buying the output or monopoly power on the part of the sellers of the final products to be produced with the project output, then problems arise, for the market price no longer can be taken as an acceptable measure of economic value.

Similarly, in other cases there will be no established market for the project output (i.e., the final processing activities which will use the project output have not yet been established). Thus, there will be no established market price. The best approach in such cases is to evaluate the proposed project as part of a larger integrated project which would include everything up through the final production of consumers goods.

For example, if the initial project were defined as one to produce pulpwood for a proposed pulp and paper mill, and there is no other market for pulpwood, then the pulpwood output

could be considered as an intermediate input (cost) in an overall project (pulpwood, pulp and paper project) and the pulpwood could be valued as an input on the basis of the opportunity costs involved in producing it (see Chapter 8).

The analyst also could attempt to survey converters' w.t.p. for the project output. Such surveys are fraught with various difficulties similar to those mentioned for consumer surveys. The problems are even more difficult if the project output will not be sold competitively, since converters or producers of the final goods are not likely to reveal their true w.t.p. if they realize that they will be the only ones buying the output. Yet, under the circumstances, this type of survey coupled with judgement on the part of the analyst may provide the best information possible.

Another common approach used in financial analyses of forestry projects is to calculate a "surplus value" for the intermediate output and then attribute that value to the project producing the intermediate output. The surplus value is derived by estimating the final product price and then subtracting all costs other than the value of the project output (which will be an input in production of the final product). The amount left after these subtractions is then divided between profit and the surplus value to be attributed to the project output. This approach can provide an approximation of what the producer of the final product could afford to pay for the project output and still make an acceptable return or profit. (In calculating the surplus value allowance should be made for a profit element, usually equal to the going rate of return on similar types of investments.) In the absence of other means for approximating values, and if it is not possible to combine the proposed project with the further processing stages so the total integrated operation is treated as a whole, then the surplus value approach can at least provide some order of magnitude estimate of value.

It should be emphasized that the process of calculating a surplus value can be extremely difficult and time-consuming and also is fraught with potential errors, if adequate information is not available on the economic value of the final product and all the intermediate costs down to the proposed intermediate output of the project being analysed. For example, in the pulpwood plantation project mentioned earlier it would be necessary to develop an estimate of the value of the final paper production, estimates of all the costs involved in producing it and an estimate of the normal profit which could be expected. If there is no paper production in the country then these estimates can only be derived by going through a complete economic analysis of the proposed pulp and paper project, in which case, an evaluation of both the pulp and paper project and the plantation project as an integrated whole might be done.

#### 7.4 OUTPUT SUBSTITUTING FOR EXISTING DOMESTIC SUPPLY

In this case, total supply available remains the same. The project would substitute for another domestic source of supply, which, when curtailed, would release resources for other uses (production of other goods and services). It is consumers' w.t.p. for these other goods and services (which would not have been produced in the absence of the project) that is used as a measure of value of the project to society.

This approach is quite different to the one for an output which increases supply. In a project that adds to total supply, it is the w.t.p. for the additional output of the project itself that is relevant. In a project that involves substitution, the relevant

comparison is between the opportunity costs of alternative sources of the same output, since with or without the project the total amount of the good or service would be the same.

In some cases tracing the relevant substitution impact of a project can be a difficult process. Assume, for example, a situation where a fuelwood project output would partly substitute for non-commercial fuels, such as animal dung and crop residues which would be used for fuel in the absence of the project. Assume further that if these alternative fuels were left on the land they would increase the value of agricultural crops because of their properties as soil builders and fertilizers. In this case the net value of the increase in crop output or the value of crop losses avoided (i.e., "with" and "without" leaving the dung and residues on the land) can provide a measure of the benefits of the project. The fuelwood is considered as an indirect substitute for fertilizer and soil builders, and its value is determined by the value of these resources released and now available for agricultural production.

This value is being used as a measure of w.t.p. in the sense that it is assumed that farmers would be willing to pay to the fuel gatherers an amount up to the value of the crop loss avoided, say \$20/ha, if the gatherers would leave the dung and crop residues on the fields. In turn, if these gatherers were given this amount of money, they would be willing to pay up to this amount to buy fuelwood with the same calorific value as the dung and residues left on the ground. Both farmers and gatherers would be just as well off as before. But crop consumers would be \$20 better off, assuming that this value of crop loss avoided is based on consumer's w.t.p. for the crop. Thus, this is the benefit. An example shown in Table 7.1 illustrates the approach.

As another common example, assume that a project is being proposed to establish fuelwood plantations for a local community. The output would substitute for fuelwood presently being collected by local community members from natural forests on surrounding hillsides.

At the present time (without the project) village families have to spend time gathering fuelwood from natural forests some distance from their homes. If there is alternative productive work available for these families, then they have to give up the income from such alternative work in order to get the fuelwood, and society gives up the value that the fuelwood gatherers could have produced by working in alternative employment. This income given up (or the benefits society gives up) provides an estimate of the value of fuelwood. For example, suppose that a given family takes two days a week to gather its weekly fuelwood requirements of 20 kg and that the family members involved in the gathering would have produced a total of \$2.00 in alternative work (either producing food for home consumption or in the employ of someone else) if they did not have to gather the fuelwood. This \$2.00 that they give up would provide an estimate of their w.t.p. for the fuelwood, or the value to society of the resources saved.

In order to use this approach the analyst has to accept the assumptions that:

- the value to the fuelwood gatherer of additional fuelwood (beyond 20 kg in the case of the example) is not worth the additional income he would have to give up by going out to collect more fuel. In other words, the value of an additional unit of fuelwood to the gatherer is just equal to the value of the income he would have to give up to collect it. If it were more, then he would go out and collect more fuel (and give up income). If it were worth less, then he would give up an additional unit of fuelwood and work more;

Table 7.1

DERIVATION OF SHADOW PRICE FOR PROJECT FUELWOOD SUBSTITUTING FOR CROP RESIDUES <sup>1/</sup>

Basic Information :

- Crop residues removed per ha/year (a)	2 tons
- Corn crop value increase per ha/a if residues left on fields	\$20.
- Heating value of 2 tons crop residues	376 000 kilocalories (kcal)
- Heating value, 1m <sup>3</sup> of project fuelwood	188 000 kcal

Calculation of fuelwood shadow price:

- Heating value of 1m <sup>3</sup> of project fuelwood	=	heating value of 1 ton of crop residues
- Corn crop value increase due to 1 ton of crop residues	=	$\frac{\$20}{2}$ = \$10
- Value of 1m <sup>3</sup> of fuelwood	=	\$10

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<sup>1/</sup> Hypothetical example

- the value of each unit of fuelwood consumed is the same to the gatherer. In fact, this assumption is common to all the valuation approaches suggested. While the first units consumed are likely to have a higher value than the last, there generally is no practical way of taking this into account quantitatively. Thus, the assumption is made that all units will have equal value and that this will be equal to the estimated value of the last unit. The result in most cases is a tendency to understate the real value of (or w.t.p. for) the total output. (This issue - and a confirmation of the fact that it is almost impossible to deal with it in practical valuation problems - is amply discussed in the literature under the heading of "consumer surplus.")<sup>1/</sup>

To take another example, assume that the family members involved in the fuelwood gathering have no alternative productive uses for their time. Does this mean that the proposed plantation fuelwood should be valued at \$0? So long as there is fuelwood available for families to collect elsewhere, then an appropriate measure of value for the plantation output may be close to \$0 from an economic efficiency point of view.<sup>2/</sup> It would not likely be zero since fuelwood collection may involve a higher food intake than complete idleness, i.e., the collectors must have a higher calorie intake for them to be able physically to carry out the arduous task of collecting the wood. If the family is willing to incur this additional "cost" then the value of the fuelwood is at least equal to this cost, i.e., it is above zero. Similarly there may be health and fatigue costs. However, these are difficult to measure and value. Normally, they are merely described qualitatively in project reports.

Even if the value of the alternative uses of fuelwood gatherers' time is zero, there may be some benefits associated with a fuelwood project that permits natural vegetation to remain on areas that should be protected to prevent erosion or to provide habitat for wildlife (food). To the extent that these benefits can be quantified and valued, they should be included. If they cannot be valued, they should at least be treated explicitly in qualitative or physical quantitative terms in the analysis document.

Finally, it may be that while the local families can currently go out and collect fuelwood, scarcity of wood is increasing (e.g., as indicated by increasing amounts of time required to collect fuelwood). If this is the case, then the analyst has to allow for this changing situation in his analysis (by applying the 'with and without' concept). If the families are likely to have increasing opportunity costs over time, then the analyst can value future project output on this basis. For example, the one day of fuelwood gathering per week required now may not carry any opportunity cost, but if the time required is expected to increase to three days, then the family's home food production may suffer and this could constitute a basis for attributing a positive benefit to a fuelwood plantation project that would avoid this loss of home food production.

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<sup>1/</sup> cf. United States Department of Agriculture, Economic Research Service, October 1977. It is stated, for example, that "dissatisfaction among economists about the usefulness of consumer's surplus has brought outright condemnation by Samuelson...who remarks: 'The subject is of historical and doctrinal interest, with a limited amount of appeal as a purely mathematical puzzle.'" (p. 117).

<sup>2/</sup> It is emphasized that efficiency is not the only concern in the economic analysis. The project may have value on the basis that it reduces the drudgery and toil of people (i.e. reduces "costs"), which was labelled in Chapter 2 as a legitimate goal for a project.



Many projects may involve both substitution and additions to total supply of consumption. For example, there may be an increase in the consumption of fuel because a fuelwood project provides it at a lower financial cost to the consumer than the price of the present fuel (the one for which the fuelwood will substitute). In this case, the two components have to be separated - the substitution part and the increase in total supply part - and each has to be appropriately valued according to the guidelines above. Suppose in a case where fuelwood substitutes for coal that without the fuelwood plantation project one million calories per day is consumed now using coal and that with the project, because of a lower financial price put on plantation fuelwood, consumption increases to 1.2 million calories per day. Substitution of fuelwood for the 1 million calories could be valued on the basis of the opportunity cost for production of the coal for which the wood is substituting. However, the additional consumption - 200 000 calories per day - should be valued on the basis of the consumer's w.t.p. for the additional consumption as discussed in Section 7.2, since it is adding to total supply and not substituting for the domestic coal. It is only being consumed because the financial price is lower for the fuelwood. The w.t.p. for it (its economic value) is also likely to be lower.

As another example, assume a project designed to improve a forest road so that hauling/transport costs for logs delivered to mills can be reduced. Part of the benefits can be measured in terms of the costs saved for the volume of wood that normally would travel over the road. In other words, as in the typical substitution project, the new road releases resources which had been used in transporting wood and which now can be used in other activities (production of other goods and services). This part of the benefits is appropriately valued on the basis of the opportunity cost of the resources released. However, it is also possible that the improved road results in an expansion of wood output. The logic is as follows. With lower transport costs, total production costs decrease. Producers of the wood products, if dealing in a somewhat competitive market will tend to lower prices as their costs go down. With lower prices, consumers will be willing to purchase more. Thus, the project also has resulted in an expansion of consumption of the products being produced. The net increase in the value of the expanded consumption (i.e., net of additional costs) can be attributed to the project as a benefit. Since this part of the output adds to total supply, it has to be valued as suggested in Section 7.2 or 7.3, depending upon whether the expanded supply involves a direct consumer good or an intermediate producer good.

To summarise, for a category of output that will substitute for other domestic supply of the same product or another product with the same use value, the appropriate measure of value of the benefits due to the project is the opportunity cost of the resources released, or the value of what these resources would produce if they were released. If the resources released have no other use, then the value of the project output may be zero or close to it. On the other hand, if the resources released are otherwise fully employed in the economy, and they are traded in a fairly competitive market, then the prices of the resources released provide an adequate approximation of the value of the project output. In between there will be cases where some of the resources released will have alternative uses and some will not. The analyst's task is to identify the various inputs released and then to determine their alternative use values or their opportunity costs. Finally, if the proposed project output, say lumber, will substitute for other domestic lumber supply, and that other supply will now be exported, then the project output is treated as an export output for valuation purposes (see following section).



## 7.5 EXPORTS

In this case the relevant measure of value is the local w.t.p. for the goods and services which will be purchased with the foreign currency earned. The foreign currency earned is reflected in the FOB value for the exports. If there is a free market exchange rate and no tariffs or subsidies attached to goods or services which will be imported with the foreign currency earned through the project, then the FOB value expressed in foreign currency (say dollars) can be converted to local currency using the market exchange rate that is expected to exist at the time the project output is exported.

However in reality there will seldom be a situation where there is a free exchange rate and no tariffs or subsidies. This means that something other than the existing exchange rate has to be used to convert the FOB value to local w.t.p. terms. For this purpose a shadow exchange rate (SER) can be used.

### 7.5.1 The shadow exchange rate

Before suggesting guidelines for use of a SER, it is necessary to look at how it is derived by national planners. The SER is defined as the real purchasing power of a unit of foreign currency expressed in local market price terms. It measures the average difference between local prices including tariffs and subsidies and prices calculated using the existing exchange rate, i.e., the average level of price distortion caused by tariff barriers. In an economic analysis the analyst is interested in actual w.t.p. or opportunity cost in local price terms. Therefore, the influences of tariffs and subsidies have to be included in the estimates. Sometimes the SER is adjusted to reflect non-tariff barriers, e.g., import and export quotas and controls on buying and selling foreign exchange.

The SER is generally calculated to reflect the average price distortion in the economy, considering all imports and exports. Thus, for example, assume a country situation where the existing exchange rate is set at 10 units of local currency (LC) per unit of foreign currency (say \$). The average level of import tariffs and export subsidies (treated as "negative" tariffs) is calculated to be 10 percent. Simplifying somewhat, it can be assumed that the local currency is actually overvalued by 10 percent by the existing exchange rate. While officially the local price of foreign currency, or the rate of exchange is LC10 per \$1, in fact, when people go to buy foreign goods in the local market, they pay on the average 10 percent more (because of the import tariffs) or LC11 per dollar worth of imported foreign goods. The SER in this case is 11 to 1 in contrast with the existing rate of 10 to 1. Similarly in the case of exports. Assume a project that earns \$100 by exporting lumber. In terms of local currency converted at the existing exchange rate of LC10 per \$, the benefits of the project would be \$100 x LC10 or LC1 000. In fact, given the average tariff distortion of 10 percent, goods and services can be bought with \$100 that are worth \$100 x LC11, or LC 1 100 in terms of local w.t.p. Thus, in terms of the economic analysis, the benefits of the project in terms of local w.t.p. in local prices should be LC1 100 rather than LC 1 000.

Some guidelines for forestry project planners follow. As mentioned in Chapter 5, the SER used in a country should be a general one that reflects the entire trade picture and the average tariff or trade barrier effect on trade, where the average is calculated as a weighted average of all tariffs and subsidies on trade (i.e., tariffs and subsidies

weighted by the amount of the trade to which they apply). Thus, it should be calculated by national planners for use in all project analyses in the country.

If such a national SER is available, it is recommended that the analyst use it. If the analyst believes that he has a strong case for modifying the SER imposed by the Central Planning body, he can try to persuade this body to change it. Until it is changed, he should use the given SER. In any case, he can develop a test of sensitivity of the project to potential alterations in the SER.

If a generally accepted SER is not available in the country (developed by the national planning office or some other national planning body), then the existing exchange rate can be used. The analyst of forestry projects should generally not try to develop a SER of his own, since the task is quite complex, and if it is not done correctly, it could easily lead to distortions and to results which are not comparable with those for other projects. However, he should test the sensitivity of the project results to alternative rates considered to be closer to the actual w.t.p. than the existing rate of exchange.

#### 7.5.2 Valuing exports using FOB values and the SER

As mentioned earlier, the gross amount of foreign currency earned by an export project is measured by the FOB price for the output times the volume of output. In other words, the FOB price becomes the unit value of the export output expressed in foreign currency. Since local w.t.p. for goods and services expressed in local currency is being used to measure economic value, the foreign currency has to be converted to w.t.p. for what the foreign currency can buy in terms of local prices expressed in local currency. This is done by multiplying the FOB value by the SER.

In deriving the FOB value the market to which output will be exported can be determined, and using the CIF price in that market the FOB value for the output at the port of export can be derived. Obviously, if a FOB value already exists at the port of export, that value can be used. If several possible markets are being considered, then the FOB values associated with each can be derived, and if they differ the highest can be picked under the assumption that exports would go to the most profitable market. If the output is intended for several specified markets and they result in different FOB values, then a weighted average FOB value can be used, basing the weights on the proportion of output that will go to each market.

Projects that indirectly result in increased exports can also be considered in this category. For example, assume that the project output of sawnwood will replace other locally-produced sawnwood in the local market and this other sawnwood will now be exported. In this case, the FOB value still provides the relevant basis for measuring benefits, since the project will result in an increase in the nation's exports which will permit expanded imports of other goods and services. Applying the 'with and without' test, the shadow priced foreign exchange value of the exports is the relevant measure of value for the benefits due to the project.

## 7.6 IMPORT SUBSTITUTES

If the project output will substitute for imports which actually would have taken place in the absence of the project, then the correct basis for valuing the output is the foreign exchange savings made possible by the project. The CIF price in foreign currency of the substituted imports is multiplied by the SER (discussed in section 7.5.1) to obtain the local w.t.p. value, just as in the case of exports.

The project output may also substitute for another completely different imported product which has the same use. In this case, the project output can be valued on the basis of the CIF price for the other product times the SER, when appropriate adjustments have been made to equate the use-value of the project output with that of the other product.

For example, assume that project fuelwood will substitute for imported kerosene. In this case, the CIF price for the imported kerosene for which the fuelwood will substitute can be used to derive the shadow price for the fuelwood, by converting fuelwood and the imported kerosene to a common basis, e.g., cost/kilocalorie. An example is given in Table 7.2.

## 7.7 AVOIDING SOME POTENTIAL OUTPUT VALUATION ERRORS

Several of the valuation approaches suggested are based on the assumption that a project's output will substitute for some other good or service. In using this approach the analyst should pay particular attention to the following questions:

- are the goods indeed substitutable technically and in terms of consumer preferences?
- if they are, will the assumed level of consumption (substitution) actually take place ?

With regard to the first question, the analyst can draw on technical information and perhaps carry out a survey of consumer willingness and ability to substitute the two products. For example, some cooking and heating systems might be able to burn kerosene but not be properly designed for wood. In this case, the analyst looking at a fuelwood project that would substitute wood for kerosene would either have to doubt substitutability or suggest to the project planner that the project also include a component for redesign or remodelling of cooking/heating systems, if such is not already included. At the same time he would also want to check very carefully the substitutability of wood for kerosene in terms of some common heating and/or cooking values. Such measures may be calories per unit volume or weight, or it may be in terms of less accurate measures such as "average" amounts needed to cook common foods or to provide heat in homes, etc.

The same types of considerations would be necessary in looking at the substitutability of lumber or plywood for other building materials, domestic paper production for imported paper, etc. For example, a domestic newsprint project is proposed, based on the use of mixed tropical hardwoods. The resulting newsprint would have different quality characteristics than the imported newsprint for which it would supposedly substitute. Is it valid to use the price of imported newsprint to value the domestic (project) output? That will depend on whether the project output would be acceptable as a direct substitute in terms of use. Or assume a project to produce exterior or marine plywood intended as a

Table 7.2

ESTIMATING PROJECT OUTPUT VALUE ON THE BASIS OF THE VALUE  
OF ANOTHER PRODUCT FOR WHICH IT WILL SUBSTITUTE

Project output: Fuelwood

Substitute product: Kerosene, now imported with an estimated CIF price of \$.40/litre (1)

Calorific values: Kerosene: 3 200 kcal/l  
Air-dry wood: 188 000 kcal/m<sup>3</sup>

Inputed substitution  
for wood:

$$\frac{(\$ / m^3)}{188\ 000\ kcal} = \frac{\$.40}{3\ 200\ kcal}$$

or

$$(\$ / m^3) = \frac{(188\ 000 \times \$.40)}{3\ 200}$$
$$(\$ / m^3) = \$23.50$$

(This value could be used for the fuelwood if it is actually going to substitute for imported kerosene. It would be converted to local currency equivalent using the SER.)

substitute for non-treated interior plywood that is being used for exterior uses at present. In this case, the price of the local interior plywood would not be an adequate measure of the value of the project output, since the life (use value) of the two products would be quite different. Thus, the replacement rate over time would be different. A consumer w.t.p. survey would have to establish whether consumers would be willing to pay more for the better use value of the marine plywood. Such a survey would have to establish price-quantity relationships. This type of survey would be needed in any case as part of the market study for the financial analysis, so the additional effort for the economic analysis would be slight.

The last point brings up the second question raised. Assume that it is found that the marine plywood would be substituted for the interior plywood that had been used in exterior uses. Would the same quantity be consumed? This would likely depend on the actual pricing policy adopted for the project output (i.e., a financial consideration). If it were to be sold at the same price as the interior plywood, it might be substituted in equal quantities. But if the price were to be higher (because cost would be higher), then volume would likely be lower. In this case, the analyst has to watch the assumption about quantities of project output that would actually be directly substituted for interior plywood. Similarly, if it is to be sold at a subsidized price below the price of the substitute, volume may increase.

Finally, it should be reemphasized (as was done in Chapter 6 dealing with market prices) that relative values often change over time, i.e., the value estimated for an output today may not be the relevant or appropriate value for some future period, even after taking out the influence of expected general price inflation. Thus, to the extent possible, the analyst should attempt to estimate what likely changes in output values will take place over time due to the same types of factors discussed for market prices in Chapter 6. It is often difficult to project values into the future. There is uncertainty and many unquantifiable variables involved. Often the best thing to do is to assume constant relative values over time and then test the sensitivity of project results to potential changes in values. This is discussed further in Chapter 10, which deals with the treatment of uncertainty.



## Chapter 8

### SHADOW PRICING INPUTS

#### 8.1 INTRODUCTION

This chapter deals with approaches to shadow pricing project inputs. As shown in Figure 5.2, inputs can be classified into five main categories for the purposes of empirical estimation of shadow prices:

- inputs that are imported when no quota exists on imports
- locally produced inputs which would have been exported if not used in the project
- locally produced non-exportable inputs
- imported inputs when a quota on imports exists
- resources (land and labour)

Each of these categories is discussed separately in the following sections. As in the case of outputs there are several categories of inputs that involve foreign exchange effects. The SER as discussed in Section 7.5.1 is used to value such inputs. Specific uses of the SER are discussed below where they are needed.

#### 8.2 IMPORTED INPUTS WHEN NO QUOTA EXISTS

Imported inputs not limited by any quota are valued on the basis of the local value of the foreign currency required to import them. This is measured in terms of the CIF value for the input times the SER. There are two exceptions to this approach:

- In some cases, inputs are financed by a grant which is tied to the project, i.e., a grant which only can be spent on importing the input for its exclusive use in the project. If this is the case, then there is no difference in total foreign exchange availability for other uses with or without the project. Therefore no alternative benefits are sacrificed by using foreign exchange in importing the input. The economic cost to the domestic economy of the input financed by a tied grant is equal to zero.
- When the input is financed with a tied loan, the economic cost does not materialize when the input is paid for (imported), since there is no alternative use permitted (no opportunity cost) for the foreign loan. The cost occurs at the time of repayment of the loan, when alternative imports could have been financed with the foreign exchange used up in paying the debt (principal plus interest).

### 8.3 EXPORTABLE LOCALLY PRODUCED INPUTS

If the input used by the project actually would have been exported in the absence of the project, then the value foregone by the economy by using the input in the project is represented by the reduction in the availability of foreign exchange. The domestic w.t.p. for the imported goods and services foregone is the correct measure of the economic cost of using the input in the project. The basis for this value is the FOB price of the input (the foreign currency earnings foregone) converted to local prices of imported goods/services using the SER.

### 8.4 NON-EXPORTABLE LOCALLY PRODUCED INPUTS

The appropriate value measure for a non-exportable locally produced input (i.e., an input for which local production cost is greater than FOB value or where prohibited by government policy) is related to whether or not use of the input in the project reduces total supply of the input available to the economy. (See input categories C1 and C2 in figure 5.2.)

- If the project's use of the input reduces total supply of the input available to the rest of the economy, then the relevant shadow price of the input is based on the net benefits which are sacrificed (i.e., opportunity cost) in using the input in the project rather than in the next-best alternative use.
- If the project use of the input induces additional local production of the input, then the relevant cost is measured in terms of the value of the resources used up in increasing the supply of the input, i.e., their opportunity costs.

Note that if use of the input in the project induces additional or new imports of the input for use elsewhere in the economy, then the input can be treated as an imported input for valuation purposes, i.e., the foreign currency cost (CIF value) becomes the relevant measure of economic value when converted to local prices using the SER. (This parallels the case of a local consumed project output which induces exports of the same product from other producers.)

### 8.5 IMPORTED INPUT FOR WHICH A QUOTA EXISTS

If there is an import quota affecting an imported input, its value should be measured in terms of the w.t.p. for its contribution to the value of alternative outputs that would have been produced with the input elsewhere in the economy if the project were not implemented. The reasoning is that the total amount of the input allowed by the quota would have been imported with or without the project and, therefore, in these circumstances there would be no net drain of foreign exchange induced by the project. If imports of the input are below the quota, then the quota is ineffective and, from the point of view of the analysis, it does not exist. Thus, the input's CIF value could be used as a basis for valuing the input (see Section 8.2).



## 8.6 RESOURCES: LABOUR

The objective in valuing labour is to arrive at a measure of the value of the benefits foregone by employing labour in the project rather than in its next best alternative use. If labour is hired away from other productive work and there is little unemployment in the project region, the value of the labour in the other work, or the market wage, provides an acceptable measure of opportunity cost for the economic analysis. This chapter discusses situations where these conditions do not hold, i.e., the market wage does not adequately reflect opportunity cost.

### 8.6.1 Unskilled labour

The main questions of interest in shadow pricing unskilled labour relate to the following situations:

- (i) Labour hired in the project is from the pool of unemployed persons in the project region. The value of these unemployed workers is equal to the production foregone by putting them in the project. If they were producing food or materials at home for their own consumption, and they have to give this up when they work in the project, then the value of what they give up is an appropriate measure of opportunity cost. If they were producing nothing (which is an exceptional case), then a shadow price close to zero can be used. The cost will probably never reach zero since there is generally some cost involved in training, housing or otherwise taking care of unskilled labour that has been unemployed for some time. This cost has to be added in somewhere in the accounts as a cost.
- (ii) Labour hired in the project is taken from other productive jobs, but there is unemployment in the project region (i.e., persons willing and able to work in paid jobs). In this case the assumption generally adopted is that even if the project merely hires workers away from other jobs, these other now vacant jobs will then absorb new workers from the pool of the unemployed. Thus, the project will result indirectly in a reduction in unemployment and the labour used in the project should thus be valued in the same way as for (i). Application of the 'with and without' test demonstrates the logic of this approach.
- (iii) Labour is hired only part-time in the project. In the case of unskilled seasonal labour, it is generally desirable to take into account general periods of seasonal employment and unemployment. First, the analyst can determine by observation or from records the periods of general seasonal employment existing in the market area for the labour that will be used in the project. He can then compare these periods with the periods during which temporary employment is required by the project. To the extent that the two periods do not overlap, he can use the shadow wage for unemployed labour as derived above in valuing seasonally unskilled labour employed in the project, since, by definition, such labour is unemployed during the off-season. However, if the project's requirements overlap with the general

period of seasonal employment (for crop harvest, planting, etc.), and if there is no general unemployment during the period of seasonal employment, then he has to attribute a shadow price for seasonal labour employed in the project equal to the actual wage paid for seasonal labour in the regional economy.

A case study from Korea indicates how this was done in the case of fuelwood plantation project. <sup>1/</sup> Since the fuelwood labour requirements overlapped somewhat with the seasonal requirements for agriculture, an average shadow wage rate based on the full seasonal wage rate and the off-season income (monetary and in-kind) of unskilled village labour was used as the shadow wage rate. The weighting was based on the proportion of project employment which overlapped with the period of general seasonal full employment.

In handling these three types of situations, it is necessary to look at the nature of the market and distinguish between unemployment in an economic sense and unemployment in the sense that it appears that people are "doing nothing". In an economic analysis, it is unemployment in an economic sense that matters, and this is determined by both supply and demand. As an example, assume a situation as follows:

In the project region there are some 1 000 persons in the unskilled labour category presently employed. About 100 persons are "unemployed" in the sense that they are not working in paid jobs (i.e., receiving wages). The project will require 10 full-time unskilled workers. How should they be shadow priced? The answer depends partly upon what the apparently "unemployed" workers are willing to work for (i.e., what they give up by going to work in the project). It may very well be that they are producing at home for their own consumption. If they go to work in the project they may have to give up this production (consumption). If there is a competitive labour market (and no minimum wage set by government or unions), then there is no unemployment in an economic sense. Those who are not working feel that spending their time doing other things is worth at least as much as the minimum wage paid in the competitive market. Thus, this minimum wage would provide a reasonable measure of labour value (or opportunity cost for labour) at the margin.

In cases where unemployment exists due to some policy and/or regulation of minimum wages, a shadow wage rate based on alternative production foregone has to be ascertained, and this will likely be lower than the regulated minimum market wage. For example, if a government-set minimum wage is in effect, it may be possible to locate an "informal" competitive labour market in rural areas where the actual wage paid is below the set minimum. This would provide an approximation of the appropriate shadow wage rate. If no informal market can be located, then the analyst will have to rely on rough estimates of what the "unemployed" would give up in terms of other production if they were employed in the project. This information might be obtained from surveys of local community households.

Confusion sometimes arises if the unemployed who will now be employed in the project are receiving unemployment payments (benefits) while they are unemployed. This type of payment is a transfer payment, or a transfer of consumption from some members of

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<sup>1/</sup> Case Study No. 2, FAO 1979

society to others. While it is relevant in a financial analysis carried out from the government's point of view, it will not be relevant in the economic analysis, where the analyst is attempting to estimate the opportunity cost of labour, or the value of consumption foregone by employing labour in the project being analysed.

#### 8.6.2 Professional and Skilled Employees

Professional and skilled employees are required by most projects. In many developing countries there is an acute shortage of this type of employee. It is also common in these countries that the government imposes wage and salary increase limits (salary ceilings). As in all cases where an effective maximum price is imposed, the result is that the willingness of employers to pay the skilled labour might be higher than the current salary level. Skilled persons may be fully employed, but they are being paid less than the producers are prepared to pay, i.e., their real opportunity cost. In such cases the analyst may wish to use a shadow wage or salary level above the market level.

If skilled or professional labour is unemployed in the economy, then it can be treated in exactly the same way as unemployed unskilled labour, i.e., valued on the basis of its opportunity cost without the project.

#### 8.7 RESOURCES: LAND

The appropriate measure of value for land is the highest net return that actually would have been obtained from the land in the absence of the project. The analyst thus needs to estimate what the net return would be from the best actual alternative use. This he uses as the shadow price for land.

In estimating the opportunity cost of land, the analyst can use information obtained from interviews and data on land use in the project region, particularly as such relate to land availability and uses of land similar to the proposed project lands.

In valuing land, the analyst should guard against over-valuation of land cost due to:

- attributing to the land a net value from alternative use which will be obtained from some otherwise idle area if the project is implemented;
- ignoring the fact that in some cases an alternative use which would take place in the absence of the project would not continue over the entire project period;
- forgetting to subtract all costs (other than land) needed to obtain the gross benefits from the best alternative use (i.e., it is the net value foregone which is the relevant opportunity cost).

Each of these points is discussed in greater detail in the following paragraphs.

In many cases, there are no actual alternative uses for lands devoted to forestry projects. This may be because of the low quality of the land for other uses, but it also may be because there is no land pressure in the project area and abundant other lands exist to accommodate other potential uses. For example, suppose there are two large idle land

areas, A and B. It is proposed to put area A into the forestry project. Cattle production in the project region is expanding. The analyst estimates that the project area could support a net return from grazing of \$10/ha/a over the project life. So could area B. If idle area B will likely absorb the foreseeable demand for such grazing land over the life of the project, if the project is undertaken, then there is no cost to society by putting land area A into project use and using area B for the grazing expansion. Thus, the opportunity cost of putting the land into project use would be zero. On the other hand, if the foreseeable expansion of grazing would require more than area B - i.e., if demand for area A is anticipated over the project life - then some cost would have to be attributed to the land area A put into project use, since some net grazing value would be foregone. The timing of this opportunity cost would have to be adjusted to the time when A actually would be needed.

Another potential over-valuation error to avoid relates to the assumption that a piece of land considered for a forestry project will have an alternative use which will continue to be viable over the entire project period. An example will illustrate this type of situation. Consider the case of a tropical land area having poor soils. There may be an immediate alternative annual crop value that would have been obtained in the absence of the project. If such an alternative use would have taken place, then this is an appropriate value to consider for the period during which the use would take place. However, someone knowing little about tropical soils may suggest that the estimated initial annual net crop value foregone should be used as a cost during every year of the forestry project's life - say fifteen years in this example. In general, for most tropical soils and environmental conditions, it will not be possible to have continuous production of annual food crops on the same land without introducing drastic measures, including very heavy applications of fertilizer which would increase costs and reduce potential net returns (i.e., the opportunity cost). The cost of such fertilizer and other treatments could result in the net value of the crop (the opportunity cost) reaching zero after only a few years of initial production. To shadow price land correctly the analyst might develop a shadow pricing schedule for the land such as shown in the hypothetical figures in Table 8.1. Note that the calculations in Table 8.1 would give quite a different answer if it were merely assumed that the opportunity cost per year would be the same over the entire life of the project and equal to the opportunity cost in the first year.

A third potential over valuation error relates to what is included in the opportunity cost calculations. It is the net value foregone which is relevant as an opportunity cost, not the total value of the output foregone. Thus, in a particular situation, a plantation project may be taking land out of crop production where the total or gross value of the crop foregone is \$100/ha/a. To get an appropriate shadow price for the land, the analyst would have to subtract all the costs (other than land) required to bring forth that \$100 of gross value. It may be, because of a depressed price due to over-supply of the crop that the costs would be equal to the \$100 of gross value, in which case the opportunity cost of the land would be zero in terms of the forestry project. Society would not be giving up any net consumption benefits, since the costs would equal the benefits and the net value foregone would be zero.

Table 8.1

SCHEDULE OF NET CROP VALUE FOREGONE FOR USE IN SHADOW PRICING LAND <sup>1/</sup>

Year	Shadow price based on annual net food crop value foregone (\$/ha)
0	\$75
1	\$75
2	\$70 - productivity starting to decrease
3	\$65
4	\$50 - heavy fertilizer application
*	*
*	*
9	\$0 - value of required fertilizer is equal to net crop value increment
10	\$0 - all nutrients removed; soil has essentially become sterile and of no further use for annual crop production
*	*
*	*
*	*
n (end of project)	

<sup>1/</sup> Hypothetical data

## 8.8 CHANGES IN SHADOW PRICES OVER TIME

As indicated in Chapter 6, when market prices are used as a basis for shadow pricing, the analyst should keep in mind that the opportunity costs associated with inputs may change over the life of the project. Such expected changes have to be taken into account.

For example, in the case of land, although there are no apparent alternative uses for the land at the time of appraisal of the project, such uses may easily develop during the project period. Thus, a land cost should be included for the appropriate period. In a typical forestry project, the period of time involved can be substantial - say twenty years or more. Thus, the analyst should be concerned with what developments in the region would likely take place in the future which would make the land valuable for other uses during the project period. For example, even slight shifts in agricultural prices can make previously idle land attractive for agricultural production or livestock grazing, i.e., move the opportunity cost from zero to some positive value. To the extent possible, following the "with and without" principle, the analyst should try to anticipate such future uses and value them so they can be entered as a cost for the project. Note, however, that this does not mean that all idle resources will have some productive use in the future. It is very possible that a shadow price of zero is appropriate. The point is that the analyst needs to consider the possibility that there will be an opportunity cost involved during the project period. In cases of great uncertainty, he may merely wish to test alternative assumptions in a sensitivity analysis (Chapter 10).

Similarly, in situations where there is some indication that the employment situation existing at the beginning of the project will not hold over the entire project period, e.g., unemployment is expected to decrease due to general improvement in economic conditions even without the project, the analyst may wish to make adjustments in the shadow wage rate for latter years of the project. Again, this remains a matter of judgement. If the situation is very uncertain, the analyst may merely wish to consider such possibilities in the sensitivity analysis.

## Chapter 9

### COMPARING COSTS AND BENEFITS

#### 9.1 INTRODUCTION

Once inputs and outputs have been identified and quantities designated in the physical flow table and unit values have been estimated for inputs and outputs (or at least for those for which values can be estimated), the next step is to combine the information from the physical flow and unit value tables into a total "value flow" table.

The value flow table provides total cost and benefit information in a form needed for the calculation of measures of economic efficiency or worth. Development of the value flow tables and measures of economic worth for projects are the subjects of this chapter.

Section 9.2 looks at the derivation and nature of the total value flow table and discusses some differences between this table and the "cash flow" table derived for and used in the financial analysis. Section 9.3 discusses the question of how to treat time in an economic analysis. Section 9.4 looks at the most common measures of project worth which take time into account and discusses their differences and similarities. Section 9.5 discusses the relationships between the most common measures of economic worth of projects.

The discussion in this chapter applies to the situation where a value flow table is being prepared for an entire project (i.e., total costs and benefits are being analysed) as well as to the situation where a component of a larger project is being analysed, i.e., total component cost and benefit comparisons.

#### 9.2 THE "VALUE FLOW" TABLE AND ITS RELATION TO THE "CASH FLOW" TABLE

Chapter 2 mentioned the "value flow" table which displays aggregate values (quantities multiplied by unit-values). Table 9.1, used in an economic analysis of tree-farm plantations in the Philippines, <sup>1/</sup> illustrates the common format for a value flow table. There are three major row headings in a value flow table: benefits, costs, and net benefits (costs). Columns are arranged by years, starting with the initial year of the project, which is labelled "year 0", and ending with "year n", the last year of the project. Thus, the value flow table describes the pattern of project associated real costs and benefits over time, by years. <sup>2/</sup>

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<sup>1/</sup> Case Study No. 1, FAO, 1979.

<sup>2/</sup> See Chapter 3 for further discussion on time period designations and appropriate project period. In this chapter a time interval of one year is used. Other intervals can be used without changing the basic points of the discussion.

Table 9.1

VALUE FLOW TABLE: 10 ha PLANTATION, PHILIPPINE PROJECT  
(value in constant pesos)

	YEARS															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>Benefits</b>																
1. Thinning	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Harvest	-	-	-	-	-	-	-	5523	6174	6174	6810	6810	7434	7434	8046	6174
<b>Total</b>								5523	6174	6174	6810	6810	7434	7434	8046	6174
<b>Costs</b>																
3. Land preparation	295	295	295	295	-	-	-	-	-	-	-	-	-	-	-	-
4. Purchase of seedlings	78	78	78	78	-	-	-	-	-	-	-	-	-	-	-	-
5. Lining/dig/plant	150	150	150	150	-	-	-	-	-	-	-	-	-	-	-	-
6. Replanting	65	65	65	65	-	-	-	-	-	-	-	-	-	-	-	-
7. Fertilizing	200	200	200	200	-	-	-	-	-	-	-	-	-	-	-	-
8. Weeding	275	275	275	275	-	-	-	137	137	137	137	137	137	137	137	137
9. Singling	-	-	-	-	-	-	-	-	50	50	50	50	50	50	50	50
10. Administrative	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
<b>Total</b>	1163	1163	1163	1163	100	100	100	237	287	287	287	287	287	287	287	287
<b>Net Benefits (costs)</b>	(1163)	(1163)	(1163)	(1163)	(100)	(100)	(100)	5286	5887	5887	6523	6523	7147	7147	7759	5887



The bottom row of the table shows for each year the difference between benefits and costs, or the net benefits (costs) for that year. (If costs are greater than benefits for a given year, then the figure appears in brackets, a common way of expressing a negative figure or a net outflow.)

It is instructive to look at the main differences between the value flow table for the economic analysis and the cash flow table used in the financial analysis (as described in Chapter 2). Not only will such a comparison provide insights into the differences between the economic and financial analyses, but it will also be useful in cases where the analyst will adjust directly the cash flow table to derive the economic value flow table. Three types of adjustments need to be made; they involve:

- adding some costs and benefits that are not included in the cash flow table;
- revaluing some costs and benefits in the cash flow table, using shadow prices instead of market prices;
- removing transfer payments from the cash flow table and adjusting for differences in timing of economic and financial costs and economic benefits and financial returns.

The first two of these adjustments have already been discussed (the first in Chapter 4 and the second in Chapters 5, 7 and 8). The third adjustment - the treatment of timing problems and transfer payments which show up in the cash flow table - is discussed below.

The main types of transfer payments of interest are taxes, subsidies, and loan receipts and repayment of loans and interest. Total value flow tables should be adjusted so that taxes and loan costs are not subtracted from benefits (or treated as costs) and so that subsidies and loan receipts are not added to benefits or netted out of costs.

In the case of loans, Squire and van der Tak (1975) explain the adjustments needed as follows:

...the payment of interest by the project entity on a domestic loan merely transfers purchasing power from the project entity to the lender. The purchasing power of the interest payment does reflect control over resources, but its transfer does not use up real resources and to that extent is not an economic cost. Similarly, the loan itself and its repayment are financial transfers. The investment, however, or other expenditure that the loan finances involves real economic costs. The financial cost of the loan occurs when the loan is repaid, but the economic cost occurs when the loan is spent. The economic analysis does not, in general, need to concern itself with the financing of the investment: that is with the sources of funds and how they are repaid.

Similar arguments hold for taxes and subsidies, although one additional point needs clarification to avoid a common confusion. Chapter 5 argued that tariffs (taxes) and subsidies should be considered in deriving measures of local w.t.p., i.e., their effect on local prices should not be removed if they are expected to persist during the period of the project. Why is it now argued that taxes levied on the project and subsidies provided to the project should be removed (or not be considered) in the economic analysis?

The answer is that two different considerations are being dealt with. In the case of derivation of values to use for inputs into the project and outputs from the project, the interest is in measures which reflect local w.t.p. for these items in the existing markets. The effect on w.t.p. of transfer payments is relevant, given the definition of economic value used in EAFP.

On the other hand, in deriving the appropriate economic measure of project worth, the interest is only in real resource flows and real flows of consumer goods or services coming from the project, valued in terms of the opportunity cost and w.t.p. value measures discussed earlier. A tax on the project output value merely means that some of the control over the benefits due to the project are transferred from the project entity to the public sector (government). The real benefits (the increase in consumer goods and services due to the project) do not change because a financial entity pays a tax. To society, the tax is not a cost associated with the project. To the financial entity it is a cost. Similar considerations hold in the case of subsidies given to the project (i.e., where the government shares the money cost of the project). The real costs (the opportunity costs) of the resources used in the project remain the same with or without a subsidy, and these are the costs which are of interest in the economic efficiency analysis.

To summarize, taxes and subsidies do influence the w.t.p. for goods and services (and the size of the market and the local price which is established), but they do not alter the real costs of a project nor the real benefits produced by the project. The two considerations are quite separate.

Depreciation should not be included in the economic analysis (nor should it have been included in the cash flow table). Depreciation is merely an accounting item and represents an internal transfer of some of the money profit from one account to another, in order to provide for replacement of assets. In the economic analysis, it is the real cost of an input that is relevant and its cost is entered at the time it is used in the project.

Finally, it should be pointed out that if the value flow table for the economic analysis is derived directly from the cash flow table, the analyst has to be careful to adjust the timing of entries in the value flow table to take into account the fact that costs in the economic analysis occur at the time resources are actually used in the project and benefits occur when outputs are consumed.

In the financial analysis, costs occur when payments are made, and this may be at some time other than when resources (inputs) are actually used in the project. For example, a given input may be used in the project in year 5, but paid for in years 6 through 8 (on an instalment basis). In the cash flow table, the cash outflow would occur in years 6 through 8, while in the economic analysis, the value of the input should be entered in year 5.

Similarly in the case of outputs or benefits. In the cash flow table for the financial analysis, the cash inflows or returns are entered when they actually occur. A given output may be paid for (to the project financial entity) after (or before) it is actually used (consumed). Thus, the return may appear in the cash flow table in a year that is different from that in which the output actually becomes available. In the economic analysis, the benefit should always be entered in the year in which the output is consumed or used.

These considerations are only of concern when the total value flow table is derived directly from the cash flow table. If the total value flow table is derived from the physical input and output tables and the unit value tables, then financial transactions such as taxes and subsidies will not appear and will thus not be of concern in preparing the total value flow table.

### 9.3 THE NET VALUE FLOW AND THE "TIME VALUE" OF CONSUMPTION

The main focus of the value flow table is on the bottom line, or the net value flow. If all costs and benefits of a project occurred at the same point in time, then the analyst could merely add up costs, add up benefits, and compare them without further adjustment. However, costs and benefits of a project occur over the life of the project. Typically, the life of forestry projects can cover a substantial number of years.

Project costs and benefits which occur at different points in time (in different years) cannot be directly compared. That is because value is intimately associated with time. The "value" of costs and benefits depends on when these costs and benefits occur. Thus, \$1 of benefits occurring ten years from now is not as "valuable" in today's terms as \$1 of benefits occurring immediately. If \$10 is spent today and \$15 is received back tomorrow that may be acceptable. But if \$10 is spent today and the \$15 is not received back for 40 years, that would probably not be acceptable. The amounts are the same. The difference is time.

From Table 9.1 the P 6 523 of net benefits occurring in year 10 are not worth P 6 523 in present value terms, simply because 10 years elapse to get them. It would be preferable to have the P 6 523 to use or to invest today and get a great deal more than P6 523 back 10 years from now.

For any given year, all costs and benefits have the same relative time value in terms of the present since they occur at the same point in time. In terms of the previous discussion, there is no problem in summing costs and benefits for any given year (such as shown on the bottom line of Table 9.1). The problem is how to compare net benefits (costs) which occur in different years. Since time does have an influence on value as considered at any given time, the analyst will want to develop information that permits the decision-maker to compare the costs and benefits which occur at different times and to compare projects which have different cost and benefit streams over time.

More specifically, the question is: How can a value occurring in year  $n$  (some future year) be equated with a value occurring in year 0 (the present), i.e., how can the net benefit (cost) items occurring in the bottom line of the value flow table be compared?

The common approach is to apply an "adjustment" factor to future net costs/benefit values so they can be expressed in terms of values occurring today. The adjustment factor is derived from the accepted time value of money; it is commonly called the "discount rate". The adjustment process is called "discounting".<sup>1/</sup>

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<sup>1/</sup> The discount rate is often called the "interest rate".

#### 9.4 THE DISCOUNT RATE

Since EAFP uses consumer's willingness to pay for goods and services as the common yardstick for valuing both costs and benefits, the discount rate used to discount costs and benefits should be the "consumption rate of interest". This rate should measure the discount attached to having additional consumption next year rather than this year. The appropriate magnitude of this discount rate (or rate of interest) is determined by a number of factors, including society's preference for present consumption at the expense of more rapid growth (higher savings and investment now with higher consumption in the future).<sup>1/</sup>

As it turns out in practice, just as in the case of the SER, the forestry project analyst will generally not have to concern himself with the derivation of an appropriate consumption rate of interest (or shadow discount rate) to use in his analysis. The rate used should be one that is in general use in the project country. Thus, the analyst should obtain the appropriate discount rate from a central planning unit (e.g., national planning office) or from his administrative agency. <sup>2/</sup>

At the extreme, if there is no discount rate available from the central planning office at the time the analysis is being undertaken, the analyst can pick a rate such as 8 or 10 percent and use that in the main analysis, and then test the sensitivity of the worth of the project to alternative rates of discount. (As will be discussed later, one widely used measure of economic efficiency does not directly require determination of the appropriate discount rate in order to calculate the measure).

There is sometimes a tendency to argue for use of "lower" discount rates in forestry project analyses. The argument is that there are certain "non-quantifiable benefits" from such projects which justify the use of a discount rate that is lower than the one used to evaluate other projects in the general economy. <sup>3/</sup> This is not recommended. Instead, analysts should use the established or acceptable discount rate used for evaluation of other projects and then discuss in qualitative terms the "unique" conditions associated with their project that make it "different" from other projects. This forces analysts and project planners to be explicit about their assumptions, thus avoiding the possible hiding of the efficiency shortcomings of a project behind a lower than normal rate of discount.

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<sup>1/</sup> See Squire and van der Tak 1975, p. 27.

<sup>2/</sup> This recommendation provides a convenient excuse for not getting into the problems involved in determining the appropriate rate of discount. Since there is no general agreement among economists or policy makers concerning the appropriate derivation of the discount rate to use for public projects, it would, in any case, be futile to try to resolve the problem in this type of guide. An excellent review of the arguments is provided in Mikesell 1977.

<sup>3/</sup> The same argument is often used by planners in the water resources field.

## 9.5 MEASURES OF PROJECT WORTH CONSIDERING TIME VALUE

Several indexes or indicators of project worth which take the influence of time into account (i.e., involve discounting) are in common use. There is no single measure of a project's worth which is universally accepted, since all share the characteristic of providing only partial information on project performance. Different indicators are needed and used for different purposes. There are, however, two measures that are widely used in economic analyses. <sup>1/</sup> These are the net present worth (NPW), and the economic rate of return (ERR). Since both are derived from the same basic data, namely, the project's costs and benefits, the two measures are intimately interrelated. The analytical information they provide is, however, somewhat different because of the different ways in which they combine cost and benefit data.

This section discusses the process of discounting and then the two commonly used measures of project worth. Other, specialized indicators of project performance, e.g., related to employment, foreign exchange effects, etc., are discussed elsewhere. <sup>2/</sup>

### 9.5.1 Discounting costs and benefits - deriving "present value" estimates

The process of adjusting a future value to the present is called discounting. The resulting "adjusted" value is called "present value" (PV).

The basic formula for discounting is the following:

$$PV = FV_n \left( \frac{1}{(1+i)^n} \right)$$

where

PV = present value

FV<sub>n</sub> = future value in year n

i = discount rate (expressed in decimal form)

n = number of years until future value occurs

$\left( \frac{1}{(1+i)^n} \right)$  is commonly called the "discount Multiplier"

Given a discount rate of 8 percent, the present value of a \$100 payment occurring 2 years from now can be calculated as follows:

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<sup>1/</sup> A third measure which some institutions use is the benefit-to-cost ratio. It is not dealt with further in EAPP, although its derivation is considered in Appendix D.

<sup>2/</sup> Papers by McGaughey and Schuster in FAO, forthcoming.

$$PV = \$100 \left( \frac{1}{(1.05)^2} \right)$$
$$PV = \$100 \left( \frac{1}{(1.1664)} \right) = \$100 (.8573) = \$85.73$$

If the 8 percent discount rate represents the consumption rate of interest, then the result,  $PV = \$85.73$ , indicates that \$100 of consumption occurring 2 years from now is equivalent in present value terms to \$85.73 of consumption occurring today. Put another way, it can be said that society is indifferent between (a) consuming today goods and services valued at \$85.73 and (b) waiting two years and being able to consume \$100 worth of goods and services. In other words, \$10.43 more of goods and services would be required 2 years from now (or a total of \$100 worth) in order to forego \$85.73 of consumption at present.

In this discounting example the value of  $\left( \frac{1}{(1.08)^2} \right)$  was calculated directly.

There are tables prepared and widely available which give the value of the discount multiplier  $(1/(1+i)^n)$  for a wide range of interest rates and years. Further, it can also be calculated with simple pocket calculators, if they have a constant or a  $y^x$  key. Thus, the analyst will have no problems deriving the value of the discount multiplier for any number of years. For example, using Table 9.2,  $1/(1.08)^2$  is equal to 0.8573, and this value times \$100 gives the result of \$85.73 arrived at earlier.

The basic discounting formula and tables are all that is needed to derive a NPW or an ERR for a project. However, in some cases, other formulas - derived from the above basic formula - can provide useful shortcuts in carrying out calculations. For example, sometimes equal annual or periodic payments are associated with a project for a number of years during its life. In this case, there are formulas and tables which provide the present value of such payments without having to discount each of the annual or periodic amounts separately. Similarly, in some cases the analyst will want to find an annual equivalent of a given value occurring at some time, or to find the present value of an annual series of payments occurring every year. The most common of these formulas are shown in Appendix B.

### 9.5.2 Net Present Worth

Going back to the Philippines tree-farming project example and its value flow (Table 9.1), and using the basic discounting process described, a measure of the present value (PV) of all net benefits (costs) occurring in the various years of the project can be developed once an appropriate discount rate has been chosen. If a discount rate of 5 percent is used, the present value of each of the net future benefit (cost) entries is as shown in row 2 of Table 9.3. Adding these items up (taking into consideration whether they are positive or negative) the NPW for the project is P29 310.

What does this NPW of P29 310 indicate? It indicates that, given the assumptions concerning the opportunity costs of the resources used in the project and the w.t.p. for the project output, this project will return a net surplus of P29 310 of consumption benefits in present value terms taking into account the assumed consumption rate of

Table 9.2

DISCOUNTED SINGLE PAYMENT MULTIPLIER -  
THE VALUE OF A ONE DOLLAR PAYMENT DISCOUNTED FOR N YEARS

YEARS	RATE OF INTEREST			
	.045	.050	.055	.060
1	.95694	.95238	.94787	.94340
2	.91573	.90703	.89845	.89000
3	.87630	.86384	.85161	.83962
4	.83856	.82270	.80722	.79209
5	.80245	.78353	.76513	.74726
6	.76790	.74622	.72525	.70496
7	.73483	.71068	.68744	.66506
8	.70319	.67684	.65160	.62741
9	.67290	.64461	.61763	.59190
10	.64393	.61391	.58543	.55839
11	.61620	.58468	.55491	.52679
12	.58966	.55684	.52598	.49697
13	.56427	.53032	.49856	.46884
14	.53997	.50507	.47257	.44230
15	.51672	.48102	.44793	.41727
16	.49447	.45811	.42458	.39365
17	.47318	.43630	.40245	.37136
18	.45280	.41552	.38147	.35034
19	.43330	.39573	.36158	.33051
20	.41464	.37689	.34273	.31180
21	.39679	.35894	.32486	.29416
22	.37970	.34185	.30793	.27751
23	.36335	.32557	.29187	.26180
24	.34770	.31007	.27666	.24698
25	.33273	.29530	.26223	.23300
26	.31840	.28124	.24856	.21981
27	.30469	.26785	.23560	.20737
28	.29157	.25509	.22332	.19563
29	.27902	.24295	.21168	.18456
30	.26700	.23138	.20064	.17411
31	.25550	.22036	.19018	.16425
32	.24450	.20987	.18027	.15496
33	.23397	.19987	.17087	.14619
34	.22390	.19035	.16196	.13791
35	.21425	.18129	.15352	.13011
36	.20503	.17266	.14552	.12274
37	.19620	.16444	.13793	.11579
38	.18775	.15661	.13074	.10924
39	.17967	.14915	.12392	.10306
40	.17193	.14205	.11746	.09722

Table 9.2 (continued)

YEARS	RATE OF INTEREST			
	.070	.080	.090	.100
1	.93458	.92593	.91743	.90909
2	.87344	.85734	.84168	.82645
3	.81630	.79383	.77218	.75131
4	.76290	.73503	.70843	.68301
5	.71299	.68058	.64993	.62092
6	.66634	.63017	.59627	.56447
7	.62275	.58349	.54703	.51316
8	.58201	.54027	.50187	.46651
9	.54393	.50025	.46043	.42410
10	.50835	.46319	.42241	.38554
11	.47509	.42888	.38753	.35049
12	.44401	.39711	.35553	.31863
13	.41496	.36770	.32618	.28966
14	.38782	.34046	.29925	.26333
15	.36245	.31524	.27454	.23939
16	.33873	.29189	.25187	.21763
17	.31657	.27027	.23107	.19784
18	.29586	.25025	.21199	.17986
19	.27651	.23171	.19449	.16351
20	.25842	.21455	.17843	.14864
21	.24151	.19866	.16370	.13513
22	.22571	.18394	.15018	.12285
23	.21095	.17032	.13778	.11168
24	.19715	.15770	.12640	.10153
25	.18425	.14602	.11597	.09230
26	.17220	.13520	.10639	.08391
27	.16093	.12519	.09761	.07628
28	.15040	.11591	.08955	.06934
29	.14056	.10733	.08215	.06304
30	.13137	.09938	.07537	.05731
31	.12277	.09202	.06915	.05210
32	.11474	.08520	.06344	.04736
33	.10723	.07889	.05820	.04306
34	.10022	.07305	.05339	.03914
35	.09366	.06763	.04899	.03558
36	.08754	.06262	.04494	.03235
37	.08181	.05799	.04123	.02941
38	.07646	.05369	.03783	.02673
39	.07146	.04971	.03470	.02430
40	.06678	.04603	.03184	.02209



Table 9.3

NET PRESENT WORTH - PHILIPPINE PROJECT. (5 PERCENT DISCOUNT RATE; VALUE IN CONSTANT PESOS)

	Y E A R S															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Net Benefits (cost) <sup>1/</sup>	(1163)	(1163)	(1163)	(1163)	(100)	(100)	(100)	5286	5887	5887	6523	6523	7147	7147	7759	5887
2. Present value of Net Benefits (costs) <sup>2/</sup>	(1163)	(1107)	(1055)	(1055)	( 82)	( 78)	( 75)	3757	3784	3795	4004	3814	3980	3790	3919	2832
NPW = 29310 <sup>3/</sup>																

<sup>1/</sup> Last row of Table 9.1

<sup>2/</sup> Item in row 1 divided by  $(1.05)^n$  for years 1-15.

<sup>3/</sup> The sum of items in row 2.

interest (discount rate) of 5 percent, or the relative weight which society places on present consumption versus investment and future consumption. By using the discount rate it has ensured that the NPW result is comparable with those obtained for other projects that would involve different cost and benefit streams over time, i.e., the effect of different time values associated with consumption gained or foregone at different times in the future have been eliminated.

In general, given the above, it can be said that in economic efficiency terms any project that provides a positive NPW is an efficient use of the resources involved, assuming that each separable component also has a  $NPW \geq 0$  and the project is the least cost means of achieving the particular benefits. (See Chapter 2 for review of the three conditions for economic efficiency.)

While a project meeting these conditions is economically efficient, it still may not be chosen for implementation. That depends on the total budget available and the NPW associated with other projects on which the budget could be spent (see Section 9.5.4).

A project for which the estimated NPW is negative is not economically acceptable. The negative NPW indicates that there are better uses for the resources involved in the project, i.e., given their opportunity costs and timing and the discount rate, they could be used elsewhere to produce more consumption benefits in present value terms.

### 9.5.3 The Economic Rate of Return

In the previous example of NPW calculation, the NPW was P29 310 when a 5 percent discount rate was used. The question could be asked: What rate of discount would have to be used to obtain a NPW of zero, i.e., what is the implied discount rate that would make the PV of project benefits equal the PV of project costs? That rate is called the internal economic rate of return, or the ERR. It is essentially a "breakeven" discount rate in the sense that the PV of benefits equals the PV of costs.

One of the most commonly used measures of project worth in a financial analysis is the internal financial rate of return (FRR). It is comparable to the ERR in terms of derivation, although it means something slightly different. The FRR shows the investor what the average earning power is associated with a given investment of his funds. More specifically, it is the average rate of return on the invested funds outstanding per period while they are invested in the project, or that rate of interest which makes the NPW (using market prices) equal to zero.

Thus, a FRR of 10 percent indicates to the investor that he will receive \$.10 back per year for each \$1 invested during the years in which the investment is left in the project. This is a useful measure for an investor, since it provides a clear means for comparing alternative uses of his funds. Say that his best use of funds, other than putting them in the project, is to put them in the bank at 6 percent interest per year. He compares the rate of return on the project (10 percent) with the rate of return from the bank (6 percent), which is called the alternative rate of return (ARR), or his opportunity cost of capital <sup>1/</sup>, and he then knows that the project use will give a greater return than the best alternative use. <sup>2/</sup>

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<sup>1/</sup> This concept of "opportunity cost" is analogous to the one used throughout EAFF.

<sup>2/</sup> The FRR and the ARR should be calculated net of inflation, i.e., in real terms.

The ERR is similarly interpreted, except it shows the decision-maker what society can expect to receive back in consumption benefits for a given investment of its scarce resources. In other words, if the calculated ERR is 10 percent, this tells the decision-maker that the average annual return of consumption benefits on resources outstanding per period while they are invested in the project will be \$10 for every \$100 of resources invested and left in the project. The ERR will be compared with the consumption rate of interest to see if the project earns enough to make it worthwhile to invest (forego consumption now in favour of future consumption). Say that the relevant consumption rate of interest is 5 percent. This means that society wants to get at least a 5 percent rate of return on investment of its resources to make it worthwhile to forego present consumption in favour of investment and future consumption. If the ERR turns out to be 10 percent for a given project, this means that on the average society will get more than the minimum acceptable 5 percent back. Thus, the project is economically efficient in terms of its use of scarce inputs assuming that the other two conditions for economic efficiency are met.

The Philippine example is used to show how the ERR is calculated. The undiscounted net benefit (cost) items for each year are shown in row 1 of Table 9.4. By discounting these by 32 percent the PV figures as shown in row 2 are obtained. If these values are totalled, the NPW is zero which by the definition occurs when the economic rate of return is used to discount all net benefits(costs). Thus, 32 percent is the ERR.

The calculation to find the ERR or the interest rate which makes NPW equal to zero has to be by trial and error.<sup>1/</sup> Since the NPW is positive at 5 percent (Table 9.2) the ERR must be greater than 5 percent. <sup>2/</sup> By using a simple bracketing approach, the mechanics of which are shown in Appendix C, the estimated ERR is obtained.

What does the ERR of 32 percent indicate in the Philippine example? It represents the "yield" of the resources used in the project over the project period. It means that \$1 invested in the project will generate \$0.32 per year for every year that the \$1 remains committed to the project. It also indicates that this return is greater than the assumed consumption rate of interest of 5 percent, which measures the trade-off between consumption in a given year  $t_0$  and consumption delayed until the following year,  $t_1$ . Society should be interested in leaving its resources in a project such as this rather than consuming them now because it will receive more back in the future than is needed to satisfy its perceived trade-off between present and future consumption.

Just because a project has an ERR that exceeds its consumption rate of interest, this does not automatically mean that the project will be accepted and implemented. It does mean that the project represents an efficient use of resources, given acceptance of the consumption rate of interest as being the relevant one. <sup>3/</sup> However, there is always the possibility that other uses of a limited budget can provide higher rates of return than the project being studied.

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<sup>1/</sup> Some pocket calculators now available will calculate the ERR directly.

<sup>2/</sup> If  $NPW > 0$ , then  $ERR > i$  used;  
If  $NPW = 0$ , then  $ERR = i$  used;  
If  $NPW < 0$ , then  $ERR < i$  used.

Where "i" equals the discount rate used.

<sup>3/</sup> Assuming that the other two conditions for economic efficiency are met.

Table 9.4

## ECONOMIC RATE OF RETURN (ERR) - PHILIPPINE PROJECT

	Y E A R S															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Net Benefits (costs)	(1163)	(1163)	(1163)	(1163)	(100)	(100)	(100)	5286	5887	5887	6523	6523	7147	7147	7759	5887
2. Present value of Benefits (costs) discounted at 32%	(1163)	( 881)	( 667)	( 506)	( 33)	( 25)	( 19)	757	639	484	406	309	255	193	159	92
3. NPW at 32% $\checkmark$	0															

$\checkmark$  i.e., sum of the present values of net benefits (costs) discounted at 32% per year.

The above two measures of economic worth can be used to analyse the economics of project components and entire projects. When NPW is used, the usual approach - as discussed in Chapter 2 - is to analyse components first, making sure that all separable components ending up as part of a project "package" have NPW's at least equal to zero. Once a set of economically efficient project components has been assembled into a project, then exactly the same approach can be used in calculating the NPW or ERR for the total project. As mentioned, the least cost condition for economic efficiency does not involve calculation of a NPW or an ERR. Rather, the costs of alternatives are compared directly to find the least cost alternative. Some analysts prefer to treat the costs avoided by undertaking the project instead of the least cost known alternative as the "benefits" of the project alternative being analysed. These "benefits" are then used in calculating a NPW for the project alternative being analysed. If it is positive then this shows that it is the least cost alternative among the known set of alternatives. If the NPW is zero, then the least cost alternative to the project has costs exactly the same as the project being analysed. If the NPW is negative, then the alternative to the project being analysed has lower costs. While there is nothing conceptually wrong with this approach, it can become confusing; thus, it is recommended that costs of alternatives are compared directly. (Confusion can arise in cases where the project has to be compared with other entirely different projects which are competing for the same budget. In point of fact, the costs avoided by undertaking one alternative rather than another to achieve a given output do not necessarily represent a true measure of benefits.)

#### 9.5.4 Relationships between NPW and ERR

NPW and the ERR represent alternative means of presenting the relationship between costs and benefits. In mathematical terms the relationship between the two is as follows:

$$\text{Net present worth} = \sum_{t=0}^n \left[ \frac{(B_t - C_t)}{(1 + i)^t} \right]$$

Economic rate or return is that discount rate  $d$  such that

$$\sum_{t=0}^n \left[ \frac{(B_t - C_t)}{(1 + d)^t} \right] = 0$$

where

$B_t$  = benefits in each year  $t$

$C_t$  = costs in each year  $t$

$n$  = number of years to end of project

$i$  = discount rate or consumption rate of interest (CRI)

$d$  = the internal economic rate of return (ERR).

From these definitions, the following relationship holds: When NPW = zero, then the ERR = CRI, or the consumption rate of interest (or the discount rate used in calculating the NPW). Given the definitions and the above relationship between the two measures, what can be said about the information provided by each of them in terms of the three conditions for economic efficiency mentioned in Chapter 2 ? <sup>1/</sup>

Neither of the two measures of project worth tell anything about the least cost (or third) condition for economic efficiency. This condition has to be studied in a separate analysis undertaken in the design and preparation stages of the project. (See Chapter 11).

Both measures do provide information related to whether PV of benefits are less than, equal to, or greater than the PV of costs for a project component and the total project. In point of fact, they both provide exactly the same answer to the question of whether or not a project or project component is economically efficient in terms of these first two conditions. If a project is accepted as being efficient in terms of one measure (i.e.,  $NPW \geq 0$ ), it will also be acceptable in terms of the other measure (i.e.,  $ERR \geq CRI$ ) and vice versa.

So far in the discussion, it can be seen that either of the two measures could be used equally well to determine whether a project is economically efficient (assuming no lower cost means to achieve the project objectives is known to exist). Thus, the choice of which of the two to calculate and use is unimportant in terms of this basic question, although the analyst obviously has to calculate the measure commonly used by the institution for which he is carrying out the analysis.

Each of the two measures provides additional information that the other does not provide. The NPW measure, in contrast to the ERR, provides information on the absolute value or magnitude of the present value of net benefits of a project. Yet it tells nothing about how large the cost will be to achieve the NPW. Thus, there could be a project with a NPW of \$1 000 which costs \$2 million or one with the same NPW that costs \$5 000. Both would have the same NPW. On the other hand, the ERR is a relative measure of project worth, which gives information on the returns per unit of cost and thus provides more relevant information for comparing the benefits which can be expected from alternative uses of a limited budget. Therefore, it is more useful for ranking independent project alternatives when it is not possible for budget or other reasons to undertake all projects that meet the basic economic efficiency conditions.

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<sup>1/</sup> These are -

- (1) Total present value of project benefits must be equal to or greater than total present value of project costs.
- (2) Each separable project component must have PV of benefits at least equal to PV of costs.
- (3) There is no lower cost means of achieving the project benefits.

This latter point brings up an important consideration. Because a project alternative is shown to be economically efficient, using either of the two measures of economic efficiency or worth, that does not mean that the project will be undertaken. Budget considerations as well as many other factors will enter the picture and the decision-making process. If a number of alternative uses (projects) exist for a limited budget, some system of ranking projects in terms of their economic worth has to be developed to provide guidance in choosing from the set of alternatives that has been shown to meet the basic efficiency conditions. The two measures of project worth do not necessarily provide the same order of ranking for projects. In point of fact, the NPW measure provides no guidance in terms of ranking projects that are not mutually exclusive.<sup>1/</sup>

The whole problem of choice among alternative uses of a given budget is complex and goes beyond the confines of an economic analysis of a given project alternative. The choice of ranking system is often made on the basis of political objectives. Even in terms of the economic efficiency objective, one or the other of the two measures is often chosen for ideological reasons or because it is "simpler to understand".

While consideration of choices among projects for a limited budget, i.e., decision-making, is beyond the subject of EAFP the following points are emphasized:

- (i) Neither of the two measures of project worth discussed provide information related to the third condition for economic efficiency; namely, that there is no known lower cost means to achieve the project benefits. This condition needs to be tested by other means - generally through a cost comparison as described in Chapter 11.
- (ii) Both measures of project worth provide the same answer to the question of whether or not a given project alternative or project component is economically efficient in and of itself (assuming that the third condition is met).
- (iii) Since the NPW provides an absolute measure of project worth, while the ERR only provides a relative measure of average expected returns per unit of cost (and no information on the absolute size of the net benefits), it is recommended that the analyst should calculate both the NPW and the ERR for projects. Regardless of which measure will be used by decision-makers in making project decisions, information on both absolute and relative economic efficiency is useful.
- (iv) Finally, while calculation of the NPW requires that the analyst has an estimate of the appropriate discount rate (or CRI) in hand, the discount rate is not required in order to calculate the ERR. Still, in order to make use of a calculated ERR, i.e., in order to determine whether or not the project (or project component) being analysed represents an economically efficient use of resources, some estimate of the CRI is needed, since the ERR only has meaning in the context of the other possible uses for resources.

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<sup>1/</sup> Mutually exclusive project alternatives are those for which only one of a set of alternatives can be undertaken. For example, two projects which envisage using the same area of forest land are mutually exclusive alternatives. Only one of the two can be undertaken at a given time.





## Chapter 10

### TREATMENT OF UNCERTAINTY

#### 10.1 INTRODUCTION

Mention has been made that (a) identification and valuation of costs and benefits for any project involve looking into the future, (b) estimates of future values are subject to uncertainty, and (c) the analyst needs to recognize and to treat explicitly the uncertainty surrounding his forecasts of future events and values. This chapter considers how to treat uncertainty in a project analysis. The main technique suggested is sensitivity analysis, or the testing of the sensitivity of the chosen measure(s) of project worth to alternative assumptions about values of inputs and outputs and various technical relationships, i.e., how will the value of the NPW or ERR change if the assumed value(s) of a given parameter (group of parameters) is (are) changed?

Uncertainty refers to the fact that the analyst cannot be sure today about anything that is going to happen in the future. Or, because of inadequate information, he cannot be sure about past and present events which he needs as a basis for forecasting future conditions. Using available information relating to past events he makes estimates (or guesses) of what is likely to happen - what future demand for pine sawnwood will be, what the cost of labour will be, how natural hazards will affect a plantation project, etc. However, he is never certain how close his estimates will be to what actually will happen. There is always some uncertainty involved.

The analyst may feel more confident about some estimates than others, probably because he has more experience (more accurate observation of past events and trends) on which to base the estimates. In some cases he may even have enough quantitative information on past occurrences to be able to estimate the statistical probability of occurrence of some future event. A situation where this is possible is often referred to as a situation of "risk". In contrast, when there is little or no basis for deriving quantifiable probabilities, there is a situation of "uncertainty".

While this distinction between risk and uncertainty is useful in conceptual discussions, it may merely serve to confuse the analyst dealing with a real project, since in reality he is dealing with a continuum from one extreme where probabilities of occurrence can be quantified (e.g., in cases where actuarial evidence is available) to the other extreme where no information is available on which to base probability estimates. In most cases, the forecasting problems faced in project planning fall somewhere between situations of risk and total uncertainty.

10.2

PURPOSE OF TREATING UNCERTAINTY

Using information which has been generated with time and funds available for the analysis, the analyst identifies and then values the inputs and outputs associated with the project being analysed (Chapters 4 through 8). The resulting "expected" values, i.e., those considered to be most likely to occur, are then used in the initial calculation of the chosen measure(s) of project worth (Chapter 9). To make a complete and useful economic analysis the analyst also has to provide some idea of what would happen to the chosen measures of project worth or efficiency if the actual values of various inputs and/or outputs turn out to be different from the expected values used in the analysis. If a "reasonable" change in the assumption about the expected value for a given parameter (or value of a combination of parameters) is "critical" in terms of the expected measure of project worth or efficiency, he generally will want to take some steps to reduce the uncertainty. The term "reasonable" in this context refers to an estimate of what the possible values are for a parameter around the expected value used in the basic analysis. The term "critical" generally refers to the point where the measure of project worth or efficiency moves from positive to negative (or vice versa) in terms of the relevant decision criterion. <sup>1</sup>

As an example, assume a 20-year plantation project where labour is a major cost component. The expected value of labour used in calculating the NPW of P1 200 for the project is P2 per day. This value (shadow price) for labour is based on a reduction of 50 percent in the current actual wage to account for high unemployment in the project area. The P2 per day figure is used for the entire project period. However, looking at developments in the project region over the past 10 years, and considering planned developments in the region, it is felt that, even if the project being analysed were not undertaken, unemployment may be reduced gradually over the project life. Thus it is reasonable to test the sensitivity of the project NPW to an assumption that labour value will gradually increase to P4 (the actual wage level) by year 10 and then continue at that level until the end of the project (10 more years). Note that no quantitative basis exists on which to estimate how the wage rate will change in the future, with or without the project. The different wage rate assumption used in the sensitivity analysis is considered "reasonable" on an intuitive basis. Most such judgements have to be made on an intuitive basis. The analyst may want to test several other wage rate assumptions in addition to the P4 per day, for example, an increase beyond P4/day for the last ten years of the project. That will depend on his judgement, the time and funds available for the analysis, and the results of the sensitivity analysis using the initial "reasonable" assumption concerning possible changes in labour value (from P2 to P4/day). If the project outcome is not sensitive to this assumption, then it will not be sensitive to a change in the expected labour value that is less extreme than P4 per day. Thus, there will be no need to test other, less extreme values. However, more extreme values can be tested.

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<sup>1</sup> For example, when the NPW moves from positive to negative, using the guiding discount rate to discount costs and benefits, or when the ERR falls below the discount rate used for evaluating public projects.

### 10.3 GUIDELINES FOR TREATMENT OF UNCERTAINTY

The following practical systematic approach to analysing uncertainty is recommended. It involves three steps which are explained in more detail later:

- (i) identify likely major sources of uncertainty for the project being analysed and for each source establish some estimate of a reasonable range of values for the parameters involved;
- (ii) carry out a sensitivity analysis for the project using various combinations of different assumptions concerning the values of the parameters associated with the major sources of uncertainty. Analyse in more detail the parameters for which changes in value assumptions are critical in terms of project outcome;
- (iii) determine appropriate ways of changing the design of the project or modify it to eliminate or reduce the major sources of uncertainty which are critical in terms of project outcome.

An underlying rationale for this approach is avoidance of unnecessary expenditure of funds on detailed analysis of parameters which do not appear to have much influence on the outcome of the project decision. The sensitivity analysis provides a low cost means to identify project parameters in order to design a sound, workable project, and to understand and reduce the uncertainty surrounding the project outcome.

The degree to which further information is generated on various parameters to which the project outcome is sensitive will ultimately depend on the budget available for project preparation and appraisal, the estimated impact of uncertainty on project outcome, and the particular orientation of the institution undertaking the analysis. The steps suggested provide a logical framework for the process, regardless of the funds and effort devoted to the analysis and the orientation of the analysis.

### 10.4 IDENTIFYING LIKELY MAJOR SOURCES OF UNCERTAINTY

From the planner's point of view, a useful distinction can be made between controllable and uncontrollable uncertainty. It may be possible to assess and to account for uncontrollable uncertainty in the appraisal of, and decision on, a project. However, nothing can be done within a given project framework to alter the underlying conditions which cause it. Controllable uncertainty, on the other hand, relates to factors which can be changed within the design of the project itself.

From a practical point of view, the analyst and decision-maker are mainly interested in how uncontrollable uncertainty could and should affect the decision whether or not to undertake a particular project and how controllable uncertainty can and should be handled in project design.

Uncertainty is associated with the availability and timing of most inputs and outputs, relationships between inputs and outputs (production functions), their prices (or values), and even the objectives of the project. However, it is obviously difficult and expensive to deal with uncertainty associated with every factor involved in a project.

Thus, a first step is to identify systematically the likely major categories of uncertainty associated with a proposed project and to make an initial assessment of their potential importance to the decision on a particular project being studied.

In forestry projects some of the main types of uncertainty which may be important relate to:

- (i) Natural factors such as wind, rain, fire, insects, diseases, natural variation between species and in a given species grown in different locations. These elements of uncertainty are often particularly important for plantation projects since the period between investment and return (harvest) can be long. (In some cases these factors can be analysed in terms of probabilities.)
- (ii) Technology and productivity factors related to processing different types of wood, input-output relationships in tree growing, processing yields, effects of alternative technologies (including silvicultural systems) on non-wood values derived from forests, labour productivity, transportation systems, etc.
- (iii) Financial and economic factors related to values assumed for inputs and outputs, availability and cost of capital, etc.
- (iv) Human factors related to labour availability and cost, the ability of man to forecast future events (wood volume availability, markets, etc.), and, most important, management capability.

The potential importance of any of these sources of uncertainty will depend on the circumstances surrounding the particular project being analysed. Theoretically, the analyst could test the sensitivity of project outcome to changes in assumptions concerning any input or output parameter or combination of such. In practice, the sensitivity analysis will be limited to a few major potential sources of uncertainty for any given project. The analyst has to use his own judgement in deciding on which parameter values he will test in the sensitivity analysis, given his time and budget constraints. If he is particularly uncertain about future labour values, for example, and labour is an important input item in the project, then he would likely carry out a sensitivity analysis for alternative assumptions concerning future labour value (see previous example). Similarly, he also should analyse the impact on project worth or the chosen measure of economic efficiency of changes in assumptions concerning output values, since generally these have the greatest impact on project outcome. There are no rules which can be made for choosing the parameters or combinations to be tested. The FAO case studies provide some examples of choices of items tested in a variety of actual forestry project situations.

In general, if an acceptable NPW and/or ERR is obtained for a project, using the initial estimates of parameter values (the "expected" values), then the analyst will be interested in testing alternative value assumptions that are less favourable in terms of project outcome, i.e., higher cost assumptions and/or lower benefit assumptions. The results provide some indication of how large unexpected cost increases or benefit value reductions would have to be to have a critical effect on the chosen measure(s) of project worth (see previous definition of "critical").

To summarize, the analyst first assesses what the main elements of uncertainty and risk are likely to be for the proposed project. This type of assessment may uncover some common problems, e.g., delay in start-up, potential factor cost increases, wood supply bottlenecks, market uncertainties, etc. Such information provides the analyst with a first approximation of the factors which should be tested in the sensitivity analysis. The analyst then looks at the relative magnitude and timing of various input and output items (which can be identified from the value flow tables for the project being analysed) and lists all those which represent a significant part of project benefits or costs. He then makes an initial estimate of a range of values which could reasonably be expected for each, relying on past experience and projected trends. At this stage, he should err on the side of making the range too broad, rather than too narrow - narrowing can occur in later stages of the analysis. He also makes some estimate of the interdependence of the values of the input and output factors, e.g., the extent to which lower or higher prices for some inputs and outputs are associated with lower or higher prices for other inputs and outputs.

In practice, he generally ends up with a limited number of major parameters which will be tested in the sensitivity analysis. As mentioned, the case studies cited in Appendix A provide some examples of practical sensitivity analyses for some actual forestry projects.

#### 10.5 THE SENSITIVITY ANALYSIS

Using the list of parameters and estimates of the reasonable range of values for them (as developed in the previous step), the analyst then carried out the sensitivity analysis. A number of computer programmes are available for handling the calculations. However if systematically organized, it is comparatively simple to carry out the analysis using a hand calculator. There are also programmable hand calculators which can easily handle the complex calculations involved in a sensitivity analysis. If time permits, it is better to include a number of sensitivity analyses rather than a few, since sometimes it is not easy to anticipate the factors to which the project outcome is sensitive.

In addition to an analysis of alternative parameter values, the analyst may also want to test the sensitivity of results to (a) delays in implementation, and (b) changes in assumptions which reflect different objectives. This latter type of sensitivity analysis is relevant in cases where objectives include redistribution of income, environmental quality, increased employment, etc., in addition to the economic efficiency objective.

##### 10.5.1 Using net present worth measures for sensitivity analysis

It is usually desirable to test the sensitivity of project outcome to a combination of changes in input and/or output value assumptions and different levels of changes in the values for given inputs or outputs. If this is the case, then it is usually easier to work with NPW rather than ERR. The effort and time involved generally will be less, as indicated below. However, the sensitivity analysis can be carried out using either NPW or ERR.

Table 10.1 shows the sensitivity analysis results for a fuelwood project in the Republic of Korea.<sup>1/</sup> Using a 12 percent discount rate, the project had a NPW of 102 500 Won/ha. The table shows the sensitivity of NPW to a 20 percent change in any of the major cost and benefit elements shown in Column 1.

The entries in the body of the table are interpreted as follows (using planting cost as an example):

- if planting cost were 20 percent higher than expected, then the NPW (column 2) would be Won 8 400/ha lower, other assumptions remaining as before;
- if planting cost were 20 percent lower than expected, then NPW would be Won 8 400/ha higher.

In other words, the table can be used to estimate changes in NPW due to increases or decreases in the value of any given item.

In addition to these basic interpretations estimates of sensitivity of measures of project worth can also be derived from:

- Different magnitudes of changes for a given parameter value. For example, a 40 percent increase in planting cost would result in a W 16 800 (W 8 400 x 2) decrease in NPW. Similarly, a 30 percent increase would result in a W 12 600 (8 400 x 1.5) decrease in NPW.
- Combinations of changes in input/output values. For example, suppose all costs except harvesting cost were assumed to be 20 percent higher. The cumulative effect on NPW would be to reduce it by W 31 570/ha, or  $((0.72 + 14.20 + 8.40 + 0.58 + 2.10 + 4.07 + 1.50) \times 1\ 000)$ . Since the "expected" value of the NPW was Won 102 500/ha, the project would still be considered economically efficient since the NPW would still be positive (Won 102 500 - Won 31 570). Any other combination of changes and magnitudes of changes could be tested in the same way. Thus it is an extremely flexible and inexpensive approach to testing the outcome of the project (NPW) to a great variety of value assumptions.

It should be noted that the table does not tell the analyst anything about the interaction between factors, i.e., which combinations and magnitudes could likely be expected. That still remains as a judgemental task of the analyst. But once he has settled on likely combinations, he can assess their impacts by using the sensitivity table. Further, the effects of changes in a parameter value are assumed to be linearly related to the measure(s) of project worth (i.e., the NPW in this case).

It is recognized that in some cases an ERR is used instead of NPW as the measure of economic efficiency. A sensitivity analysis using the ERR measure involves recalculation of the ERR for each change in assumption or combination of assumptions.

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<sup>1/</sup> See Case Study No. 2. FAO 1979.

Table 10.1

## KOREA FUELWOOD CASE STUDY - SENSITIVITY ANALYSIS ('000 Won/ha.)

A 20 percent change in:	Causes changes as follows in the NPW $\frac{1}{2}$
(12.00 Percent Discount Rate)	
1. Seedlings	14.20
2. Planting	8.40
3. Fertilizing	2.10
4. Supervision	4.07
5. Miscellaneous - Tools	1.50
6. Harvesting	32.65
7. Fuelwood	79.58
$\frac{1}{2}$ Net present worth (NPW) at 12 percent	102.55

Source: See Case Study No. 2 FAO, 1979



The sensitivity analysis using NPW as a basis can also provide some critical information concerning sensitivity of ERR to changes in input or output parameter values. This follows from the definitions discussed in Chapter 9, where it was pointed out that when NPW is zero the ERR is equal to the discount rate used in calculating the NPW. Thus, in the NPW sensitivity analysis, when costs are increased (benefits decreased) to the point where NPW is zero, then the ERR is equal to the discount rate used. This "breakeven" point is of interest to decision-makers. (See Section 10.5.2)

If the analyst wants to test the sensitivity of ERR to specified changes in parameter values (other than those which result in a NPW of zero), he will have to recalculate the ERR each time for each change in value. If a computer is available, it is a simple matter to run through a great number of different combinations in a short time. If a desk calculator is used, it is equally simple in terms of process, but more cumbersome in terms of the time and steps involved. (It should be pointed out that even at this point in time there are some relatively inexpensive calculators which can handle this type of sensitivity analysis in a short time and in a relatively simple manner.)

#### 10.5.2 Breakeven analysis

One common type of sensitivity analysis is the breakeven (BE) analysis. Given the fact that the calculated measure(s) of project worth are primarily used as an aid in deciding whether or not a project will be economically efficient, it is natural that decision-makers are interested in how much less favourable parameter values can be before a calculated positive measure of project worth falls below the criterion (or criteria) for acceptability, i.e., how much higher can costs be and/or how much lower can benefits be before the NPW drops below zero or the ERR drops below the accepted discount rate? Similarly, for projects where use of expected values for parameters produce negative NPW's or ERR's below the guiding rate, the decision-maker will be interested in seeing how large parameter value changes (decreases in costs or increases in benefits) have to be in order to make the project acceptable in terms of the chosen economic efficiency criteria. This type of BE analysis provides useful information particularly in cases where the decision on a project will be based on a number of considerations in addition to economic efficiency.

Strictly speaking, BE analysis is usually carried out by varying the value of only one parameter, with all others taking on their expected values (i.e., holding other values constant). However, it can also be carried out for a general change in costs or benefits, e.g., by determining what percentage change in all costs is needed to reach the breakeven point (where NPW = zero, or ERR = the accepted discount rate).

The values of parameters being tested which make the NPW = 0 or the ERR = accepted discount rate are called "switching" values, i.e., the values which switch the decision on a project (based on these criteria) from a "yes" to a "no", or vice versa.

In cases where uncertainty about future values or benefits is particularly high, the analyst can use a "cost-price" approach. In this case, he calculates the price or value of the output which would make benefits equal to costs when both are discounted at the accepted discount rate. Thus, this is merely a variation on the basic BE analysis. The following example of calculation of cost price illustrates the approach.

A plantation project is being planned. The analyst is fairly certain about the costs involved - \$250 for establishment in year zero and \$10/ha/a starting in year 1. Technical personnel are fairly sure about their estimates of average yields and optimum



rotation. The expected yield is 428 m<sup>3</sup> on a 15-year rotation. Present stumpage value is \$5/m<sup>3</sup>, but there have been fluctuations and the expectation is that demand pressure on the limited supply will push up the stumpage price in the future. The analyst is uncertain about his estimate of a stumpage value 15 years from now. (He used an expected value of \$7/m<sup>3</sup> based on projection of past trends in real prices.) Given this uncertainty, one useful piece of information would be the stumpage value which would make NPW equal to zero at the relevant discount rate of 10 percent. The task for the analyst is to calculate this value, which is called the "cost-price".

He can approach the task dealing with future values (in year 15) or present values. Since it is easier (one less step) and makes more sense to deal with the future, he approaches it by compounding values instead of discounting them. <sup>1/</sup> He uses the following basic equation:

$$\begin{aligned} & \text{Establishment cost (C) compounded to year 15} \\ & + \text{Annual costs (Ai) compounded to year 15} \\ & = \text{Price (P) x Yield (Y)} \end{aligned}$$

Since he is solving for P, he arranges the equation as follows:

$$P = \frac{C(1+i)^{15} + A \frac{(1+i)^{14} - 1}{i}}{Y}$$
$$P = \frac{(1.10)^{15} (250) + \$10 \frac{(1.10)^{14} - 1}{.10}}{428 \text{ m}^3}$$
$$P = \$3.1/\text{m}^3$$

(Note: The compounded annual payment factor comes from Appendix B).

What this cost-price of \$3.1/m<sup>3</sup> means is that with other values as assumed, the project could afford to return as little as \$3.1/m<sup>3</sup> and still break even at 10 percent. Since the analyst and decision-maker are quite certain that the price will be at least at the current level of \$5/m<sup>3</sup>, they accept the project as having a good chance of obtaining at least the 10 percent return required for this type of project.

If the cost-price had turned out to be around \$6/m<sup>3</sup> (i.e., higher than the present price but lower than the analyst's estimated \$7/m<sup>3</sup>), then the analyst might want to take a closer look at the project, treating it in one of the ways suggested in the following sections.

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<sup>1/</sup> Compounding is the exact opposite of discounting.

The cost-price approach has further application in cases where a project involves non-market priced goods and services, e.g., environmental effects. It provides the decision-maker with information on what such goods or services have to be "worth" if the project is going to breakeven in terms of the relevant social rate of discount. While the decision-maker may not be able to decide on a specific value for some non-market priced output, he may be able to say to himself: "It is at least worth that much, therefore, the project is acceptable from an economic point of view." Alternatively, if the cost-price is very high, he may say: "I cannot justify the value implied by the cost-price calculation. Therefore I will not accept the project as being acceptable in economic terms and I will reject it, or attempt to redesign it to reduce costs."

#### 10.6 DEALING WITH CRITICAL FACTORS IDENTIFIED IN THE SENSITIVITY ANALYSIS

Where a reasonable change in the assumption about the expected value for a given parameter (or values of a combination of parameters) is critical in terms of the expected outcome of a project, it is desirable to generate additional information about the parameter(s), if this is possible.<sup>1/</sup> This may involve statistical estimation of probabilities of occurrence of different values using sampling techniques and available data, or it may merely involve developing subjective probabilities, or a number of other less formal approaches to increasing the knowledge about the likelihood of occurrence of the values that are critical to the project outcome.

Technical personnel and available literature can be consulted to obtain estimates of parameter values and ranges of such under varying conditions and more detailed effort can be spent on market surveys. Further, project planners can often find a wealth of information on species characteristics and other properties of woods available from national or international wood testing laboratories. Such information should be used to full advantage. The same general comment can be made about biological production function information, information related to insect and disease problems, etc. In most cases, data on which to base an objective probability analysis are lacking and cannot be generated in a short period of time. Yet considerable usable information is often available for use in developing subjective probabilities.

If further information on the critical parameter(s) indicates that there is a reasonable chance (1 in 20, or whatever is chosen) that the parameter(s) could indeed take on values which would influence the decision regarding a project, then the alternatives for further treatment of them in project planning fall into three categories which are not mutually exclusive:

- change project design
- build in contingencies and safeguards
- adjust the decision criteria used.

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<sup>1/</sup> Again, "reasonable" here refers to an initial estimate of what the possible range in values might be. "Critical" in terms of project outcome refers to the point where a factor's value reaches its "switching value", i.e., where the NPW moves from positive to negative or the ERR falls below the guiding rate of interest.

The first two of these possibilities are discussed below. The third relates to the broader issues surrounding project decision-making and is outside the scope of EAAP.

#### 10.6.1 Changing the project design

Controllable uncertainty may be reduced by redesigning the project, e.g., changing its scale, changing factor proportions, integrating it with further processing or with raw material production, etc. Flexibility may also be built into the project by staging various project activities in a different way and with a different time schedule than initially planned, or by redesigning it to include more flexibility in terms of choice of factor inputs or outputs after implementation, etc.

Some examples will help illustrate how redesign can reduce uncertainty. In the case of scale, if an initial project design is for a scale of project that would fully meet an estimated future market demand which is somewhat uncertain, then the project possibly can be scaled down so that its capacity is near a lower estimate of market demand. This would reduce market uncertainty effects on the project. At the same time, if economies of scale are involved, it may increase costs. In this case the project planner has to weigh reduced uncertainty against higher costs. In the case of phasing of project activities, it might be possible to redesign so that the project starts with a smaller capacity sawmill or plantation and gradually builds up in phases as estimated future market conditions, factor availabilities, etc., become less uncertain. For example, investment in some of the fixed infrastructure, such as roads and buildings, could be delayed until the situation regarding future conditions became more certain. The potential impact of an uncertain market for one specific product could be reduced by expanding a forest industry project to include a more diversified output mix. For example, a sawmilling project could have a moulding production unit attached to it so there would be some flexibility in terms of shifting production from sawwood to moulding as market conditions warranted. Diversification in plantation projects could also help to reduce uncertainty. For example, planting more than one species could help to reduce the risk of insect and/or disease problems in monoculture plantations. Species diversification could also reduce uncertainty with regard to markets, if the planted species have some overlap in characteristics and uses but also some unique characteristics which permit placing them in different markets as conditions warrant it. An example of a project which explicitly included this type of flexibility is the Korean fuelwood project; part of the area planted included "dual purpose" species which could be used for either fuel or timber, depending on how future market conditions developed for fuelwood.

A few words of caution are needed concerning redesign. In most cases, if the initial project design was based on thorough analysis of alternatives, then it was likely considered to be an optimum design in terms of the criteria for judging project worth and contribution. If redesign is undertaken, it is likely that expected costs will be increased and/or expected returns reduced over the initial optimum design. What this amounts to is a need for consideration of trade-offs between lower levels of uncertainty and lower levels of project worth (as compared with the expected return for the initial optimum design project). While the project planner can attempt to calculate and point out some of the trade-offs involved, it remains a matter of judgement as to the choice between alternatives. There are no general rules which can be made since it is difficult to quantify a decision-maker's subjective weighting of uncertainty.

Redesign is not the answer to all problems of uncertainty and should be approached cautiously. In many cases, redesign may not be desirable, and it will be necessary to resort to other methods of treating uncertainty. In cases of uncontrollable uncertainty, redesign may not be possible in the context of the project objective. In such cases other approaches can be used to take uncertainty into account.

#### 10.6.2 Building safeguards into a project

Safeguards may be built into projects, including insurance on various elements of the project (which increases the project cost but reduces risk to the project entity); providing for physical contingencies (really a form of self-insurance); adding a premium to the discount rate used in calculating the NPW of the project, or arbitrarily lowering the output values and/or increasing the input cost estimates in calculations of the ERR or the NPW.

These approaches may not be sensitive to the uncertainties identified. For example, adding a premium to the discount rate penalizes future costs and benefits more than present or early costs and benefits, and this is not necessarily related to where the main uncertainties exist. On the other hand, an arbitrary increase in costs (e.g., contingency or insurance) and/or decrease in benefits would, for any given discount rate, suggest that uncertainty concerning future values is less important than uncertainty concerning present or early values. This may not be in keeping with the levels and timing of uncertainty identified. Despite their shortcomings the approaches suggested are used widely as a convenient way to reduce the chance of failure or a lower than expected rate of return. It essentially amounts to the same thing as saying that the acceptance criterion is made more stringent, i.e., a project has to show better than marginally acceptable performance. Adding a contingency allowance for physical uncertainty is likely to be the preferable way to treat the problem, since it does not tend to hide what is being done from the decision-maker. <sup>1/</sup>

Projects can be designed with specific contingencies in mind. For example, in the case of an industrial plantation project planned for Tanzania, it was recognized that a principal uncertainty facing the project would be that the yet-to-be built pulp and paper mill, which would use the wood would not be built. Contingency plans for the project, in the unlikely event that the mill was not built, were (a) gradually to scale down the planting programme and stop it after five years, and (b) to grow the trees planted on a 25 year sawlog rotation instead of the shorter planned pulpwood rotation. The project analysis showed that there would be an acceptable market for the resulting volumes of sawlogs. The same type of contingency planning was included in the Korea fuelwood plantation programme, by planting a part of the area with "dual purpose" trees, i.e., ones that could be used both for fuel and timber.

Two additional points should be mentioned about uncertainty. First, uncertainty is often associated with the objectives for a project and the appropriate criteria for measuring the contribution of a project toward meeting objectives. This topic is not discussed here, mainly because it fits better in a discussion of sector planning, i.e., it is a question that transcends the subject of planning a particular project, given an

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<sup>1/</sup> See Gittinger 1972, pp. 100-104 for further discussion of contingency allowances.

objective. Objectives for a given project should be derived from a more general evaluation of the present condition of the sector and what goals it should be moving toward. The main problem with objectives at the project level relates to lack of definition. There is no sense in planning projects and project alternatives if objectives are not first defined explicitly. Criteria follow logically if objectives are defined. However, there are cases where criteria are poorly specified, mainly because objectives conflict or are loosely defined. The uncertainty in such cases is related to the lack of specified trade-off functions for the various conflicting objectives. Sensitivity analysis can contribute information on which decision-makers can base subjective judgements regarding trade-offs. The uncertainty involved really relates to uncertainty concerning the relative values placed on various objectives by society or decision-makers.

Second, a logical question is "How much should be spent on reducing uncertainty?" In general, the amount spent depends on the nature of the project and the available budget. In some cases, slight additional effort/expenditure can result in a marked reduction in uncertainty. In other cases, substantial expenditure will have little impact on reduction of uncertainty. Judgement based on past experience and knowledge about information availability and cost of information will provide some idea of the particular cost/benefit relationship facing the analyst. How much reduction of uncertainty is worth to the decision-maker is a judgemental question which has to be answered for each case separately.

For example, in the case of plywood production expansion project in the upper Amazon, the project analysts and sponsors decided that the substantial uncertainty surrounding estimates of total wood availability in the region was not significant to project viability. Ample volume was known to be available for the project at acceptable cost, and even the lower limit estimate indicated an available volume large enough to provide an ample margin of safety for the project. On the other hand, in the case of an integrated sawnwood and pulp and paper project currently being designed in Honduras, a large amount of money is being spent for detailed inventories so the project sponsors can be more certain that an adequate volume of wood is available at acceptable cost before they decide on the scale of the processing facilities and commit large sums to plant, equipment and infrastructure. In this case, uncertainty surrounding wood supply and cost is considered a critical factor by decision-makers.

PART II

USES OF ECONOMIC ANALYSIS IN FORESTRY PROJECT PLANNING

## Chapter 11

### USE OF ECONOMIC ANALYSIS IN PROJECT DESIGN

#### 11.1 INTRODUCTION

This Chapter discusses the main uses of economic analysis in project identification and design. As pointed out earlier, many of the most critical decisions in the planning process are made at the early stages of identification and design. If economic efficiency considerations are absent, then opportunities might be lost to explore better alternatives.

Even the most simple projects can be designed in alternative ways. Thus, even for such projects, the economic analyst may have a role to play in project preparation and in the development of the most economically efficient project designs.

The process of design should encompass a number of project dimensions, such as scale, location, technology and timing for the various identifiable components of a given project. Once separable components have been identified and analysed, the analyst should look at the economic efficiency of alternative groups of components in terms of the project dimensions which will lead to the desired objective(s). The purpose is to arrive at the most economically efficient overall design, taking into account technical options, uncertainty, and interactions between separable components. Since the potential combinations of design components can be numerous, some technical judgement and experience are desirable in choosing the alternatives to be analysed.

Only one design for a given component can be chosen. For example, an analyst might be considering three alternative technologies or designs for the logging component of a particular project - one using mainly labour and cheap hand tools, one using power saws and less labour, and one using heavy machinery. Only one of them can be chosen for a given harvest and area at any one time. Similarly, only one overall project design can be chosen for a given situation.

When a situation exists where only one alternative out of several can be chosen at any given time to use a given resource or to meet a specific goal or objective it is referred to as a situation of mutually exclusive alternatives. The use and interpretation of indicators of project or component worth will vary according to whether projects or components are mutually exclusive or independent (not mutually exclusive).

Once the most efficient design for each mutually exclusive project component has been determined, the next task is to integrate them back into a total package, thus arriving

at a design for the whole project. There may be several total project alternatives to compare. Therefore, once the analyst has chosen among mutually exclusive designs for a component, he still faces the choice between mutually exclusive projects. The approaches discussed in this chapter are relevant whether dealing with a component or an overall project.

When consideration has been narrowed down to one alternative project, then the final appraisal for the total project is developed. This process is discussed in Chapter 12, applying the general principles defined in Part I.

## 11.2 IDENTIFYING ALTERNATIVE PROJECTS AND THEIR COMPONENTS

There is no formula for determining the number and type of project alternatives which should be considered in a given situation. The process should strike a balance between covering the range of alternatives available and design costs, but no guidelines can be laid down regarding how to obtain an appropriate balance. This remains a matter of judgement based on circumstances. Technical competence and experience are important ingredients. However, some general considerations can be mentioned.

Sources for alternative designs are many. In many developing countries the range of project and project component alternatives considered are often moulded by political commitments, crises and experience. Project ideas might surface as a result of an analysis of the forest-based sector where the purpose is to develop a programme (an interrelated set of projects) to accomplish some broad objectives for the sector which fit within the general framework for national development. For example, in a large South American country an exercise was carried out in which estimated future demands for forest products were compared with the existing and expected industrial and resource capacities in order to determine the areas where important gaps existed or were more likely to materialize in the future. This exercise suggested possibilities for investment projects to attain a high level of self-sufficiency, which was one of the main policy objectives of the government. Ideas were advanced for several potential industrial expansion projects and for increasing the existing industrial plantation targets to levels consistent with the proposed industrial projects.

Most project ideas are identified in a less systematic fashion, without reference to an overall sector strategy for development. A forest service field officer may seek an opportunity to undertake a plantation project in his region; a rural development official may see the potential for including a forestry component in a regional employment programme for a given region. An industry specialist may come up with an idea for a processing project which could make better use of a given forest resource, and so on.

While the integrated and systematic approach might seem more attractive because of its internal consistency, in practice both ways of generating ideas are desirable and complementary. It has been repeatedly observed that one of the main obstacles to forestry development in many countries is the dearth of constructive project ideas. Therefore, from a practical perspective, in many cases it is better to have good independent ideas than no project ideas at all. The way in which a project idea surfaces is not as important as the way in which the project idea is defined relative to an objective or set of objectives.



Given a project idea (or several ideas) the project analyst is concerned with two things initially. First how does the project idea relate to a definable and acceptable objective or set of objectives? Second, to what extent are there alternative ways in which that objective or set of objectives could be met? In answering the latter question, the project planner will want to take a given project concept and look at alternative ways in which the concept could be implemented. For example, the initial concept presented may be to utilize and manage a given unexploited 200 000 ha forest area. A plywood mill has been suggested initially. The project planner will want to ask: Is it possible that some other alternative - perhaps an integrated utilization complex that will use a greater number of species from the area - might be better? Perhaps the initial project idea should be expanded to include an integrated management and utilization scheme for a larger or smaller area, with conversion of the cutover forest to plantations which will, in turn, have a different use. Perhaps instead of one large plywood mill, it may be better to develop five or six small sawmills either alone or in combination with a larger central resaw unit that can provide further elaborated sawnwood products.

Some considerations can be suggested for avoiding passing over good project components and overall project ideas.

First, to the extent possible, the forestry project planner should be aware of the different developments taking place in the sector and he should understand thoroughly the policies and objectives set forth for sector development. If these are considered in a systematic fashion, the planner will have a better perspective on the relative merits of alternative approaches available for a given idea. Since one person is seldom an expert in all areas of forestry, it is generally better to develop project ideas using an interdisciplinary team which can consider project concepts and objectives from a number of different perspectives. In any case, a great deal of discussion of project ideas is desirable before focussing attention on any one idea.

Second, the project planner should follow the dictum that there are always alternative ways to design a project to meet a given objective or set of objectives. If all but one alternative are initially eliminated, then the project planner has in effect made a major project decision before he has even started the task of designing and analysing projects. That, in general, should not occur. Options should be developed so the decision maker has some choice.

One working objective in project planning is to avoid unnecessary expenditure of time and effort on analysis of project alternatives which at an early stage can be determined to be inferior (for a variety of reasons). Thus, the advantages of generating alternatives must be balanced against the costs of doing so. Only realistic alternatives should be considered.

Determination of whether or not a given alternative is "realistic" involves consideration of a number of factors other than financial and economic ones. First, and most obviously, the project alternative has to be technically sound and feasible. Second, it has to be commercially feasible. Inputs have to be available when needed, i.e., sources of supply have to be ascertained. Outputs have to be considered in terms of whether they will be purchased, in the case of market goods/services, or whether they will be required and used, if non-market goods or services. Third, the organizational and managerial feasibility of the project has to be ascertained, i.e., does it fit within the present

legal and administrative framework, or can the administrative framework be changed so that it will fit? Will there be personnel available to manage the project appropriately? These three considerations are beyond the scope of EAFF. However, they need to be mentioned in the context of the present discussion, since they are central to a definition of realistic alternatives which will be subjected to economic (and financial) analysis.

In cases where multiple conflicting objectives exist - for example, where the objectives of employment of unskilled labour and economic efficiency conflict - it is particularly important that the project planner consider a range of alternative designs. In such cases a clear, quantifiable objective function cannot be defined and the decision-maker will want a number of alternatives to consider in making his subjective judgement on the trade-offs between different objectives.

The project identification stage is one of the most important stages in the project planning process. It often is not given enough systematic attention. It does not matter how good the design and appraisal of a project alternative is if it is not the "right" alternative to meet the objective. Although adjustments can be made at later stages, it is quite often true that after considerable effort has been spent appraising a given alternative there is a reluctance on the part of planners to abandon what they have been working on and to admit that the wrong alternatives were chosen. Thus, the obvious suggestion is to spend enough time and thought initially at the identification stage to ensure as far as possible that the right alternatives for a given objective and situation have been identified.

When a range of alternative project and project component designs have been defined, the economist can commence his task of analysing the economic efficiency of alternative designs for components as well as the overall economic efficiency associated with alternative projects made up of a number of separable and nonseparable components. These types of analyses are the subject of the remainder of this chapter.

The basic questions asked are: (a) What is the most economically efficient design for a given separable project component? and (b) Is it worthwhile adding a component (designed in the most efficient manner) to the total project? These are discussed in Sections 11.3 and 11.4.

### 11.3 USE OF ECONOMICS IN DESIGN OF SEPARABLE PROJECT COMPONENTS<sup>1/</sup>

Assume that a limited number of separable project components have been identified initially for a total project package that will meet certain objectives. Each of the components can be designed in alternative ways by varying the technology, the scale, the location and the timing of the component. The question here is: "What guidance can the economist give in terms of identifying and determining the design which is most economically efficient?"

The question of alternative designs for a project component (or a total project) involves analysis of mutually exclusive alternatives. The basic steps involved in analyses of mutually exclusive alternatives are exactly the same as discussed in Part I. Inputs and

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<sup>1/</sup> If there are no separable components associated with a given project, then what follows applies directly to the project as a whole.

and outputs for the alternatives are identified and economic values are estimated for the identified inputs and outputs to arrive at estimates of costs and benefits. Then the costs and benefits associated with each alternative are compared to find the most economically attractive alternative among the ones being analyzed.

Depending on the relationship between the mutually exclusive alternative designs being considered, one of the following two types of comparisons will be relevant (see also Section 2.2.4).

- (i) If the mutually exclusive alternatives produce the same benefit streams but involve different inputs and/or cost streams, then the PV of costs of the alternatives have to be compared, and that alternative that has the lowest cost chosen. This follows from the fact that if benefits are the same for all alternatives, then the alternative with the lowest cost (in PV terms) has the highest NPW. This would be the case, for example, if several alternative technologies for producing the same output are being investigated. Thus, three alternative logging technologies that could be used in harvesting the given volume of wood required for the project processing component might be identified. The lowest cost alternative would be chosen in terms of the economic efficiency objective. (Remember, though, that indirect costs that differ among alternatives also have to be considered.)
- (ii) If the mutually exclusive alternatives being analyzed were to produce somewhat different benefit and cost streams, then the NPW's of the alternatives can be compared directly. This would be the case, for example, if the analyst was looking at alternative scales for a project or for a separable component, or if he was comparing alternative final processing activities for using a given volume of project wood output, or looking at the possibilities for adding on a purpose to a project (e.g., adding soil or watershed protection purpose to a primary purpose of producing fuelwood or other roundwood).

In the remainder of Section 11.3 these approaches are applied to four main design elements, namely, technology, scale, location and timing.

#### 11.3.1 Technology alternatives

Most project components can be undertaken using different technologies (combinations of labour, land, and capital). For example, alternative sawmill designs are available that use different relative amounts of labour and capital (machinery). Plantations can be developed using different species and different establishment and maintenance practices or different combinations and intensities of inputs (e.g., fertilizer). Processing facilities can utilize different types of power. Transport of wood products can involve different combinations of equipment (and roads). Logging of a given output can be carried out with much labour and simple hand tools or with sophisticated machinery and few men.

If the output (or benefits) associated with different mutually exclusive technology options will be the same regardless of technology chosen, then a simple comparison of the PV's of costs of the alternatives can provide the appropriate information for choosing among them. That option with the lowest PV of costs is the most economically efficient to produce the given output.

From an economic efficiency point of view, the choice of technology to produce a given output will depend on the relative factor costs (e.g., the relation between the cost of labour, land, and machinery). If labour is relatively cheap, then labour intensive technologies will generally have lower average costs per unit output than capital intensive ones; if land is inexpensive (or has a low opportunity cost) then intensive management to maximize growth per acre will be less attractive than in a situation where the opportunity cost of land is high; if the cost of fertilizer is high, the less likely it is that intensive fertilization of forest plantations will provide a positive contribution to a project's NPW, other conditions being the same. The following example illustrates this point.<sup>1/</sup>

A forestry project is proposed in Tunisia. One component involves clearing land for a plantation. There are 400 ha to be cleared and a five year period for clearing is considered appropriate. Two technology options have been proposed. One involves manual clearing and the other mechanical clearing. Costs for these options are shown in columns 2, 3 and 4 of Table 11.1. Given the existing relation between costs of labour and capital, the mechanical option has a lower PV of costs if 10 percent is the discount rate chosen. However, if labour costs were lower relative to the costs of machines, say 20 percent lower, then the labour intensive alternative would have the lower PV of costs, given the same rate of discount. While the concept is intuitively evident, certain technologies which are geared to an intensive use of productive factors that are abundant in developing countries are often dismissed by project designers and preference given to "modern", usually capital-intensive, technologies developed in advanced countries with radically different resources endowments. This is a point which should be kept in mind at the earliest stages of forest-based project design in developing countries.

Another consideration of relevance in the analysis of alternative technologies is that they will, in all probability, generate different costs streams over time. If this is so, then it is likely that choice among alternative technologies will be affected by the discount rate applied to the analysis. In the example above considering the original labour cost assumption, the mechanical option has the lower PV of costs, if the rate of discount is 10 percent. If this rate were 20 percent then the labour intensive option is cheapest in PV terms. This is because the labour intensive option has a comparatively larger proportion of costs towards the end of the period, while the mechanical option involves a larger initial capital expenditure with lower operation and maintenance costs in the following years. A higher "discounting" of future costs then favours that alternative which has a greater proportion of its costs occurring in the future.

By following an iterative process, the analyst arrives at the "cross-over discount rate" of 14 percent. This is the discount rate at which a pair of alternatives with different cost-streams have equal NPW's. Its comparison with the social discount rate provides a straightforward decision rule, concerning mutually exclusive alternatives. Thus, if the relevant social discount rate is below 14 percent, then the mechanized alternative is more efficient because the PV of its costs will be lower. If the appropriate rate is above 14 percent, then the labour intensive option is the best choice from an economic point of view.<sup>2/</sup> The results of this type of analysis can be presented in graphical form (Figure 6).

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<sup>1/</sup> Adopted from Gittinger 1972.

<sup>2/</sup> As Gittinger points out, there may be various social reasons why the labour intensive option is preferred even if the appropriate social discount rate is below 14 percent. In this case, the choice involves objectives and criteria quite separate from those associated with the economic efficiency analysis.

Table 11.1

CHOICE BETWEEN MECHANICAL AND MANUAL LAND CLEARING ALTERNATIVES - TUNISIA  
(US\$)

Manual clearing

(1) Year	(2) Wages	(3) Other costs	(4) Total costs
1	44 050	3 800	47 850
2	44 050	3 800	47 850
3	44 050	3 800	47 850
4	44 050	3 800	47 850
5	44 050	3 800	47 850
Total	220 250	19 000	239 250

Mechanical clearing

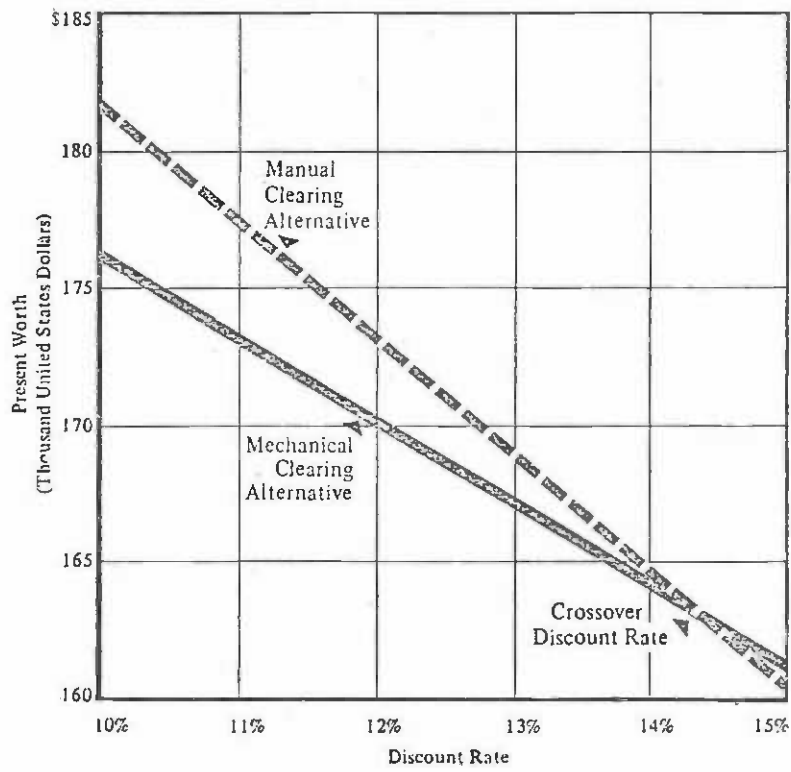
Year	Equipment cost	Operation & Maintenance	Total costs
1	90 700	21 586	112 286
2	-	25 134	25 134
3	-	25 134	25 134
4	-	26 227	26 227
5	-	26 227	26 227
Total	90 700	124 308	215 008

Present value 10 percent discount rate:	manual clearing	US\$ 181 399
Present value 10 percent discount rate:	mechanical clearing	175 905
Present value 20 percent discount rate:	manual clearing	143 101
Present value 20 percent discount rate:	mechanical clearing	148 759
Present value 10 percent discount rate, labour costs 20 percent lower:	manual clearing	133 586

Source: based on Gittinger 1972. p. 124.

Figure 11.1

TUNISIA: Choice between Mechanical and Manual Land Clearing Alternatives Illustrating Graphical Derivation of Crossover Discount Rate



Source: Table 15 and Gittinger 1972 p. 125.

In some cases, different technologies for a component will involve different total benefits. While the primary purpose benefits (e.g., the value of wood produced) may be the same, there can be some secondary benefits that differ. For example, an alternative that involves use of locally produced simple machinery can have different secondary benefits for an economy than an alternative that involves use of imported heavy machinery to produce the same primary output.

In these cases the NPW's of the alternatives need to be compared rather than just the PV's of their costs.

Another important consideration in the analysis of technological options relates to the quality of the output and questions related to the value of the output. For example, the quality of output of a mechanized operation can be considerably more uniform than the quality of output from small labour intensive operations. Even if the output volume is the same, the value of the output (the benefits) associated with the alternatives may be different because of quality differences.

Similarly, the analyst has to be certain that he has adequately defined the project purpose and final output in making technology comparisons. For example, in forestry there is a common tendency to think of a faster growing species as being superior to a slower growing one (i.e., the "objective" is taken to be maximum volume yield per unit area per unit time). While in many cases this is the relevant criterion to use in choosing among alternative species, there are also many cases where it is not true. The analyst has to keep in mind that what matters in an economic analysis is the increase in value and that this increase might or might not be closely related to physical increases in volume per unit area per unit of time.

The technology options considered for a component or project will depend heavily on the experience and knowledge of the technical personnel involved in planning the project. Choice of the most efficient (best) alternative will also depend on the decisions regarding other project components. Thus, in some cases, the analyst will be presented with alternative packages of technologies for all project components and asked to analyse these alternatives as a whole without separating out the components for separate analysis. The same approaches as suggested above for analysing separable components can be used in this case.

### 11.3.2 Scale options

For many types of activities, substantial "economies of scale" in certain ranges of production can be encountered. Economies of scale refer to the variation in average per unit costs that can be achieved by varying the scale of operations. The economist may be asked to analyse the economics of alternative scales of production in cases where the

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project or component output level is not set by the market (e.g., in the case of some types of export oriented projects, or in the case where a project could be designed to include several small production units or one larger unit).

The most practical approach is to define several mutually exclusive alternative scales - perhaps combined with several alternative technologies - and then to analyse each separately, picking the one with the highest NPW as the optimum scale for the project. There are no new conceptual problems involved in this process. This question of scale can be treated in exactly the same manner as the question of technology. Indeed, it is often the case that the two are analysed together.

The main problem encountered in dealing with the question of scale is the general lack of adequate information on the variations in costs which will occur with different scales of output. For some types of processing activities, there are fairly good estimates available. However, such figures often reflect factor cost relationships in countries other than the project country. The analyst has to use caution in adapting such information directly to his analysis. For most forestry activities there is very little specific, empirical information available on economies of scale. Rough estimates have to be used, based on experience and judgement of technical personnel.

In cases where economies of scale exist, it is sometimes of interest to calculate the breakeven size for a given operation, or that scale of operation at which the PV of costs equals the PV of estimated benefits. At scales larger than this breakeven level NPW would be positive and at scales below it the NPW would be negative. Breakeven analysis is also used in sensitivity analyses, as explained in Section 10.5.2, where the breakeven price (or cost-price) calculation was used as an example. The approach to calculating a breakeven size for a given operation is exactly the same, except output quantity is being solved as the unknown.

### 11.3.3 Location alternatives <sup>1/</sup>

In some cases, the analyst will be asked to analyse alternative locations for a given project or project component. The analytical work can be reduced by looking only at those cost and benefit elements which vary with location. For example, in the case of alternative plantation locations, the analyst generally need look only at effects of site, transport cost and land value differences. Information on these differences can be presented in simple tabular form to give the decision-maker a clear picture of the costs and benefits associated with alternative locations.

Quite often taxes will vary by location, as will subsidies given for development in relatively backward regions of a country (e.g., in the case of Brazil). These differences will not affect the economic analysis in terms of NPW, but will affect the financial analysis as discussed in Chapter 9.

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<sup>1/</sup> The term "location" as used here can refer to either the region or area in which the project will be located as well as the specific site within a region for locating production facilities.



In analysing mutually exclusive alternatives, the nature of the comparison must first be established i.e., in terms of what factors are the alternatives mutually exclusive or what is the limiting factor being considered? In some cases it will be a given input (e.g., the land area); in other cases it will be an output constraint (e.g., the size of the project market, etc.). Constraints have to be clearly specified before a meaningful economic analysis of mutually exclusive alternatives can be undertaken.

#### 11.3.4 Timing alternatives

Some of the most common questions faced in forestry related projects concern timing of components of a project. Of particular importance is the question of rotation or felling age determination. There are also other questions which relate to timing of activities. Many of the critical timing problems encountered in project analyses relate to timing of a given component in relation to other components. These problems are discussed in Section 11.4, which deals with interactions and choice of component alternatives to include in a total project package.

##### 11.3.4.1 Rotation determination or appropriate felling age

The basic question from an economic point of view is - given a species, site conditions, and values for costs and benefits associated with a given situation, what rotation length or growing period maximizes NPW?

The determination of the optimum economic rotation or felling age raises no new problems which are different from those involved in analyses of other aspects of mutually exclusive alternatives. NPW's are calculated for alternative felling ages and the one that results in the highest NPW is chosen as the preferred option from an economic point of view. If yield and unit value information by years is available, then it becomes a straightforward process to find the rotation with the highest NPW.

As shown in Table 11.2, the analyst estimates the total benefits (col. 3) and the total costs (col. 4) which would occur if the stand was held for each of n years. He then discounts these values and subtracts PV of costs (col. 6) including land opportunity cost from PV of benefits (col. 5) for each alternative rotation to get a NPW (col. 7) for each. That rotation with the highest NPW is then chosen. In this case, the peak of NPW is reached in years 20 and 21.

In order to arrive at the optimum rotation it is not necessary to calculate the NPW for all years. The analyst can quickly arrive at the optimum rotation length by calculating NPW's for a few years spread apart, and then concentrating on the years where the NPW is near its maximum and then starts to drop.

Alternatively, as shown in column 8, the analyst can estimate the marginal rate of return (MRR) (marginal ERR) on holding the stand another year, which is the same as the rate of increase in the net current benefits from one year to the next. The last year for which the MRR is above or equal to the relevant discount rate (in this case 7 percent is assumed) is the rotation length that will maximize NPW. In this example the MRR drops to 7 percent between years 20 and 21. Thus, again the optimum rotation length is between 20 and 21 years.

Table 11.2

## ROTATION DETERMINATION (PER HA BASIS)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Year	Yield <sup>1/</sup> (m <sup>3</sup> r)	Benefits	Costs <sup>2/</sup>	PV of Benefits (7%)	PV of <sup>2/</sup> Costs (7%)	NPW (7%)	Rate of increase in current net benefits (7%)
0	0	0	30	0	30	(30)	
1-4	0	0	2	0	36		
5	7.7	11	2	8	45		
6	17.1	24	2	16	46		
7	27.0	38	2	24	48		
8	37.7	53	2	31	49		
9	49.2	65	2	35	50		
10	61.4	86	2	44	51	( 7)	
11	74.5	104	2	49	52		
12	88.5	124	2	55	53	2	
13	103.3	145	2				
14	119.2	167	2				
15	136.2	191	2				
16	154.4	216	2	73	56	17	
17	173.7	243	2	77	56	21	12
18	193.2	270	2	80	57	23	10
19	212.6	298	2	82	57	25	10
20	231.3	324	2	84	58	26	8
21	248.9	348	2	84	58	26	7
22	265.6	372	2	84	59	25	6
23	281.3	394	2	83	59	24	5
24	296.1	414	2				
25	310.0	434	2				
26	323.1	452	2				
27	335.6	470	2				

<sup>1/</sup> Based on Gregory, 1972, data for pine yields in Lota, Chile.

<sup>2/</sup> Establishment costs, \$29; annual management cost starting in year 1, \$1, annual opportunity cost for land, \$1.

The MRR approach is probably the easiest to use. For each year, the total benefits are estimated as shown in column 3. To get the MRR the analyst subtracts the benefits in one year from those in the succeeding year, then subtracts any costs which would occur during that year, (i.e., col. 4) and divides the result (the net current benefit increase) by the benefit which would be obtained if the stand were cut instead of being held for another year. For example, the benefit in year 20 (\$324) is subtracted from the benefit in year 21 (\$348). The result equals \$24. Then the \$2 annual management cost is subtracted from the \$24 to give \$22. This is the net benefit gain which could be obtained if the stand were held during year 20 (until year 21) instead of being cut at the beginning of year 20 (or end of year 19). This net benefit is then divided by the benefit which could be obtained at the beginning of year 20, i.e., \$324, and multiplied by 100 to give a MRR of 7 percent.

The logic of this approach is quite simple. As long as benefits are growing at a rate higher than the discount rate, it is worth leaving the stand since NPW is increasing. This approach applied to analyses based on market values is basically the "financial maturity" concept familiar to foresters.

It is not necessary to calculate MRR's for all years in order to arrive at the appropriate felling age. The MRR was calculated first for years 16-17 and found to be above 7 percent (the assumed discount rate). It was then calculated for year 23 and found to be below 7 percent. At years 20-21 it was found to be 7 percent.

When two or more mutually exclusive alternatives that involve different time periods are being compared (e.g., alternative rotation lengths), adjustments have to be made to take into account the different time periods involved. In the example, this adjustment was made by including the annual opportunity cost of land in its best alternative use. For example, if a 20 year rather than a 15 year rotation was chosen, 5 years of net value which could be obtained from the land (\$5, or \$1 per year) if it was harvested in year 15 and used for the ensuing 5 years in its best alternative use would be foregone.

A common way that foresters take unequal time periods into account in choosing between rotation ages is to calculate what is called the land or soil expectation value (SEV). The one with the highest SEV is then chosen as the optimum rotation from an economic point of view.

The SEV is essentially a financial measure, equal to the present value of an infinite number of equal periodic net returns of \$R received every r years. In forestry, r is identified with the rotation age and \$R with the net returns from one rotation. In the calculation of SEV, the land value is not included, and therefore the SEV essentially indicates what could be afforded for land and still breakeven (have value of benefits equal to value of costs when both are discounted back to the present using the relevant discount rate). Further details on the SEV and how it is calculated are shown in Appendix B.

If the opportunity cost of land as used is correctly estimated, then the NPW for one rotation, the MRR and SEV approaches should all give the same answer with regard to which rotation length or felling age is optimum in economic terms. As mentioned the MRR

approach is probably the easiest to use. Once the optimum rotation of felling age has been determined, then the NPW and/or ERR can be calculated. <sup>1/</sup>

#### 11.3.4.2 Other timing considerations

In addition to rotation determination, optimum scheduling of other project activities will have to be considered. For example, what would be the impacts on NPW of scheduling investments in plant and equipment over longer periods than initially envisaged, i.e., phasing project build-up? Or, how should investments in infrastructure be phased, i.e., when should roads be built? These questions may or may not be relevant depending upon the assignment of the analyst and the project being analysed. In many cases, the technical personnel set the initial timing of various activities. If other questions of timing are relevant to the economic analysis, then the analyst would again define, with the help of the technical personnel, several alternative timings. Using the value flow tables for each alternative, he would analyse each as a separate alternative, comparing the NPW's to find that alternative with the highest NPW. If amounts and timings of outputs (benefits) remain the same for all alternatives, then the analyst can compare the PV's of costs and pick the one with the lowest value as being the relatively most economically efficient one.

#### 11.3.5 Comments on design choices for separable components

Alternative designs of components in terms of the appropriate approaches to analysing mutually exclusive alternatives have been discussed. While the assumption of mutual exclusivity holds for any given situation involving the same resource (e.g., land area) or output constraint, it is also possible that a detailed analysis will indicate that two or more designs should be incorporated in the same project for different segments of the project. For example, two or more different logging systems can be employed in the same project if different conditions exist for parts of the total project area. Similarly, different management intensities can be used for different parts of the project area, or two or more different technologies can be used to produce the total project output, depending on specific conditions encountered in the project environment. The point still remains that for any given segment of project area, or for any given portion of the planned project output, only one or another design can be chosen. Thus, an analysis of disaggregated sub-components can be dealt with, but the relevant consideration for each still relates to which of the mutually exclusive alternatives identified has the highest NPW for each subcomponent.

Table 11.3 summarizes the appropriate approaches to analysing mutually exclusive alternatives for different design elements.

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<sup>1/</sup> The MRR only relates to the difference between holding or harvesting a given stand in year  $t$  or year  $t+1$ . A NPW or the interval rate of return (financial or economic) still has to be calculated to indicate whether in fact planting the trees is worthwhile in the first place.

Table 11.3

APPROACHES TO ANALYSING MUTUALLY EXCLUSIVE ALTERNATIVES  
FOR DIFFERENT DESIGN ELEMENTS

Design Elements	Alternative Designs Have the Same Timing and Value for Benefits	Alternative Designs Have Different Timings and/or Values for Benefits <sup>1/</sup>
Technology	For each alternative calculate PV of costs that differ between alternatives. Pick the one with lowest PV of costs.	Compare NPW's of alternatives; pick one with highest NPW.
Scale	N.A. <sup>2/</sup> (benefits will vary with scale for any given component being analysed).	Compare NPW's of alternatives; pick the one with highest NPW. Or analyse increments in scale using MRR approach, and pick that size where MRR drops down to the discount rate.
Location	For each alternative, calculate PV of costs that differ with location. Pick the one with the lowest PV of costs.	Compare NPW's of alternative locations; pick the one with highest NPW.
Timing	N.A. (timing of outputs and thus benefits will vary).	Compare NPW's of alternatives; pick the one with highest NPW. Or use MRR approach, e.g., in the case of rotation or felling age determination. (Make sure to adjust for time differences, e.g., by adding in land opportunity costs.)

<sup>1/</sup> If two (or more) alternatives have a number of cost and/or benefit elements in common, then the net difference in PV of costs and benefits that differ between alternatives can be compared. If the net difference between alternative i (considered the base alternative) and j (the one being compared) is positive then j is preferable. If the difference is negative, then i is still preferable. This approach holds for all design elements. It is essentially the MRR approach discussed for rotation or felling age determination.

<sup>2/</sup> N.A. = not applicable.

#### 11.4 INTERACTIONS BETWEEN DESIGN ELEMENTS AND SEPARABLE PROJECT COMPONENTS

The four design elements discussed - technology, scale, location and timing - are generally interrelated for a given component. The discussion in Section 11.3 treated the four separately in order to clarify some of the differences in approach which can be applied in arriving at the most economically efficient design for each element, holding other design elements constant. It is often practical to separate the elements initially when the analysis is started. However, at some point the analyst has to consider the interactions between elements i.e., allow for variation in several elements at the same time.

The variety of interactions which theoretically may be considered for different project situations is virtually limitless, while those that practically can be considered in any given project analysis are generally severely limited by budget and time constraints imposed on the project planning effort. Thus most analyses will start with a few alternative designs for a component (and a project) which include specified technology, scale, location and timing combinations. In this case, the economist develops for each of the specified alternatives a value flow table and a NPW and then compares the NPW's of the limited number of mutually exclusive alternative designs being considered.

If the situation calls for it, he may also make some more detailed investigations of alternative timings for a component, or suggest looking at alternative scales not included in the limited alternatives provided by the technical personnel. He might also look at a few technology options not initially considered. For example, if data were available on the response of several potential species to different management intensities (e.g., thinning regimes and application of fertilizers) he might analyse the benefits and costs associated with such alternatives to arrive at a more efficient technology for the particular project situation. In this case, he would be looking at the interaction between technology, timing and location elements for the plantation component, but also the implications for other project components. An example will illustrate this.

Assume an integrated wood production-processing project is being considered. The scale and output level of the processing component have been fixed by the estimated requirements for the output at the time it becomes available. Thus, given the processing technology and output level, the volume of wood input is also fixed. The wood production technology envisaged would require 300 ha of land to supply the wood input requirements of the processing component on a sustained basis, starting 6 years after the first planting. Thus, the processing component investment has been timed to come on stream in 6 years, the minimum period required to generate the wood raw material needed.

Although fertilization of the plantation is not considered in the initial design, there is information available which provides some indication of the response of the chosen species to fertilization. Thus, the economist could undertake a partial analysis of the economics of fertilization. Fertilization could have several impacts in terms of the overall project. First, less land would be required to grow a given volume of wood required. Second, this would have implications not only in terms of land costs, but also in terms of silvicultural management, logging and transportation costs.

Third, the trees might reach optimum economic rotation at an earlier age. The impacts of these differences might be felt in terms of other input requirements, location of plantations and timing of the processing investment. (Since wood would become available

before 6 years, the processing component could come on stream earlier than initially planned.) Therefore, these changes could result in significant differences in the total project NPW's with and without the fertilizer application. A partial analysis that only considers effects on yield changes on an average per unit area per year basis would not capture all the implications of fertilization in terms of the overall project. There are implications for other design elements and for other components included in the project.

Another more complex situation arises when substantial economies of scale exist for a given activity (component), but the volume of output required to take full advantage of the potential economies of scale is above estimated requirements for the output of the project, at least in the initial years. In such cases, the analyst will want to look at the economics of capacity utilization. It may be that the economies of scale are so great that the larger design of the component should be undertaken, even though its capacity would not fully be utilized for several years. The physical flow and value flow tables can be prepared for several alternative combinations of investment, operating and output assumptions, and the NPW's of the alternatives can be compared to arrive at the most economically efficient one, given the constraint identified for requirements. For example, one alternative would be to build initially a pulp and paper mill with 150 000 tons per year capacity and operate it below capacity for the first five years until requirements reach 150 000 tons per year. Another alternative could be, for example, to build initially a mill that produces 110 000 tons (the assumed initial requirements) and then put another mill on the stream in 5 years that would produce an additional 60 000 tons (the assumed minimum economic capacity) and have a reduced excess capacity only from year 5 to year 7 where requirements are expected to reach 170 000 tons.

This particular problem involves considering both scale and timing elements in the same partial analysis. It also involves technology considerations in arriving at the relevant cost estimates for the two alternatives. Location considerations may also enter the picture in terms of location of the two, phased mills against the one larger mill. Thus, here is an example of a case where four design elements are closely interrelated.

Even in the case of an analysis of a single separable project component, consideration of many alternatives with regard to technology, scale, location, and timing can become a major task in terms of the computations involved. Once it is recognized that there are interactions between components, the task becomes even more complex, if many such interactions are considered. Take the example shown in Table 11.4, which only includes four components and a few limited designs for each. Since two locations are being considered for the processing component and two for the plantation component, there are  $4 \times 2 \times 2 \times 8$  or 128 possible combinations. If the assumptions regarding fixed elements are relaxed slightly, over 500 different alternatives could be obtained.

Naturally, in most cases, the number of alternatives considered will be limited in the technical analysis stage to considerably fewer than 128. If a computer is readily available and fairly good data exist on which to base physical input-output relationships for the alternatives, then it is simple to run through a great number of alternative designs and to arrive at the optimum design in terms of economic efficiency. If computer facilities (and the expertise needed to use them) are not readily available, then the project planners will probably want to reduce the number of alternatives to a few, using their judgement and experience concerning which ones are most desirable in the particular project context.

Table 11.4

CONSIDERING COMBINATIONS OF COMPONENTS IN A TOTAL PROJECT PACKAGE

Project: integrated plantation, harvesting and processing project to produce sawnwood for local market.

Constraints: output is fixed (i.e., scale of lumber production).

Processing of sawnwood:

- Alt. 1 labour intensive sawmill
- Alt. 2 capital intensive sawmill

For each of these alternatives, two locations are being considered; scale is fixed by market; timing will depend directly on when first harvestable wood will become available.

Transport of wood to mill:

- Alt. 1 large trucks with road improvements
- Alt. 2 smaller trucks utilizing existing roads

For each alternative, location considerations are fixed depending on sawmill location and location decided on for plantation; scale is fixed by wood volume needed (actually grown) to meet mill requirements; timing is fixed within limits by when wood becomes available.

Harvesting of wood:

- Alt. 1 labour intensive with cheap hand tools
- Alt. 2 capital intensive technology with machinery and less labour

For each alternative, timing depends on rotation or harvest age set for plantations (from 12 years to n years); scale is fixed by volume requirements and volume actually grown; location is fixed by location of plantations.

Growing of wood:

- Alt. 1 species X with fertilization
- Alt. 2 species X without fertilization
- Alt. 3 species Y with fertilization
- Alt. 4 species Y without fertilization

For each alternative, two locations are being considered, timing of planting depends on calculation of optimum rotation (most profitable age for harvest), scale is fixed for any given alternative by volume requirements at mill and area available.



## 11.5 COMPARING HORIZONTALLY RELATED COMPONENTS

In some cases there are several horizontally related components which are being considered for the same project, and the components are not mutually exclusive, i.e., one or both could be included in the same project. The approach to analysing such alternatives can be illustrated with a simple example.

Assume a project which is initially designed to produce plywood and sawnwood from a given and limited raw material base. The two components are independent in terms of processing and marketing, but they both depend on the same raw material, which is considered the limiting factor in this example. The economic analyst may be asked to provide information on the relative efficiency of producing one or the other or both of the products in combination. The question really boils down to one of the optimum allocation of a scarce resource, in this case the wood. Assume the simplest case, where both products can be produced from the same raw material and the market analysis indicates that if the raw material were utilized solely for either produce the resulting output could be fully marketed without influencing prices. Given the above, the analyst would want to provide information on the net benefit if the wood were put into (a) plywood production, and (b) sawnwood production. If he finds that one gives a higher NPW than the other, then the project may be redesigned to include production of only the one with the highest NPW.

This example represents the simplest situation. If only some of the wood is suitable for plywood, while all of it can be used for sawnwood, or if the market capacity for one or the other or both of the products is limited within the range of possibilities offered by the available raw material, then the constraints change and it is possible that some combination of components will provide the maximum NPW possible.

In determining that combination which gives the maximum NPW, the analyst can be guided by net benefit estimates per unit of input or output for each product and the various constraints identified. Table 11.5 provides an example of a simple analysis of optimum product mix, given expected market prospects and other constraints. In this case, plywood gives a much higher estimated net return than sawnwood per m<sup>3</sup> (r), i.e., \$40 vs. \$20, and is thus the best product from an efficiency point of view when wood is a scarce resource and taken to be the limiting factor. However, the market potential for plywood is only 20 000 m<sup>3</sup>. Thus, the first step is to allocate all the wood needed to produce 20 000 m<sup>3</sup> of plywood, or 40 000 m<sup>3</sup> (r). The remainder of the wood is then allocated to sawnwood production. This amounts to 110 000 m<sup>3</sup> which can produce 68 750 m<sup>3</sup> of sawnwood. As can be seen, both constraints - market and wood availability - enter the analysis at different stages.

The same approach could be taken if the alternative uses of a plantation output were being investigated. For example, the output might be used for sawnwood or plywood or for pulp, paper or fibreboard. In this case, the alternatives are compared using different value assumptions for the wood output, depending on the particular use being analysed. For each alternative, the benefits would be calculated in terms of the value assumptions for each alternative product or use, and the costs would be based on the costs of producing the wood or the opportunity cost of the wood, whichever is highest. For example, assume that the cost of wood production in the project has a PV of \$150/ha; the value of the wood from the project if used for sawnwood has a PV of \$200/ha, and the value of the wood from the project if put into pulp production has a PV of \$180/ha. If the sawnwood alternative is

Table 11.5

DETERMINING OPTIMUM PRODUCT MIX

Plywood:

Market constraint:	20 000 m <sup>3</sup> /a
Wood required:	40 000 m <sup>3</sup> (r)/a (2m <sup>3</sup> (r)/m <sup>3</sup> plywood)
Average PV of net return per m <sup>3</sup> (r):	\$40

Sawnwood:

Market constraint:	100 000 m <sup>3</sup> /a
Wood required:	160 000 m <sup>3</sup> (r)/a (1.6m <sup>3</sup> (r)/m <sup>3</sup> sawnwood)
Average PV of net return per m <sup>3</sup> (r):	\$20

Wood available:

Total:	150 000 m <sup>3</sup> (r)/a
Usable for plywood:	50 000 m <sup>3</sup> (r)
Usable for sawnwood:	All

Design project to produce:

20 000 m<sup>3</sup> plywood from 40 000 m<sup>3</sup> (r)  
68 750 m<sup>3</sup> sawnwood from 110 000 m<sup>3</sup> (r)

NPV (maximum possible, given market constraint)

40 000 x \$40 =	1 600 000
110 000 x \$20 =	2 200 000
	<hr/>
Total	\$3 800 000

being analysed \$200/ha will be used as the measure of benefits and, if land is the limiting factor, then \$180/ha will be used as the measure of opportunity cost, since this is the value given up by using the wood for sawnwood rather than for pulpwood. If land is not the limiting factor - i.e., the pulpwood could be produced in another location for \$150, then the relevant opportunity cost would be based on production costs and would be \$150. This follows from the fact that, by using the wood for sawnwood, an extra cost of \$150 would be incurred to get the equivalent amount of wood for pulpwood.

#### 11.6 ADDING ON A PROJECT PURPOSE

In some cases, the analyst may want to look at the economics of adding on a secondary purpose to the initially conceived project purpose(s). For example, he may be considering a plantation project to produce fuelwood for a local community. The suggestion is made that with slight additional expenditure, the project design could be modified so it would produce significant soil protection benefits (valued in terms of crop losses avoided). How would he determine whether it is worthwhile adding on this project purpose?

The difference here from the case of a separable component being considered for inclusion is that the costs of the two purposes - fuelwood and soil protection - are for the most part shared costs. Both purposes share the major expense, namely the basic plantation establishment and maintenance costs. The approach in this case is to compare the present value of the incremental costs required to add on the purpose with the incremental benefits associated with the add-on purpose. Put another way, the NPW of the differences between the value flows with and without the soil protection component can be calculated. If it is positive, then it is worth adding on the purpose. If it is negative, then the additional benefits do not justify the additional costs. This approach essentially parallels that suggested in Table 11.3 for dealing with mutually exclusive alternatives for specific design components. The MRR approach could also be used in this case, where the MRR associated with adding on a purpose would be calculated.

The difference shown in Table 11.6 (col. 4) in the cost streams for the two alternatives (fuelwood purpose alone and fuelwood/soil protection combined) is due to the higher cost associated with shifting the plantation activity to a steeper more critical area that can produce protection benefits, modification in the planting rate per unit area, and modification in the maintenance and harvesting approaches. The differences in benefit streams are due to the inclusion of the soil protection benefits (valued in terms of crop losses avoided).

As noted in Table 11.6, the NPW of the difference between the two value flows is a positive \$75 770 which means that it is worthwhile to add on the soil protection purpose, given the discount rate of 5 percent.

If the analyst is uncertain about the value of the benefits associated with an add-on purpose, then he can estimate the minimum value which such add-on benefits must have in order to justify the incremental costs associated with producing such benefits. To do this, he calculates a cost-price such as discussed in Chapter 10.

Table 11.6

DETERMINING WHETHER A PROJECT PURPOSE SHOULD BE ADDED TO THE MAIN PURPOSE(S)

Item	(Values in \$ '000)			
	Fuelwood	Combined w/soil Protection	Difference between the two	PV of the difference (at 5 percent)
(1)	(2)	(3)	(4)	(5)
Costs (by years)				
0	150	180	30	30.00
1	30	50	20	19.05
2	20	30	10	9.07
3	20	25	5	4.32
4-15	15	18	3	20.5 <sup>✓</sup>
Total	-	-	-	82.94
Benefits (by years)				
2	-	10	10	9.07
3	-	15	15	12.96
4-15	90	110	20	136.68 <sup>✓</sup>
Total	-	-	-	158.71

NPW of difference (at 5 percent) equals  
 $158\ 710 - 82\ 940 = \$75\ 770$

<sup>✓</sup> The formula for the PV of a series of equal annual payments was used to obtain the value of the series expressed in year 4 value terms. That value was then discounted back an additional 4 years to arrive at the PV in year zero (see Appendix B for formula).

## Chapter 12

### USE OF ECONOMIC ANALYSIS IN THE APPRAISAL OF A FORESTRY PROJECT:

#### A SUMMARY <sup>1/</sup> <sub>2/</sub>

#### 12.1 INTRODUCTION

This chapter provides a review of the main elements which should be included in a financial and economic appraisal of a project at a fairly advanced stage in its preparation<sup>3/</sup>. It is essentially a summary of the steps discussed in Part I. As it is preferable and usual that the economic and financial appraisal results be presented in the same document, and in an integrated fashion, the discussion which follows includes both types of information.

There is no unique or "best" way to present the information needed by decision makers to evaluate the financial and economic worth of a forestry project. The amount of detail required depends on, among other things, the specific nature and size of the project, its technical complexity and scope, as well as the particular requirements or standards of the institution for which the analysis is being prepared. However, though there will thus be some variations from project to project, every appraisal report should contain at least summaries of the following basic elements:

##### A. Inputs into the analysis:

- (i) Direct physical relationships, presented in the form of Physical Flow Tables, showing inputs and outputs and their relationships over time and by categories of inputs and activities as required by the objectives of the analysis. These relationships are obtained from the engineering and technical studies for the project and from financial analysis documents (see Chapter 4).
- (ii) Indirect physical relationships. These are usually not included in financial appraisals but must be included in the economic analysis. As explained in Chapter 4, the nature and magnitude of these relationships are generally identified from sources other than the technical and engineering studies required to carry out financial appraisals,

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<sup>1/</sup> Because so many tables are used in this chapter and referred to in a number of places, they are all grouped together at the end of the chapter.

<sup>2/</sup> See the case studies in FAO, 1979, and Appendix A for other examples of the suggested format.

<sup>3/</sup> i.e., the implicit assumption is that a number of studies of alternative designs, project scopes, timing, etc., have been carried out in arriving at the project design which is being subjected to appraisal (see Chapter 11).

although these are a logical point of departure from which to investigate indirect effects. These effects can be incorporated either directly in shadow prices or, preferably in the form of an Indirect Physical Effects Table and/or Statement. (Chapter 4).

- (iii) Market prices for financial inputs and outputs including their estimated changes over time net of inflation. This information is presented in a Financial Unit Value Table. (Chapters 5 and 6).
- (iv) Shadow price for economic inputs and outputs (including those for indirect effects if available) and their expected changes over time. This information is presented in an Economic Unit Value Table. (Chapters 5-8).

B. Outputs of the Analysis:

- (i) Financial effects of the project over time presented in Financial Total Cash Flow Tables for the total project, and for important separable project components. (See Chapter 9).
- (ii) Economic effects of the project over time displayed in Economic Value Flow Tables for the total project and for major separable components. (Chapter 9).
- (iii) Estimates of economic and financial measures of project worth. (Chapter 9).
- (iv) Tests of the sensitivity of the measures of project worth to changes in assumptions about input/output relationships and unit values assumed in the basic analyses, i.e., explicit treatment of project uncertainty. (Chapter 10).
- (v) Conclusions/recommendations (if required as part of the assignment).

This approach fits with the earlier recommendation that a financial analysis be performed prior to, or simultaneously with, an economic evaluation. The results of both should be presented together.

The following sections illustrate each of the above steps and their interrelationships, using as an example an afforestation project in a tropical country.

## 12.2 INPUTS INTO THE ANALYSIS

The first step in deriving and organizing information for an economic or a financial analysis involves the identification and measurement of physical input-output relationships, both direct and indirect. The second step consists of developing financial and economic values for the inputs and outputs and other values needed in the financial and economic analyses.

### 12.2.1 Direct physical input/output relationships

The technical design of a project involves the processing of a great deal of data on the physical dimensions of the proposed project. Input-output relationships have to be quantified and total input requirements to meet output goals need to be tabulated, generally by input types and activities and by the years in which inputs and outputs occur. In some cases inputs are further grouped by source, foreign or domestic, if foreign exchange is a relevant concern. Similarly, outputs are subdivided in terms of destination, foreign or domestic. Inputs and outputs are broken down into these categories in order to facilitate shadow pricing. Other groupings of inputs and outputs may also be used for other purposes.

Quite often, physical input and output data can be estimated on an "average" unit basis - e.g. average per ha input requirements and average per ha output for the project. This approach is typical where information is not available to break the analysis down by sub-areas/site classes and by locations within the project region. In cases where data are available on which to base a disaggregated analysis, the analyst can develop separate input and output tables for each different type of area or condition identified. (See Chapter 4).

In the case of the afforestation project used as an example in this Chapter, the analyst used Tables 12.1 and 12.2 to present the output conditions assumed in the analysis. The project is aimed at establishing 18 000 ha of plantations over a period of six years to provide wood for an industrial complex. The relevant project period, based on when yields will occur was set at 35 years (see Chapter 4).

The species proposed are Pinus spp. and Eucalyptus spp. A land area equivalent to the project's requirements and close to the main industrial market is already available as a public Forest Reserve. The project will be implemented by the Forest Service and financed by a loan obtained by the Service which carries an interest rate of 7 percent. According to the design of the project, pines will be planted at a rate of 2 000 ha per year and eucalypts at a rate of 1 000 ha per year to reach a total planted area of 12 000 ha of pines and 6 000 ha of eucalypts at the end of six years.

It is planned to grow both species over rotations designed to produce both sawlogs and small diameter roundwood to be used as poles and for pulp. The pine plantations will be thinned at ages 6, 8, 12 and 21 years with the final cut being made at 30 years. Eucalypts will be thinned at ages 3, 5 and 6 years with the final cut carried out at 8 years. Species trials and silvicultural treatment experiments carried out in similar ecological conditions in neighbouring countries provided the basic information for the choice of species and silvicultural treatment. Also, earlier commercial plantings and subsequent research in the country have allowed satisfactory and reliable practices to develop.

Detailed prescriptions have been worked out to protect plants at the nursery from fungus, insects and pests. Eucalypts will be treated with insecticide in the nursery as a protection against damage from termites after planting in the field. Land will be cleared by tractor followed by burning, ploughing and disking. Plantations will be weeded manually and mechanically during the first and second year. Controlled burning will be carried out early in the dry season to reduce fire hazard. It was considered that highly mechanized operations should be used because of the scale of operations and because the timing of

operations was a critical factor. Large-scale use of labour would not be feasible from a logistical point of view. It is estimated that yields after deducting for mortality, breakage, fire and other losses will be those shown in Table 12.1. These multiplied by the appropriate area under plantation in a given year generate total output flows by type of products over time as displayed in Table 12.2.

On the input side the analysts generated separate estimates of input streams for each main input. Thus, for example, Table 12.3 shows the pattern of estimated labour requirements over time. Similar physical flow tables were prepared for other physical inputs but they are not reproduced here for the sake of brevity.

### 12.2.2 Indirect physical relationships

While the project is aimed at increasing wood supplies, there are several indirect effects which will likely be generated. The following were identified by the project team:

- Reduced erosion will lower the cost of maintenance of a reservoir downstream of the pine plantations. The pine plantations will eventually cover 12 000 ha, a major part of the watershed. It is estimated that soil erosion under these plantations would be about 0.5 m<sup>3</sup>/ha/a while under present land use erosion rates are 5 times higher. The timing of these effects needs detailed examination. Soil erosion will diminish gradually when crown and litter cover increases and ends when the plantations are clear-felled. Due to lack of more precise studies of the relationships over time between forest cover and erosion rates, it was assumed that between years 5 and 15 erosion will be reduced from 2.5 to 1.5 m<sup>3</sup>/ha/a and that from year 16 to the end of the project period the full protective effect of plantations will take place reducing the erosion rate further from 1.5 to 0.5 m<sup>3</sup>/ha/a. The results are displayed in Table 12.4.
- Training and experience will be obtained in the implementation of the afforestation project and could eventually benefit other similar projects in the country. Due to the difficulty in estimating quantitatively the probable impact of this effect over time, the analyst limited his assessment to a qualitative judgement of the new skills which will become available as a result of the project. (This qualitative judgement was presented as a statement in the project appraisal document.)
- The increased economic activity in the project region will generate a stimulating effect on the depressed local economy by increasing employment and use of resources previously idle beyond increased direct use of labour and other resources in the project. Local impact studies suggest that net indirect benefits derived from increased use of resources which would remain idle without the project are roughly equivalent to 80 percent of local monetary wages in the project and therefore this coefficient was used in the calculations. <sup>1/</sup>

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<sup>1/</sup> Due to the uncertainty surrounding this figure, appraisal results were presented both with and without including this indirect effect.



### 12.2.3 Unit values

Unit values used in pricing the project's output are displayed in Table 12.5. Stumpage prices existed in the market and they were estimated to correspond to economic values in the case of small roundwood. Therefore they were used in both the financial and economic analyses. However, in the case of sawlogs, due to the existence of government subsidized prices, the economic value was estimated at 1.25 times the market value. In connection with indirect effects, the value of erosion avoided was estimated on the basis of reduced maintenance costs of the reservoir reaching \$1 per cubic metre. As explained in Section 12.2.2 the value of the increased local economic activity generated by the project was estimated to be equal to 80 percent of the project wages. On the input side, land was valued at zero in the financial analysis since it was already owned by the Forest Service (see Table 12.5). However, based on land demand projections for the project region its economic opportunity cost was estimated to be positive and rising over time. For purposes of economic analysis land was valued at \$2 per ha per year through year 8, \$3 per ha per year between years 9 and 15 and \$4 per ha per year from then on. Also due to heavy unemployment in the project area, which to a certain extent is expected to persist in the future, all labour costs were valued at 60 percent of financial costs in the economic analysis. All other unit values are assumed to be the same in the financial and economic analyses.

Finally, a 7 percent discount rate was used in the financial analysis since this was the rate to be applied to the loan used to finance the project. The Central Planning Office of the country has determined that a 9 percent discount rate should be used in all project evaluations and this was, therefore, the rate used in carrying out the economic analysis.

## 12.3 OUTPUTS OF THE ANALYSIS

This section shows how the basic data collected and processed in the form described above was utilized to develop information for decision-making.

### 12.3.1 Financial and economic value flows

Information provided in Table 12.2 and Table 12.5 was combined to generate the financial benefit flow displayed in the first four rows of Table 12.7. Information on physical input requirements and input unit prices was used to generate an estimate of total costs per activity and per hectare, as displayed in Table 12.6 which in turn, multiplied by the relevant number of hectares yielded the financial estimates of total project costs over time shown in rows 5 to 8 of Table 12.7.

Because of the great uncertainty surrounding the estimation of indirect benefits, the economic analysis was divided into two parts. The first part of the analysis includes only direct effects. Second, quantifiable indirect effects were incorporated to calculate the total (although less certain) estimated economic impact of the project. The results of these estimations are displayed in the economic value flow Tables 12.8 and 12.9 respectively.

In addition, because the project has two components which are separable (pine and eucalypts), it was necessary to explore the worthiness of each of these in both financial and economic terms. (See Chapter 4 for guidelines concerning separability). The procedure used in producing the flow tables for each component is exactly the same as that used to generate the aggregate flow table for the whole project. The results of this exercise are displayed in Tables 12.10 and 12.11 for the eucalypt component and 12.12 and 12.13 for the pine component, comprising the corresponding financial flows and economic flows net of indirect effects. In each case the relevant project component period is equal to the number of years which is necessary to materialize total physical yields. Finally, since the quantifiable indirect effects will have a differential effect on both components, the analyst also prepared Tables 12.14 and 12.15 which display the economic value flows including indirect effects for the eucalypt and pine component respectively. This completed the basic financial and value flow estimates for the project and its components.

With the basic value flow tables available, the next stage is the estimation of measures of project worth.

#### 12.3.2 Project Worth

As mentioned in Chapter 9, several measures of project worth can be calculated. The most common measures are the financial internal rate of return (FRR) and NPW and the economic internal rate of return (ERR) and NPW.

The FRR, ERR, and the two NPW measures for the project can be derived directly from Tables 12.7 and 12.8 which present the financial cash and economic value flows for the project, excluding indirect effects. The procedure for calculating these measures of project worth and efficiency was discussed in Chapter 9. Similarly the ERR and economic NPW for the project, including indirect effects, can be estimated from Table 12.9. Tables 12.10 through 12.15 set out the calculations of the measures of worth for each project component.

It can be observed from Tables 12.7 and 12.8 that the project as a whole is financially and economically profitable as both the FRR and ERR are superior to the financial and economic discount rates respectively. Also, although the project is economically viable on the basis of its direct effects alone, the inclusion of indirect effects produces a significant positive change in the ERR as displayed in Table 12.9.

The analysis of the project's worth also shows that each of the project's components is financially and economically profitable. (See tables 12.10 through 12.13), and that their economic worth is higher when indirect effects are included (Tables 12.14 and 12.15). Finally the analysis indicates that the eucalyptus component is more profitable, both financially and economically, than the pine component and therefore suggests the idea that more land might be dedicated to eucalyptus plantations provided market constraints permit. Thus, the economic analysis of the project could lead eventually to a re-examination of the project and possibly to alternative designs.

### 12.3.3 Sensitivity Analysis

The nature of the sensitivity analysis and how it should be developed have been discussed in Chapter 10. There are a number of elements which might have different magnitudes than those assumed in the analyses. Thus, it is desirable to recalculate the project value flows and worth in order to take into account possible changes in parameter values. A number of parameters which are of key importance could be tested to analyse the sensitivity of the project to changes in their values. In this case the following were chosen:

(i) Market variables - Throughout the analysis of the afforestation project it was assumed that the project's output of pulpwood would be entirely used to supply the additional requirements of a planned expansion of an existing pulp and paper mill. However, the market studies indicated that the domestic market might not absorb the additional production of paper during the first years of operation of the proposed expansion of the mill and that it is unlikely that any excess could be profitably exported because of the small amounts involved.

The analyst noted that there were practically no alternative outlets for the pulpwood-sized wood from the project. This wood is not suitable for poles and posts and is likely to be too costly to compete either with indigenous woods as firewood, or with wood residues as a raw material for a planned particleboard plant. There is, therefore, some possibility that part of the project's output of pulpwood would not be needed for some years. In the sensitivity analysis carried out to explore this possibility, it was assumed, based on alternative estimates of possible demand developments, that the planned expansion of pulp and paper would be postponed from year 6 until year 14 and that, therefore, all pulpwood produced before then will not be used. As indicated in Table 12.16, under these conditions both components still remain financially and economically viable although the pine component is clearly in a critical position with FRR and ERR close to the financial and economic cut-off rates (7 and 9 percent respectively).

(ii) Yields - In the case of the eucalypt component there was a question of whether pest control treatments will be entirely effective as no previous large scale plantations of this species existed in the country. In these circumstances the analyst assumed that an additional large amount of wood in the sawlog size would be damaged by termites and that the net effect would be to reduce the usable output of sawlogs by as much as 30 percent. <sup>1/</sup> The recalculation of this component's financial and economic worth indicates that even in these extreme circumstances the eucalypt component would remain financially and economically viable (Table 12.16).

(iii) Location - Finally, the analyst was aware that at the time of the study the Forest Service was simultaneously considering the alternative idea of dedicating most of pine component land area to a wildlife reserve and locating the pine plantations in other available land with basically the same opportunity cost but situated 40 miles further away from the market. This would mean additional transportation costs equal to \$0.074/m<sup>3</sup> per mile and therefore a reduction of the economic unit value of the component output (stumpage value) equal to \$2.96/m<sup>3</sup>. The calculations carried out under this assumption indicate, as shown in Table 12.16, that the pine component would not be financially or economically sound.

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<sup>1/</sup> Note that this particular sensitivity analysis could also provide information on other possible causes of effective yield reductions, e.g. fire damage, over-estimation of growth, etc.

#### 12.4 CONCLUSION

Many other changes in assumptions could have been introduced in the analysis of this project. However, the analyst felt that with the studies carried out so far, certain key elements had been identified which gave a clear perspective of the economic worthiness of the project.

First, the project and its component were both financially and economically viable if the conditions originally assumed materialized.

Second, the eucalypt component was substantially more attractive than the pine component on both financial and economic grounds.

Third, given the financial and economic strength of the eucalypt component, it is very likely that this component will remain viable even if adverse conditions materialize. The same cannot be said of the pine component, which would not be financially or economically sound, if it is located in the alternative site considered and only marginally viable if the market does not develop as rapidly as assumed in the original analysis.

Fourth, therefore, consideration needs to be given either to redesigning the project or to closer scrutiny of the variables influencing the development of the pine component.

This example illustrates both the procedures used in carrying out an economic analysis of a project and the use of the economic information derived. It also highlights the importance of economic analysis in identifying key elements in design and exploring areas of uncertainty as basic factors in the decision-making process.

Table 12.1

AFFORESTATION PROJECT

Yields of Thinnings and Final Harvest  
(m<sup>3</sup>/ha)

	Year	Sawlogs	Small Poles	Pulpwood
<u>Eucalyptus</u>				
First thinning	3	3	14	12
Second "	5	21	19	17
Third "	6	32	7	11
Final felling	8	67	5	16
 <u>Pines</u>				
First thinning	6	-	-	8
Second "	8	4	-	19
Third "	12	23	-	18
Fourth "	21	79	-	15
Final felling	30	297	-	39

Table 12.2

## AFFORESTATION PROJECT. TOTAL OUTPUT

('000 m<sup>3</sup>)

## Y E A R S

Product	0-2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18-20	21-26	27-29	30-35
Sawlogs	0	3	3	24	56	56	131	128	128	107	121	121	46	46	46	46	-	158	-	594
Small Poles	0	14	14	33	40	40	45	31	31	12	5	5	-	-	-	-	-	-	-	-
Pulpwood	0	12	12	29	40	40	110	98	98	81	90	90	36	36	36	36	-	30	-	78
TOTAL OUTPUT	0	29	29	86	136	136	286	257	257	200	216	216	82	82	82	82	0	188	0	672

Table 12.3

**AFFORESTATION PROJECT**

**LABOUR REQUIREMENTS**

( '000 man days)

Year	Land Clearing/ Road Construction	Planting Activities
-1	15.47	6.74
0	15.47	57.72
1	15.47	71.90
2	15.47	84.13
3	15.47	93.97
4	15.47	103.82
5		111.69
6		70.55
7		66.22
8		68.60
9		65.31
10		62.03
11		53.99
12		50.71
13		47.43
14		39.39
15		39.39
16		39.39
17		39.39
18-20		39.39
21-26		39.39
27-29		39.39
30		39.39
31		32.83
32		26.26
33		19.70
34		13.13
35		6.57

Table 12.4

AFFORESTATION PROJECT

REDUCED EROSION EFFECT

Years	Number of ha under plantation ('000)	Reduced erosion effect (m <sup>3</sup> /year)
0	2 000	-
1	4 000	-
2	6 000	-
3	8 000	-
4	10 000	-
5-15	12 000	12 000
16-29	12 000	24 000
30	10 000	20 000
31	8 000	16 000
32	6 000	12 000
33	4 000	8 000
34	2 000	4 000
35	-	-



Table 12.5

AFFORESTATION PROJECT

MAIN UNIT VALUES

<u>Output</u>	<u>Financial Analysis</u>	<u>Economic Analysis</u>
Pine Sawlogs	\$15.08/m <sup>3</sup>	\$18.85/m <sup>3</sup>
Pine Pulpwood	\$ 5.69/m <sup>3</sup>	\$ 5.69/m <sup>3</sup>
Eucalypt sawlogs	\$12.11/m <sup>3</sup>	\$15.14/m <sup>3</sup>
" poles	\$ 9.64/m <sup>3</sup>	\$ 9.64/m <sup>3</sup>
" pulpwood	\$ 4.70/m <sup>3</sup>	\$ 4.70/m <sup>3</sup>
Reduced erosion	-	\$ 1.00/m <sup>3</sup>
Increased local economic activity	-	80% of project wages

Main Inputs

Land	0	- \$2/per hectare per year years 1 to 8 - \$3/per hectare per year years 9 to 15 - \$4/per hectare per year years 16 to 35
Labour	\$0.5 man-hour	\$0.3 man-hour

All other Inputs: financial unit value = economic unit value.

Other Analytical Parameters

Discount rate	7%	9%
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Table 12.6

AFFORESTATION PROJECT  
 PLANTATION ACTIVITIES AND FINANCIAL COSTS PER HECTARE  
 (\$/ha)

ACTIVITY	Y E A R																
	-1		0		1		2-4		5		6-7		8		9-30		
	Labour	Other	Labour	Other	Labour	Other	Labour	Other	Labour	Other	Labour	Other	Labour	Other	Labour	Other	
Land Clearing	29.20	335.76															
Road Construction	12.04	97.62															
Land Preparation			6.92	95.14													
Nursery			21.80	9.34													
Planting			16.96	44.00													
Fertilizing			8.65	7.44													
Singling			23.18														
Weeding			43.77	46.70	18.82	23.72											
Pruning									19.02				9.51				
Fire Control							7.26	4.50	7.26	4.50	7.26	4.50	7.26	4.50	7.26	4.50	
Road Maintenance			1.04	6.22	1.04	6.22	1.04	6.22	1.04	6.22	1.04	6.22	1.04	6.22	1.04	6.22	
Station Overheads	9.34	21.80	9.34	21.80	9.34	21.80	9.34	21.80	9.34	21.80	9.34	21.80	9.34	21.80	9.34	21.80	
Division Overheads	8.62	20.10	8.62	20.10	8.62	20.10	8.62	20.10	8.62	20.10	8.62	20.10	8.62	20.10	8.62	20.10	

Year 0 = Year of Planting



Table 12.8  
 AMORISATION PROJECT  
 ECONOMIC VALUE FLOW  
 ('000 US\$)

	YEAR																																						
	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18-20	21-26	27-29	30	31	32	33	34	35											
<b>BENEFITS</b>																																							
Salvage					45.41	45.41	363.30	867.70	847.70	2012.71	1967.30	1967.30	1649.41	2032.11	2032.11	867.10	867.10	867.10	867.10	867.10	2978.30	11196.90	11196.90	11196.90	11196.90	11196.90	11196.90	11196.90	11196.90	11196.90	11196.90	11196.90	11196.90	11196.90	11196.90				
Small					134.36	134.36	318.12	385.60	385.60	433.80	298.84	298.84	115.68	48.20	48.20																								
Pole					56.40	56.40	136.30	279.04	279.04	570.46	514.06	514.06	434.16	496.26	496.26	204.84	204.84	204.84	204.84	204.84	170.70																		
TOTAL BENEFITS					236.77	236.77	817.72	1512.34	1512.34	3016.97	2780.20	2780.20	2199.25	2576.57	2576.57	1071.94	1071.94	1071.94	1071.94	1071.94	3449.00	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72			
<b>COSTS</b>																																							
Labour	53.28	175.64	209.68	239.02	262.65	286.28	268.05	169.33	158.92	164.63	156.75	148.87	129.58	121.70	113.83	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	94.54	
Land	6.00	12.00	18.00	24.00	30.00	36.00	36.00	36.00	36.00	36.00	36.00	48.00	45.00	42.00	39.00	36.00	36.00	36.00	36.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	
Other	712.92	1097.21	1204.97	1283.99	1362.83	1441.76	807.77	502.41	473.58	473.58	447.27	420.96	394.65	368.34	342.03	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	
TOTAL COSTS	772.20	1284.85	1432.65	1546.92	1655.48	1764.04	1111.82	707.74	669.50	674.21	655.02	617.83	569.23	532.04	494.80	446.26	446.26	446.26	446.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	
NPV	(772.20)	(284.85)	(132.65)	(154.69)	(148.71)	(152.27)	(294.10)	804.60	843.84	2342.76	2125.18	2162.37	1690.02	2044.53	2081.71	625.68	625.68	613.68	613.68	613.68	2690.74	(458.26)	6990.74	(458.26)	1182.46	11335.22	11411.59	11487.97	11564.34	11564.34	11564.34	11564.34	11564.34	11564.34	11564.34	11564.34	11564.34	11564.34	
RFN																																							
ERR																																							

RFN = 5537 (baseyear zero)

ERR = 13%

Table 12.9  
 AFFORESTATION PROJECT  
 ECONOMIC VALUE FLOW INCLUDING INDIRECT BENEFITS  
 ('000 US\$)

	YEAR																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18-20	21-26	27-29	30	31	32	33	34	35			
<b>BENEFITS</b>																													
Direct	-	-	-	-	236.77	236.77	817.72	1512.34	1512.34	3016.97	2780.20	2780.20	2199.25	2576.57	2576.57	1071.94	1071.94	1071.94	1071.94	-	3149.00	-	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	
Indirect	71.04	234.18	279.87	318.69	350.20	381.71	369.40	237.77	223.90	231.50	221.00	210.50	184.78	174.27	163.77	138.05	138.05	150.05	150.05	150.05	150.05	150.05	150.05	146.05	121.04	96.03	71.02	44.02	21.02
<b>TOTAL BENEFITS</b>	71.04	234.18	279.87	318.69	586.97	618.48	1187.12	1750.11	1736.24	3248.47	3001.20	2990.70	2384.03	2750.84	2740.34	1209.99	1209.99	1221.99	1221.99	150.05	3299.05	150.05	11786.77	11761.76	11736.75	11711.74	11684.74	11661.74	
<b>TOTAL COSTS</b>	772.20	1284.85	1432.65	1546.92	1655.48	1764.04	1111.82	707.74	668.50	674.21	655.02	617.83	569.23	532.04	494.86	446.26	446.26	458.26	458.26	458.26	458.26	458.26	458.26	381.88	305.50	229.13	152.75	76.38	
<b>NET BENEFITS</b>	(701.16)	(1050.67)	(1152.78)	(1228.23)	(1068.51)	(1145.56)	75.30	1042.37	1067.74	2574.26	2346.18	2372.87	1814.80	2218.80	2245.48	763.73	763.73	763.73	763.76	(308.21)	2840.79	(608.21)	11328.51	11379.88	11431.25	11482.61	11531.99	11585.36	

NPV = 8350

ERR = 16.2

Table 12.10

AFFORESTATION PROJECT FINANCIAL CASH FLOW  
EUCALYPTUS COMPONENT  
( '000 US\$ )

	Y E A R S														
	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
<u>BENEFITS</u>															
Sawlogs	-	-	-	-	36.33	36.33	290.64	678.16	678.16	1489.53	1453.20	1453.20	1198.89	811.37	811.37
Small Poles	-	-	-	-	134.96	134.96	318.12	385.60	385.60	433.80	298.84	298.84	115.68	48.20	48.20
Pulpwood	-	-	-	-	56.40	56.40	136.30	188.00	188.00	263.20	206.80	206.80	126.90	75.20	75.20
TOTAL BENEFITS	-	-	-	-	227.69	227.69	745.06	1251.76	1251.76	2186.53	1958.84	1958.84	1441.47	934.77	934.77
<u>COSTS</u>															
-Land clearing/ road construction:															
Labour	20.62	20.62	20.62	20.62	20.62	20.62									
Other	216.69	216.69	216.69	216.69	216.69	216.69									
-Planting and management:															
Labour	8.98	86.61	104.52	127.16	140.29	153.42	157.57	94.07	88.29	78.78	65.65	52.52	39.39	26.26	13.13
Other	20.95	138.14	174.06	200.37	226.68	252.99	258.35	167.47	157.86	157.86	131.55	105.24	78.93	52.62	26.31
TOTAL COSTS	267.24	461.06	515.89	564.84	604.28	643.72	415.92	261.54	246.15	236.64	197.20	157.76	118.32	78.88	39.44
<u>NET BENEFITS</u>	(267.24)	(461.06)	(515.89)	(564.84)	(376.59)	(416.03)	329.14	990.22	1005.61	1949.89	1761.64	1801.08	1323.15	855.89	895.33

NPV = 3562

FRR = 21.3

Table 12.11

## AFFORESTATION PROJECT ECONOMIC VALUE FLOW

## EUCALYPTUS COMPONENT

('000 US\$)

Y E A R S

	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
<u>BENEFITS</u>															
Sawlogs	-	-	-	-	45.41	45.41	363.30	847.70	847.70	1861.91	1816.50	1816.50	1498.61	1014.21	1014.21
Small Poles					134.96	134.96	318.12	385.60	385.60	433.80	298.84	298.84	115.68	48.20	48.20
Pulpwood					56.40	56.40	136.30	188.00	188.00	263.20	206.80	206.80	126.90	75.20	75.20
TOTAL BENEFITS	-	-	-	-	236.77	236.77	817.72	1421.30	1421.30	2558.91	2322.14	2322.14	1741.19	1137.61	1137.61
<u>COSTS</u>															
Labour	17.76	63.74	75.08	88.67	96.55	104.42	94.54	56.44	52.97	47.27	39.39	31.51	23.63	15.76	7.88
Land	2.00	4.00	6.00	8.00	10.00	12.00	12.00	12.00	12.00	12.00	15.00	12.00	9.00	6.00	3.00
Other	237.64	354.83	390.75	417.06	443.37	469.68	258.35	167.47	157.86	157.86	131.55	105.24	78.93	52.62	26.31
TOTAL COSTS	257.40	422.57	471.83	513.73	549.92	586.10	364.89	235.91	222.83	217.13	185.94	148.75	111.56	74.38	37.19
NET BENEFITS	(257.40)	(422.57)	(471.83)	(513.73)	(313.15)	(349.33)	452.83	1185.39	1198.47	2341.78	2136.20	2173.39	1629.63	1063.23	1100.42

NPW = 4044

ERR = 26.4

Table 12.12

APPROPRIATION PROJECT FINANCIAL CASH FLOW  
FUND COMPONENT

('000 US\$)

	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18-20	21-26	27-29	30	31	32	33	34	35			
<b>BENEFITS</b>																															
Salvage																															
Palmeod																															
<b>TOTAL BENEFITS</b>																															
<b>COSTS</b>																															
Land clearing/ Road construction																															
Labour	41.24	41.24	41.24	41.24	41.24	41.24	41.24																								
Other	433.38	433.38	433.38	433.38	433.38	433.38	433.38																								
Planting																															
Labour	17.96	145.26	183.08	809.34	235.60	251.86	289.18	186.14	776.58	195.60	195.60	195.60	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58	176.58
Other	41.90	309.00	390.84	433.46	486.06	538.70	549.42	334.94	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72
<b>TOTAL COSTS</b>	534.48	928.88	1038.54	1177.42	1196.30	1275.18	838.60	523.08	492.30	511.32	511.32	511.32	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30	492.30
<b>NET BENEFITS</b>	(534.48)	(928.88)	(1038.54)	(1177.42)	(1196.30)	(1275.18)	(838.60)	(435.04)	(407.25)	(83.42)	(83.42)	(93.42)	(64.40)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)	(743.08)

NFY = 2595  
FIR = 8.4%



Table 12.13  
 APPROPRIATION PROJECT  
 ECONOMIC VALUE FLOW  
 FUND COMPONENT  
 ('000 US\$)

US\$ M B S

	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18-20	21-26	27-29	30	31	32	33	34	35			
<b>BENEFITS</b>																															
Saloon	35.52	111.90	134.59	150.25	166.10	181.86	173.51	112.88	105.95	117.36	117.36	117.36	105.95	105.95	94.54	94.54	94.54	94.54	867.10	867.10	867.10	0	2970.30	0	11196.90	11196.90	11196.90	11196.90	11196.90	11196.90	
Palwood	4.00	8.00	12.00	16.00	20.00	24.00	24.00	24.00	24.00	24.00	24.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	204.84	204.84	204.84	0	170.70	0	443.82	443.82	443.82	443.82	443.82	
Other	415.28	742.38	814.22	866.04	919.46	972.08	549.42	334.94	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	315.72	204.84	204.84	204.84	0	3149.00	0	11640.72	11640.72	11640.72	11640.72	11640.72	
<b>TOTAL BENEFITS</b>	514.80	862.28	960.81	1033.19	1105.56	1177.94	746.93	471.82	445.67	457.08	469.08	469.08	457.67	457.67	446.26	446.26	446.26	446.26	1071.94	1071.94	1071.94	0	3149.00	0	11640.72	11640.72	11640.72	11640.72	11640.72		
<b>COSTS</b>																															
Labour																															
Land																															
Other																															
<b>TOTAL COSTS</b>																															
<b>NET BENEFITS</b>	(514.80)	(862.28)	(960.81)	(1033.19)	(1105.56)	(1177.94)	(746.93)	(300.78)	(354.63)	0.98	(11.02)	(11.02)	0.39	981.29	981.29	695.68	695.68	613.68	613.68	613.68	613.68	2690.74	(458.26)	11182.46	17335.22	11411.59	11487.97	11564.34			

NPV = 1493  
 ERR = 10%

Table 12.14

AFFORESTATION PROJECT  
ECONOMIC VALUE FLOW INCLUDING INDIRECT EFFECTS  
EUCALYPTUS COMPONENT  
( '000 US\$ )

Y E A R S

	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
<u>BENEFITS</u>															
Direct	-	-	-	-	236.77	236.77	817.72	1421.30	1421.30	2558.91	2322.14	2322.14	1741.19	1137.61	1137.61
Indirect	23.68	84.98	100.11	118.14	128.73	139.23	126.06	75.26	70.63	63.02	52.52	42.02	31.51	21.01	10.50
TOTAL BENEFITS	23.68	84.98	100.11	118.14	365.50	376.00	943.78	1496.56	1491.93	2621.93	2384.66	2364.16	1772.70	1158.62	1148.11
TOTAL COSTS	251.40	422.51	471.83	513.73	549.92	586.10	364.89	235.91	222.83	217.13	185.94	148.75	111.56	74.38	37.19
NET BENEFITS	(233.72)	(337.59)	(371.72)	(395.59)	(184.42)	(210.10)	578.89	1260.65	1269.10	2404.80	2198.72	2215.41	1661.14	1084.24	1110.92

NPV = 4811

ERR = 32

Table 12.15

AFForestation PROJECT  
ECONOMIC VALUE FLOW INCLUDING INDIRECT EFFECTS  
PINUS COMPONENT  
(1000 US\$)  
Y E A R S

	-3	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18-20	21-26	27-29	30	31	32	33	34	35		
<b>BENEFITS</b>																														
Direct																														
Indirect																														
<b>TOTAL BENEFITS</b>																														
<b>TOTAL COSTS</b>																														
<b>NET BENEFITS</b>																														
	47.36	149.20	179.46	200.46	221.47	242.48	243.34	162.51	91.04	91.04	458.06	458.06	458.06	1438.96	1438.96	1071.94	1071.94	1071.94	1071.94	3149.00	-	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72	11640.72
	47.36	149.20	179.46	200.46	221.47	242.48	243.34	253.55	244.30	244.30	626.54	626.54	611.32	1592.22	1592.22	1209.99	1209.99	1221.99	1221.99	3299.05	150.05	150.05	146.05	121.04	96.03	71.02	44.02	21.01	21.01	
	514.80	862.28	960.81	1033.19	1105.56	1177.94	746.93	471.82	445.67	457.08	469.08	469.08	457.67	457.67	437.67	446.26	446.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26	458.26
	(467.44)	(713.08)	(781.35)	(832.73)	(884.09)	(935.46)	(903.59)	(218.27)	(201.37)	169.46	157.46	157.46	153.65	1134.55	1134.55	763.73	763.73	763.73	763.73	2640.79	(308.21)	(308.21)	11328.51	11379.80	11431.25	11482.61	11531.99	11585.36	11585.36	

NPV = 3539  
IRR = 11.8

Table 12.16

AFFORESTATION PROJECT. SENSITIVITY ANALYSIS

Original assumption	New assumption	Eucalyptus component		Pine component	
		FRR	ERR	FRR	ERR
Original assumptions	Same	21.3	26.4	8.4	1.0
100 percent of project's pulpwood will be needed	No pulpwood will be needed up to year 13	18.1	23.3	7.8	9.4
Original eucalypt sawlog yields	Eucalypt sawlog output 30 percent lower	16.8	21.5	-	-
Original pine plantation site	Pine plantations located 40 miles further away from market	-	-	6.3	8.6

Appendix A

FORESTRY PROJECT CASE STUDIES PREPARED BY FAO

FAO has prepared six case studies representing a variety of actual forest-based development projects. These have been published as a supplement to EAFP. <sup>1/</sup> The main categories of projects and countries represented are as follows:

Industrial plantations

Cases 4, 5 and 6 (Kenya and Zambia)

Smallholder tree farming

Case 1 (Philippines)

Village woodlots

Case 2 (Republic of Korea)

Natural hardwood forest utilization

Case 3 (South America)

Integrated forestry and forest industry

Cases 3 and 6 (South America and Zambia)

Taken as a group they show most of the common problems and types of analytical needs which the project planner will encounter in appraising forest projects designed to produce wood and/or wood fibres. <sup>2/</sup>

The case studies are based on actual project appraisals which have been modified only in terms of presenting a clearer picture of how the analyst got from the "objective" to the measures of project worth and his recommendation on the project.

The six case studies are as follows:

(a) Case Study No. 1, Philippine Smallholder Tree-Farming Project.

This case concerns a forest plantation programme which forms part of a rural development effort. Loans are made available to smallholders, with an average of some 10 ha of land, to enable them to grow a fast-growing tree (Albizzia falcataria), that is

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<sup>1/</sup> FAO, 1979.

<sup>2/</sup> See Gregersen and Brooks paper in FAO, forthcoming, for case material illustrating the application of economic analysis to forestry projects with water and soil protection outputs.

usable as pulpwood, on part of their land. The farmers sign an agreement with a local pulp and paper company which guarantees them a price and a market, but leaves them free to try and sell their output at a higher price elsewhere. The case study considers the project mainly from the point of view of the farmer and the government. The analysis is based on a typical farm unit rather than the project as a whole.

(b) Case Study No. 2, Village Fuelwood Plantations in Korea,

This case study deals with a village fuelwood programme in the Republic of Korea which constitutes a component of a large integrated rural development project. Like the Philippines project it includes a great number of small sub-projects, but in this case in different parts of the country. The overall programme is analysed as one project. Some of the problems of averaging input/output relationships for diverse elements in a large programme are brought out. The study also emphasizes the organizational aspects of this type of project, and the problems involved in dealing with shadow pricing of inputs and outputs and future demand and markets.

(c) Case Study No. 3, South American Natural Forest Utilization Project.

This case study deals with a project for expanding an integrated forest industry development based on a natural tropical hardwood resource. The emphasis is on a practical approach to appraising such a project and the elements to consider in a financial analysis, including treatment of loans and various government fees and tax incentives.

(d) Case Study No. 4, Kenya I Sawlog and Pulpwood Plantation Project.

This case examines a six-year time slice of an on-going sawlog and pulpwood plantation programme in Kenya. At the time this project was appraised, Kenya had experience growing and processing only sawlogs. This project included some of the country's first pulpwood plantations, which were established near the site of a proposed pulpmill. The mill was designed to meet Kenya's increasing domestic demands for paper products. In addition, the project financed the continuing sawlog plantation programme, which was designed to supply domestic sawmills which produce lumber for domestic use and export. The case provides an example of analysing project components separately, and illustrates problems associated with estimating import substitution and export benefits.

(e) Case Study No. 5, Kenya II Sawlog and Pulpwood Plantation Project.

This case deals with a further six-year time slice of the on-going Kenya sawlog and pulpwood plantation programme. This project continued and expanded its predecessor, the Kenya I project. At the time of the Kenya II appraisal, the pulpmill had been completed and was just starting production. As before, the project was made up of separate pulpwood and sawlog components. A comparison of this case with the Kenya I case shows the evolution of the project planning approach over time in a particular situation. For example, in Kenya II input and output prices and quantities were revised in the light of the Kenya I experience.

(f) Case Study No. 6, Zambia Industrial Forestry Project.

Like the Kenya case studies, this one deals with a large-scale government afforestation programme, and shows how to deal with a "time slice" project. It is concerned with a situation where there is still uncertainty about both yields from the plantations and about the outlets that will be available, and shows how such uncertainty can be dealt with. It also illustrates various aspects of the relationships between forestry and forest industry activities which have to be taken into account in an integrated project.

Appendix B

COMMON DISCOUNTING AND COMPOUNDING FORMULAS

As mentioned in the text, using the value flow table as a basis for NPW and ERR calculations, the analyst avoids the need for discounting and compounding formulas other than the simple present value formula. However, there are occasions where he may find it convenient to use other formulas, all derived from the basic one, which permit him to calculate in one step the present values for equal annual or periodic series of payments or to obtain an annual equivalent for a present or future value (e.g., where he wants to calculate a rental equivalent for a purchase price).

1. Calculating the present value of a periodic series of equal payments.

Table B-1 summarizes the main formulas needed to calculate the present and future values of annual and periodic payments (costs or benefits). The PV derived by using these formulas is expressed in terms of one year (period) prior to the year (period) when the first payment occurs. Thus, the analyst has to make sure that he appropriately compounds or discounts the result if he wants PV expressed in terms of a different year (period). Application of the formulas is illustrated below.

PV of equal annual payments

Assume a situation where there is an annual maintenance fee of \$12 for a plantation which starts at the beginning of year 2 (the 3rd year) of the project and continues up to and including year 15. Thus, there are  $(15-2) + 1$ , or 14 equal payments of \$12. How would the PV of this series of payments be calculated, if the discount rate is 8 percent?

First, applying the appropriate formula from Table B-1 (Formula 1 for a finite number of payments) the following result is obtained:

$$\$12 \frac{(1.08)^{14} - 1}{.08(1.08)^{14}} = \$12 (8.24) = \$99$$

This gives the PV in year 1 of the 14 payments starting in year 2.

Second, discounting this value (\$99) back one more year ( $\$99/(1.08)$ ) the PV in year zero is \$91.60.

This formula might be useful if, for example, the analyst wanted to compare the present value of two alternative equal annual cost streams. Assume that two alternative plantation management schemes were possible, one involving four equal costs of \$30/ha for years 1-4 and another involving ten equal costs of \$10/ha for years 2-11. The PV in year zero for the first alternative would be (using 8 percent):



$$\$30 \frac{(1.08)^4 - 1}{.08(1.08)^4} = \$99.36$$

(This is already in year zero terms since payments start in year 1.) For the second alternative, the PV in year zero would be:

$$\$10 \frac{(1.08)^{10} - 1}{.08(1.08)^{10}} = \$67.1 = \text{PV in year 1}$$

$$\$67.1 / (1.08) = \$62.13 = \text{PV in year zero}$$

Thus, the analyst can see that in PV terms the second alternative provides the lowest cost, assuming that the relevant discount rate is 8 percent.

#### Present value of a series of equal periodic payments

If payments (costs or benefits) occur every  $t$  years instead of every year for a specified period of time, then formulas 5 and 6 in Table B-1 to obtain PV's can be used. For example, suppose there is a situation where fertilizer will be applied to a stand every 5 years, starting 5 years from now and lasting during the entire rotation of 50 years except for year 50. This means that there would be 9 equal applications starting in year 5 and ending in year 45. Assume that the cost each time is estimated to be \$20/ha. How would the PV of these payments be estimated? Looking at Table B-1 formula 5 would be used for a finite number of periodic payments. The PV would be calculated as follows, assuming a discount rate of 8 percent,  $t = 5$ , and  $N = 9$ :

$$\$20 \frac{(1.08)^{45} - 1}{(1.08)^{45} [(1.08)^5 - 1]} = \$41.28$$

If there were also an application of fertilizer at the time of establishment, that amount would have to be added to the PV obtained above. The most common use in forestry of formulas for calculating the PV of series of equal periodic payments is in calculation of the SEV. This is explained and illustrated below.

#### Soil Expectation Value

The SEV gives an estimate of the present value of land if it were put into forestry and produced an infinite number of net returns of \$R every  $r$  years (where  $r$  is the rotation length).

To estimate the SEV, the net benefit of forestry production at the end of the first rotation  $R$  is calculated, without taking actual land cost into account and then the NPV of a future periodic series of net benefits of \$R is computed beginning with \$R received at the end of the first rotation. Thus, for example, assume a situation for a plantation as follows:

Establishment cost	\$250
Rotation	11 years
Annual cost	\$10 starting one year from now
Stumpage value at rotation	\$1 000
Discount rate	8 percent

The compounded value of the establishment cost at the end of the first rotation (year 1) is:

$$\$250 (1 + 0.08)^{11} = \$583$$

The compounded value in year ten of the ten equal annual costs (\$10 each year between years 1 and 10, both inclusive) can be calculated by using formula 2, Table B-1:

$$\$10 \frac{(1 + 0.08)^{10} - 1}{0.08} = \$145$$

which must be compounded for one additional year:

$$\$145 (1 + 0.08) = \$157$$

Therefore, total costs at the end of the first rotation (year 11) are  $\$583 + 157 = \$740$  and net benefits at rotation age are  $\$1\ 000 - \$740 = \$260$ .

The present value of an infinite series of payments of \$260 received every 11 years, or the SEV of this forestry management alternative, can be calculated by using formula 5 in Table B-1, for an infinite number of periods:

$$SEV = 260 \frac{1}{(1 + 0.08)^{11} - 1} = \$195$$

What does this SEV of \$195 mean? It has several meanings. Most commonly in forestry it is used to determine what amount could be paid for the land to breakeven, i.e., have PV of costs equal PV of benefits, using a discount rate  $i$  (in this case 8 percent). More generally it indicates the PV of the productive capacity of the land, given the values assumed and the assumption that the land could continue to produce timber in perpetuity at the given rate.

Table B - 1

ANNUAL AND PERIODIC PAYMENT FORMULAS

(1)

(2)

Payments Begin One Year (or Period) from Present

	Finite Number of Payment	Infinite Number of Payments
1. DISCOUNTED ANNUAL PAYMENT FACTOR	$\left[ \frac{(1+i)^n - 1}{i(1+i)^n} \right]$	$\left[ \frac{1}{i} \right]$
2. COMPOUNDED ANNUAL PAYMENT FACTOR	$\left[ \frac{(1+i)^n - 1}{i} \right]$	n.a.
3. ANNUAL CAPITAL RECOVERY FACTOR	$\left[ \frac{i(1+i)^n}{(1+i)^n - 1} \right]$	n.a.
4. ANNUAL SINKING FUND FACTOR	$\left[ \frac{i}{(1+i)^n - 1} \right]$	n.a.
5. DISCOUNTED PERIODIC PAYMENT FACTOR	$\left[ \frac{(1+i)^{nt} - 1}{(1+i)^{nt} [(1+i)^t - 1]} \right]$	$\left[ \frac{1}{(1+i)^t - 1} \right]$
6. COMPOUNDED PERIODIC PAYMENT FACTOR	$\left[ \frac{(1+i)^{nt} - 1}{(1+i)^t - 1} \right]$	n.a.

i = rate of interest (discount) in decimal form

n = number of years or periods until last payment starting with 1 year from now

t = number of years between periodic payments

2. Annual Equivalency Formulas

Formulas 3 and 4 in Table B-1 are used to calculate annual equivalents of given amounts of PV of costs or benefits. The formulas are merely the inverse of formulas 1 and 2. Assume, for example, that two alternative incentive programmes for tree farmers are being compared. One alternative is to give them a lump sum today of \$100. The other alternative considered is to provide them with five equal payments over 5 years, starting one year from now. For the latter incentive to be effective, the annual amount should equal the \$100 of PV using their relevant discount rate. In this case it is assumed to be high - 30 percent - since they value present income considerably higher than future income. To find the annual payments necessary, formula 3 for a finite number of payments is applied. The annual amount that would have to be paid, starting one year from now, to make the farmers indifferent between \$100 now and the five equal payments, would thus be:

$$\$100 \frac{.30(1.30)^5}{(1.30)^5 - 1} = \$41$$

In other words, given their relevant discount rates (or their trade-off rates between present and future income) they would have to be paid \$41 per year for five years to make them indifferent between the two payment forms.

Appendix C

HOW TO CALCULATE THE ECONOMIC RATE OF RETURN (ERR)

Although several relatively inexpensive hand calculators contain programmes (or can be programmed) for rate of return calculations, the analyst might be faced with situations in which the computation of ERR would have to be based on more rudimentary methods. There is no formula for calculating the ERR when more than one cost and/or benefit is involved. Therefore, a trial and error technique has to be used. The approach is as follows:

- (a) First calculate a NPW using a rate which is estimated to be in the neighbourhood of the expected ERR. If the NPW is negative, then the ERR must be lower than the rate of discount used. If the NPW is positive, then the ERR must be higher than the discount rate adopted.
- (b) If the first NPW calculated is negative, then reduce the discount rate up to a point where the calculated NPW is positive and vice versa if the first NPW calculated is positive. The ERR must now lie between the two rates of discount used in generating the positive and negative values of NPW.
- (c) Estimate the ERR by using the following formula:

$$\text{ERR} = \left( \begin{array}{c} \text{low rate of} \\ \text{discount} \end{array} \right) + \left( \begin{array}{c} \text{difference between} \\ \text{both rates of discount} \end{array} \right) \times \left( \frac{\text{Positive NPW}}{\text{absolute difference between positive and negative PNW's}} \right)$$

- (d) Repeat steps (a) - (c) for a more precise result, if needed.

The following example, which uses the figures of the Philippine tree-farm project, illustrates the use of this technique:

Table C-1 shows in the first row the net benefits (costs) of the Philippine tree-farm project (from Table 9.1). The second row contains the PV of each annual flow discounted at 20 percent. The NPW, using this discount rate is positive and equal to P 4638 and, therefore the ERR must be higher than 20 percent. A further discounting attempt at 30 percent generated a still positive NPW equal to P 453, as shown in row 3 of Table 35. Therefore a still higher discount rate of 35 percent was tried, which rendered a negative NPW of - P 543. The ERR must then lie between 30 and 35 percent. Using the formula from step (c) above, the ERR of this project is estimated as follows:

$$\text{ERR} = 30\% + 5\% \frac{453}{996} = 32.27 \text{ percent}$$

This is rounded off to 32 percent.

A further interpolation using a narrower range of 31 and 33 percent would have produced NPW's equal to P 215.6 and P 198.5, respectively. Using these two new values, a second estimate of ERR would be 32.04 percent. But since the result is being rounded off to the nearest whole percentage point, this additional refinement is unnecessary.

Table C1

## CALCULATING THE ERR - PHILIPPINE PROJECT

	Years															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Net Benefits (costs) <sup>1)</sup>	(1163)	(1163)	(1163)	(1163)	(100)	(100)	(100)	5286	5887	5887	6523	6523	7147	7147	7759	5887
2. Present value of net benefits (costs) discounted at 20% per year	(1163)	( 969)	( 808)	( 673)	( 48)	( 40)	( 34)	1475	1369	1141	1054	878	802	668	604	382
3. Present value of net benefits (costs) discounted at 30% per year	(1163)	( 895)	( 688)	( 529)	( 35)	( 27)	( 21)	842	722	555	473	364	307	236	197	115
4. Present value of net benefits (costs) discounted at 35% per year	(1163)	( 861)	( 638)	( 472)	( 30)	( 22)	( 16)	647	534	395	324	240	195	144	116	64

<sup>1)</sup> From Table 9.1.

Appendix D

CALCULATION OF THE BENEFIT-TO-COST (B/C) RATIO

In addition to NPW and ERR, some institutions use B/C as a measure of project worth. It is generally expressed in terms of the ratio of present value of total benefits over present value of total costs.<sup>1/</sup>

The calculation of a B/C ratio involves discounting the total benefit and cost rows separately. This is shown in Table D-1 for the Philippine project (see Table 9.1). A 5 percent discount rate has been employed in the calculations. The B/C ratio is equal to 5.8.

What does a B/C ratio of 5.8 indicate? It measures the amount of benefits, expressed in present value terms, that the project generates per dollar of resources used in the project, also expressed in present value terms. Put another way, at the discount rate assumed, the present value of all consumption benefits gained is 5.8 times the present value of all costs (or consumption benefits foregone) due to the project.

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<sup>1/</sup> Several alternative forms of the B/C ratio are in use. Here the most common one is used, which is a ratio of the present value of all benefits to the present value of all costs. Another in common use is the net B/C ratio, which is the ratio of all benefits minus operating costs to total investment cost. See paper by McGaughey in FAO, forthcoming.



Table D1

THE B/C RATIO - PHILIPPINE PROJECT. (5% DISCOUNT RATE)

	Years															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Benefits	-	-	-	-	-	-	-	5523	6174	6174	6810	6810	7634	7434	8046	6174
2. Present value of benefits	-	-	-	-	-	-	-	3925	4179	3980	4181	3982	4140	3942	4064	2970
3. Costs	1163	1163	1163	1163	100	100	100	237	287	287	287	287	287	287	287	287
4. Present value of Costs	1163	1108	1055	1005	82	78	75	168	194	188	176	167	160	152	145	138

Note: From the above:

the sum of present values of benefits = 35363  
 sum of present values of costs = 6052

$$\text{Thus, B/C ratio} = \frac{35363}{6052} = 5.8$$

Appendix E

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